Short Communication

Effects of planting date and salicylic acid on physiological traits of forage maize hybrids

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Abstract

Temperature changes occur in nature faster than other stressors. Plants due to inability to move and change their position, are exposed to extensive variations in daily or seasonal temperature, and therefore, should quickly and effectively adapt to temperature stress. In order to study the effects of heat stress on physiological traits of forage maize hybrids, a factorial split plot experiment was carried out in a completely randomized block design with three replications in 2011. Treatments consisted of two maize varieties Ks 704 and N 504, 2 concentrations of salicylic acid (0 mM and 1 mM) and 2 different planting dates (July 5th and 26th). The plant height, stem diameter, plant dry weight, dry matter production (DMP) and protein content (CP) were measured. Results showed that plant height was affected under the interaction of three factors of the study, i.e., planting date, hybrid and spraying salicylic acid. Plant height in the variety N 504, treated with 1 mM salicylic acid and the planting date of July 26th was 64.76% more than in the treatment including 0 mM salicylic acid and the planting date of July 5th. Maximum dry weight per plant was observed in the plants treated with 1 mM salicylic acid planted on July 26th. Dry matter production (DMP) in Ks 704 sprayed with 1 mM salicylic acid and the planting date of July 26th was 73.71%. On the other hand, the protein content (CP) in shoots with 0 mM salicylic acid was 15.68%.

Keywords: acid salicylic; dry matter production (DMP); heat stress; planting date; protein contents (PC)

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Introduction

Maize used to be the staple food in North, Central and South America before the discovery of new continent. Maize is considered not only as the main diet for some people, but also it plays a very important role in livestock products (Nourmohammadi et al., 2010). The period of time between sowing and emergence of the plant is an important factor affecting plant growth and the subsequent crop yield. It seems that during this period the seedlings are highly vulnerable to salinity and drought stress but usually the plants' tolerance against salinity and

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drought increases over the course of their growth (Ashraf and Rauf, 2001).

Increase in the efficiency of photosynthesis of maize under the influence of salicylic acid improves the plant's growth and yield (Khan et al., 2003). Application of 1 mM acid salicylic was reported to reduce transpiration (Azizi Yegane, 2010). Spraying salicylic acid is also shown to be effective on the overall plant performance and its components (Singhvi et al., 2002).

The aim of this study was to investigate the effects of applying salicylic acid on different planting dates on yield and physiological traits of 2 varieties of maize.

Materials and Methods

In order to study the effects of planting date on the quality and quantity of forage maize hybrids sprayed with salicylic acid, an experiment was arranged in completely randomized split plot factorial design with three replications in 2011 in Damghan, Iran. Treatments included 2 varieties of maize, namely, Ks 704 and N 504, 2 concentrations of salicylic acid (0 and 1m M) and 2 planting date (July 5th and 26th). Seedbed in the experimental field was prepared by deep cultivation followed by twice perpendicular disc harrowing and application of rotating field cultivator on July 1st, 2011. The required chemical fertilizers based on the soil test were applied and mixed with soil using a harrow. At 4-6 leaf stage, when the plants were about to start rapid growth, the rest of urea fertilizer was applied to the field soil. Inter and intra row spaces in each plot were 75 cm and 15 cm, respectively. In each plot there were 5 rows of 5 m length. Furrows were first made for planting by the depth of 3-5 cm. Then using a yarn on which sowing distances were marked, 3 seeds were sown at each spot 5 cm from each other. Traits under study included plant height, stem diameter, plant dry weight, produced dry matter (DMP) and protein content (CP). DMP and CP were measured using NIR (Jafari et al., 2003). The statistical analysis of the data was performed using SAS software package and means were compared using LSD multiple range test (P≤ 5%).

Results

Plant height

Plant height was affected by planting date and the interaction between planting date × salicylic acid at 1% and 5% probability (Table 1). Minimum plant height (103.1 cm) was observed under the combined treatment of the first plantation date (July 5th) and 0 mM salicylic acid on the hybrid N 504. Maximum height on the other hand was recorded in the combined treatment of the second planting date (July 26th) × salicylic acid (1 mM) on the hybrid N 504 (159.2 cm) (Table 2).

Stem diameter

Stem diameter was affected by planting date (P≤5%) and the difference was statistically

Table 1
ANOVA results Mean squares yield variety corn on the treated The date of planting and spraying acid salicylic.

