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Effects of Salicylic Acid and Cut off Irrigation on Some Physiological Characteristics of Sweet Corn

KEYWORDS: Corn, Cut off irrigation, Salicylic Acid, physiological characteristics

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ABSTRACT *An experiment in the split-split plot arrangement using the randomized complete block design with three replications was carried out in Damghan (Semnan Province) in the crop year 2012-2013 to study the effects of spraying Salicylic acid and cessation irrigation conditions and also the mutual effects of these two factors on Chlorophylls a and b, total Carotenoid, leaf surface area and proteins of two corn cultivars. The major factor was the stress resulting from cessation of irrigation at three levels (the control, BBCH51 and BBCH61), the minor factor consisted of three levels of Salicylic acid (control, 100 and 200 ppm) and the sub-minor factor was two corn cultivars namely Chase and Sweet Corn. The results of ANOVA showed that the highest percentage of protein (20.24%) was achieved in the interactions of Chase cultivar, irrigation cessation at the control stage and Salicylic acid application (200 ppm). The mutual effects of Salicylic acid and irrigation cessation on leaf surface area, carotenoid content and Chlorophyll a, caused significant differences at the 5% level of probability. Effect of only irrigation cessation on Chlorophyll b caused significant differences at the one percent level of probability and raised its quantity to 0.086 milligram per gram fresh weight (mgg-1fw). Moreover, the maximum total Chlorophyll content of 0.349 mgg-1fw was observed in the interactions of Chase cultivar, irrigation cessation and using Salicylic acid (200 ppm). Therefore, we conclude that the effects of Salicylic acid on improving growth and on increasing yield were tangible under stress and under normal conditions and significantly improved the evaluated characteristics. Also both concentrations of Salicylic acid especially those of 200 ppm, played a role in relieving the stress caused by irrigation cessation.*

Introduction

Corn (Zea mays) is a tropical cereal of the Gramineae family belonging to monocotyledonous plants. Iran has very great potential in corn production and its yield inside the country, according to statistics, is 7100 kg hectare^{-1}, while the mean global yield is 4900 kg hectare^{-1}. Corn is one of the four major cereals in the world and ranked third in production after wheat and rice (Khodabandeh, 2009; Mojab Ghasre-dashti et al., 2012). Corn is a monoique-monoecious plant, i.e., male and female flowers are separate but these are located on the same plant. Pollination takes place directly and pollens are transferred to female flowers in various ways (Mazaherilaghab, 2008; Yu et al., 2004). Stress develops when a set of physical and environmental factors reduce available water in the root zone or inside the plant structure and, hence, reduce yield. This reduction may be caused by delay in plant establishment or lack thereof, weakness or destruction of established plants, susceptibility of plants to attack by pests and diseases, and physiological and biochemical changes in plant metabolism. Also drought stress reduces corn leaf area index and dry matter (Emami and Niknezhad, 2004).

Salicylic acid (SA) is a hormone-like compound that researchers have used in various studies in recent years (John Ping et al., 2001). Salicylic acid (SA) increases the H_2O_2 level in plant tissues (John Ping et al., 2001). Salicylic acid is soluble in water (Zakay and Radovan, 2011). It seems that, under conditions of water shortage, the use of plant growth regulators like Salicylic acid can be an effective strategy for preventing the destructive effects of cut off irrigation and for paving the way for adaptability of plants to cut off irrigation (Cong and Wang, 2003). Increasing the plant resistance can be achieved in various ways, including breeding and use of growth regulators. Compared to breeding, that is usually a long-term and costly effort, use of chemicals such as Salicylic acid (SA), Jasmonic acid, etc. is simpler and cheaper. Salicylic acid is a phenolic compound and due to its antioxidant properties plays a role in regulating plant physiological processes. Salicylic acid is known as an important messenger molecule in plant responses to various biotic and abiotic stresses (Al-Tayebi, 2005). Compounds such as Salicylic acid can increase plant resistance to salinity. As a plant growth regulator, Salicylic acid plays a pivotal role in regulating various stages of plant growth and development, ion absorption, photosynthesis and germination (Horvath et al., 2007). Researchers have proved Salicylic acid and related compounds play a role in reducing the effects of many environmental stresses (Hayat and Ahmad, 2007). Salicylic acid improves plant resistance to environmental stresses. Considering that Iran is located in the arid and semi-arid belt, and given the soil conditions in this country, the necessity of utilizing plants with a high degree of adaptability to dry climate and soil conditions in the country (while producing forage crops with high protein content to provide feed for stock) is felt more than ever before. Therefore, planting forage crops with minimum water requirements and use of cultivars that do not require a substantial volumes of water are suitable strategies for increasing livestock products in the country (Yazdani et al., 2007). The first study on plant growth stages based on the BBCH scale was conducted in 1974 (Augusti et al., 1997). The BBCH scale is included as a checklist in IT systems for reporting and analyzing agricultural data (Mitchel et al., 2007). This scale and its decimal codes were used to analyze various growth stages of corn. This research was focused on various stages of primary and secondary growth up to senescence. Use of binary-coded decimals allows the study of growth stages and the related substages. The BBCH scale considers growth stages from zero to nine, plant growth stages are carefully examined, and plants are studied meticulously