Changes in Resources	DF	Dry Weight per Plant	Dry Matter Production (DMP)	Protein Contents (CP)	Plant Height	Stem Diameter
Repeat	2	125.085	22.992	2.775	77.810	10.864
Date of planting (A)	1	** 5527.645	**202.420	1.510	** 6048.057	*33.512
Test error	2	182.446	58.764	18.091	180.557	16.448
Hybrid Corn (B)	1	286.419	*49.249	0.564	531.570	2.269
spraying Acid Salicylic (C))	1	120.646	0.003	*3.792	6.375	9.200
A × B	1	*910.078	11.157	*3.435	176.638	3.420
A × C	1	*892.186	0.187	*6.933	*773.048	0.968
B × C	1	156.621	4.200	0.035	371.542	5.960
A × B × C	1	100.573	0.608	*5.453	345.420	2.088
EROR	12	201.949	9.372	0.966	108.375	4.501

* And** The significant

significant (Table 1). As Table 2 suggests, maximum stem diameter (20.10 mm) was observed in the treatment of the 2nd planting date and 1 mM salicylic acid on Ks 704 hybrid. Minimum stem diameter on the other hand was recorded for the first planting date and 0 mM salicylic acid on N 504 hybrid (15.29 mm).

Plant dry weight

Dry weight of the plants under study was affected by planting date × hybrid and the interaction between planting date × hybrid and spraying salicylic acid at 1% and 5% probability level (Table1). Maximum dry weight per plant (49.96 g) was recorded in the treatment of the second planting date (July 26th) and 0 mM salicylic acid on N 504 hybrid (Table 2).

Dry matter production (DMP)

Dry matter production showed significant difference under the effect of planting date and hybrid at 1% and 5% probability levels, respectively (Table 1). Maximum DMP (73.71%) was recorded under the combined treatment of the second planting date and 1 mM salicylic acid on Ks 704 hybrid. Minimum DMP (64.03%) on the other hand, was observed in the combined treatment of the first planting date and 1 mM salicylic acid spraying on N 504 hybrid (Table 2).

Shoot protein contents (CP)

Protein content in shoots was statistically significant by spraying salicylic acid, the interaction of planting date × hybrid, planting date × spraying salicylic acid and the interactive effects of the planting date × hybrid × spraying salicylic acid at $P \leq 5\%$ (Table 1). Maximum amount of protein in the shoots (16.34%) was observed under the three-factor effects of planting date (July 26th) × hybrid (N 504) × spraying salicylic acid 1 mM (Table 2).

Discussion

A study by Williams and Lindquist (2007) showed a delay in corn planting led to 13 to 24 cm increase in plant height. Results of other studies have shown that the increased height is an advantage in delayed planting date (Evans et

Table 2
Comparison of corn yield under the three-factor interaction between planting date and cultivar Corn and solution Acid spray Salicylic

Date of Planting × Hybrid Corn × Solution Spray Acid Salicylic	Dry Weight per Plant (g)	Dry Matter Production (DMD) (%)	Protein in Aerial CP (%)	Plant Height (mm)	Stem Diameter (mm)
15 July × 504 × Concentration control	e 49.31	cd 65.33	15.95	c 22.71	b 15.29
15 July × 504 × Concentration 1 mM	d 64.97	d 64.03	13.05	bc 26.97	b 16.52
15 July × 704 × Concentration control	d 67.52	bcd 68.41	15.98	bc 26.48	b 16.25
15 July × 704 × Concentration 1 mM	c 85.21	abc 69.41	15.14	ab 26.74	b 18.30
5 August × 504 × Concentration control	a 108.3	ab 72.01	15.18	ab 29.43	ab 19.40
5 August × 504 × Concentration 1 mM	91.35 b	ab 71.69	16.34	ab 31.07	b 18.65
5 August × 704 × Concentration control	b 93.65	ab 72.99	15.61	ab 31.35	b 17.67
5 August × 704 × Concentration 1 mM	b 95.48	a 73.71	15.01	a 32.47	a 20.10

*: Planting date in each column respectively, 15 July and 5 August.
*: Each column in the single cross hybrid corn, respectively, including 504 And704.
*: Solution in each column spray Acid Salicylic respectively. Includes concentrations 0 and 1 mM.

al., 2003). Salicylic acid on the other hand has been demonstrated to significantly reduce ion leakage and accumulation of toxic ion in plants (Kranter et al., 2008; Zhou et al., 2009). It also mitigates abiotic stresses through increasing the growth regulating hormones such as auxins and cytokinins (Shakirova et al., 2003). Generally, flavonoids are secondary metabolites that are considered as antioxidants. It seems that increase in the content of this pigment by salicylic acid via scavenging ROS, controls oxidative stress and increases plant resistance and growth (Ververidis et al., 2003). As a result, treatment with salicylic acid leads to increase in plant length. It is argued that increased stem length is an influence of salicylic acid in stress conditions while environmental stresses reduce cellular division (Liu et al., 2003, 2004). Bulk of research studies have shown that salicylic acid enhances growth in shoots and roots and production of biomass in different plant species and under various environmental stresses (Metwally et al., 2003; Khodary, 2004).