Volume : 4 | Issue : 8 | August 2014 | ISSN - 2249-555X

from the time they start to grow and germinate until harvest time. Based on BBCH codes, the World Meteorological Organization (WMO) has defined three physiological levels of plants as their main growth stages in their own seasons (Koch et al., 2007). The first growth stage includes germination to differentiation of reproductive organs, the second starts at the beginning of differentiation of reproduction organs and ends at the start of flowering, and the third includes the start of flowering until the end of physiological maturity.

To use the BBCH scale from the time of germination at which the coleoptiles make holes on the surface of the soil to emerge, germinated plants were photographed so that all plant growth stages considered for the crop until harvest time could be studied. Samples were taken when plants had reached complete physiological maturity and were on the ground. Corn is very suitable as food for beef stock and poultry, and is of exceptional importance in rations and concentrates and, especially, high volumes of its fresh and dry fodder are consumed by stock. Therefore, the purpose of this experiment was to study the effects of Salicylic acid and irrigation cessation, and their mutual effects, on raising the efficiency and quality level of fodder production (pellet fodder production) in two corn cultivars.

Materials and methods

An experiment in the split-split plot arrangement using the randomized complete block design was conducted in Raziabad village in Damghan in the cropping year 2012-2013 with three replications. The major factor was the stress of irrigation cessation at three stages (the control, BBCH51 and BBCH61), the minor factor included two levels of Salicylic acid application (the control and 100 and 200 ppm Salicylic acid), and the sub-minor factor were two corn varieties Chase and sweet corn. The experiment was designed to find drought tolerance level of sweet corn and to determine the effects of Salicylic acid, under designed reduced irrigation on some physiological and agronomic characteristics such as protein, total Chlorophyll, Chlorophyll a and Chlorophyll b contents (Arnon, 1949), leaf area index (Watson, 1952), and Carotenoid content (Lichtenthder., 1987). Carotenoid extraction was carried out using the method introduced by Nelson et al. (2005). Hexane-ethanol solution, at the ratio of 9 (hexane) to 1 (ethanol), was added to crushed leaves and completely mixed by centrifuging at 10000 rpm for five minutes. After filtering the extract, its absorbance was read using a spectrophotometer. The factorial experiment was carried out using the randomized complete block design with three replications. The data was analyzed by SAS software, and comparison of the means was performed based on the LSD test at the five percent probability level, and graphs were plotted using Excel software.

Results and discussion

Yield

The table of comparison of the means indicated that, with irrigation cessation at the control stage and application of 200 ppm Salicylic acid, the Chase cultivar achieved the highest yield in all cases (Tables 1-5).

Table 1)Analysis of variance due to irrigation , Salicylic Acid on some plant characteristics of Corn

	MS						
S.O.V.	df	Proteins	Leaf area index	Chlorophyll a	Chlorophyll b	Carotenoids	Total Chlorophyll
Block	2	0.5515 ns	281078.47 ns	0.00048 ns	ns 0.00095	0.00110 ns	0.000401 ns
Cut off irrigation	2	14.4445 ns	66861.03 ns	0.00438 *	0.01174**	0.00703 ns	0.038135**
Error original	2	18.8067	205314.90	0.00000	0.00185	0.00023	0.008857
Salicylic Acid	4	11.0309*	225602.95 ns	0.00382 ns	0.00163 ns	0.00681 ns	0.002735 ns
Salicylic Acid * Cut off irrigation	4	11.0309*	225602.95*	0.00382*	0.00163 ns	0.00681*	0.002735 ns
Error Subsidiary	12	3.5463	60493.87	0.00094	0.00076	0.00203	0.002592
Variety	1	6.0601 ns	9734.06 ns	0.00000 ns	0.00005 ns	0.00054 ns	0.00189 ns
Variety * Cut off irrigation	2	7.1902 ns	97736.53 ns	0.00400 ns	0.00075 ns	0.00489 ns	0.001712 ns
Variety * Salicylic Acid	2	11.4624*	28035.17 ns	0.00040 ns	0.00170 ns	0.00131 ns	0.013224*
Variety * Cut off irrigation * Salicylic Acid	4	16.9393**	125998.59 ns	0.00216 ns	0.00131 ns	0.00139 ns	0.015657**
Error sub-minor	18	2.1545	104546.39	0.00163	0.00232	0.00152	0.00250556
ns,*,**:non-significant, significant at p<0.05 and p<0.01, respectively							