Salicylic acid was reported to increase cytokinins in corn and these hormones increased the stem diameter (Shakirova et al., 2003). Yonu et al (2004) in a two-year experiment on corn varieties also found a positive correlation between planting date and the stem diameter. Stem diameter is a growth parameter that can be influenced by various factors such as planting date (Ayoub et al., 2003). Zare et al. (2006) reported a reduction in the diameter of the wheat seedling stem as a result of applying growth hormones under salinity stress concluding that application of salicylic acid would improve morphological traits of the plants subjected to drought and salinity stress. While injection of salicylic acid into corn stems did not increase the plant dry weight compared with the control (Zhou et al., 2009), Frariduddin et al. (2003) reported that spraying salicylic acid 5-10 M on 60-day-old canola plants increased plant dry weight. The negative impact of temperature on photosynthesis and chloroplasts reduces energy production efficiency in photosynthetic organs and assimilation of Co_2 in the dark cycle of photosynthesis and, as a result, reduces carbohydrate production which explains the reduction in shoot dry weight (Allen and Ort, 2001). Singh and Usha (2003) and Sakhabutdinova et al. (2003) observed that application of salicylic acid increased the plant dry weight. Laboratory results showed that injection of salicylic acid into corn plants under salinity stress increased plant dry weight. (Khodary, 2004). Liu et al. 2003, 2004) attributed this increase in the dry weight to increased length of seedling roots and shoots under the influence of salicylic acid.

Jamshidi (2007) argued that concurrence of vegetative growth and environmental conditions of high heat and radiation (late spring and summer) can speed up plant growth and improve performance of the plant in making use of radiation and this in turn can improve dry matter accumulation during the vegetative stage compared with reproductive stage. It is therefore possible to increase plant dry matter through selecting varieties with longer vegetative stage with delayed plantation date provided that there is no limitation in time.

Photosynthesis is a main factor in dry matter production in plants. It is also established that growth regulating hormones can improve physiological performance of the plants such as photosynthesis and increase transfer of assimilates from source to reservoir. The result is increase in plant dry matter. In an experiment, salicylic acid 10 mM increased nitrate reductase activity compared with control which reflects the effect of salicylic acid on the process of nitrogen uptake which possibly increases the plant dry matter through its impact on growth regulators (Hamada et al., 2000).

Darby and Lavor (2002) in their experiments concluded that delay in planting resulted in lower quality forage. Mokhtarpour et al. (2008) in their study compared the effects of 4 planting dates, namely, late April, early May, late May and early June on the quality of silage corn reporting that delayed planting influenced the protein content and maximum protein content (694 kg per hectare) was obtained from the early May planting date. The same researchers (*Ibid*) in their experiments showed that the effect of planting date on crude protein was significantly meaningful and delayed corn planting reduced the plant performance.

Salicylic acid is reported to increase protein levels in plants (Apostolova et al., 2008). Free radicals can damage the protein structure and decrease protein content (Mittler, 2006). The reduction in protein content can be due to decreased activity of nitrate reductase, glutamine synthesize and glutamine 6 – eizo glutarat amino transferase. Moreover, due to the high tendency for reaction with proteins, free radicals oxidize proteins. It is likely that salicylic acid as an antioxidant, neutralizes free radical damage due to oxidation and degradation of protein structure and thus increase protein content (Keshvarz, 2010). Protein content in plants treated with salicylic acid was higher than the control plants (Majd et al., 2006). Shortening the growth period in delayed planting date also increased protein content. Various environmental factors such as humidity, temperature, day length and nutrients, especially nitrogen, cause changes in protein (Sadeghi, 2006).

Conclusion

This study aimed at finding the best planting date and investigating the impact of heat stress on germination and growth of hybrid corn in order to find the most resistant hybrid and the most suitable temperature for germination and growth of corn. Corn is very sensitive to heat stress during pollination. Therefore, to prevent yield loss planting in August should preferably be avoided in the study area, Damghan, Iran. The findings showed that ion leakage and accumulations of salicylic acid significantly reduced ion toxicity and the environmental stresses through increasing growth regulating hormones such as auxin and cytokinins. The study generally suggested that planting date had an effect on physiological traits of forage maize and the best planting date was found to be in early August. Salicylic acid did not have a significant effect on physiological traits of the plants under study compared with the control plants which had the highest response. However, salicylic acid was effective in the quality of corn and increased protein content in the plants under study.

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