Volume : 4 | Issue : 8 | August 2014 | ISSN - 2249-555X

Table2) The mean interaction Variety* Cut off irrigation* Salicylic Acid On traits in Corn

Variety * Cut off irrigation * Salicylic Acid	Leaf area (mm^2)	Chlorophyll a ($mgg^{-1}fw$)	Chlorophyll b ($mgg^{-1}fw$)	Total Chlorophyll ($mgg^{-1}fw$)	Carotenoids ($mgg^{-1}fw$)	Proteins (%)
C * control * 0 A	1589.6800^{a}	0.1193 ^{a}	0.1057 ^{a}	0.1597^{bcd}	0.0997 ^{a}	11.6293^{b}
S* control * 0 A	1120.2200 ^{a}	0.1407 ^{a}	0.1230 ^{a}	0.1967^{bc}	0.0993 ^{a}	13.0367 ^{b}
C * control * 100 A	958.0000 ^{a}	0.0807 ^{a}	0.0503 ^{a}	0.1317^{bcd}	0.1617 ^{a}	11.7133 ^{b}
S* control * 100 A	1077.9100 ^{a}	0.1180 ^{a}	0.0953 ^{a}	0.2147^{b}	0.0730 ^{a}	12.2467 ^{b}
C * control * 200 A	1393.9200 ^{a}	0.0763 ^{a}	0.0903 ^{a}	0.3490^{a}	0.0697 ^{a}	20.2400^{a}
S * control *200 A	1152.4000 ^{a}	0.0863 ^{a}	0.0513 ^{a}	0.1373^{bcd}	0.0260 ^{a}	11.9670 ^{b}
C * BBCH51* 0 A	1331.9100 ^{a}	0.0537 ^{a}	0.0627 ^{a}	0.0773^{d}	0.0347 ^{a}	12.5967 ^{b}
S*BBCH51* 0 A	1275.1600 ^{a}	0.0740 ^{a}	0.0260 ^{a}	0.1000^{cd}	0.0413 ^{a}	11.7633 ^{b}
C*BBCH51*100 A	1272.2800 ^{a}	0.0366 ^{a}	0.0327 ^{a}	0.1233^{bcd}	0.0607 ^{a}	11.4667 ^{b}
S* BBCH51*100 A	1271.3500 ^{a}	0.0860 ^{a}	0.0510 ^{a}	0.1373^{bcd}	0.0570 ^{a}	11.6167 ^{b}
C*BBCH51*200 A	931.2800 ^{a}	0.1147 ^{a}	0.0557 ^{a}	0.1707^{bcd}	0.0410 ^{a}	12.7433 ^{b}
S* BBCH51*200 A	1163.9100 ^{a}	0.0777 ^{a}	0.0237 ^{a}	0.1027^{cd}	0.0647 ^{a}	14.1800 ^{b}
C * BBCH61* 0 A	1179.4500 ^{a}	0.0773 ^{a}	0.0434 ^{a}	0.1220^{bcd}	0.0573 ^{a}	13.3233 ^{b}
S * BBCH61* 0 A	1421.7300 ^{a}	0.0507 ^{a}	0.0413 ^{a}	0.1230^{bcd}	0.0497 ^{a}	13.6333 ^{b}
C * BBCH61*100 A	1210.4200 ^{a}	0.1323 ^{a}	0.0280 ^{a}	0.1220^{bcd}	0.0273 ^{a}	15.0700^{ab}
S * BBCH61* 100 A	954.3200 ^{a}	0.0637 ^{a}	0.0230 ^{a}	0.0840^{d}	0.0427 ^{a}	15.010 ^{ab}
C * BBCH61* 200 A	1473.4600 ^{a}	0.0827 ^{a}	0.0490 ^{a}	0.1077^{cd}	0.0730 ^{a}	14.3500 ^{b}
S * BBCH61* 200 A	1661.7400 ^{a}	0.0770 ^{a}	0.0647 ^{a}	0.1633^{bcd}	0.1140 ^{a}	13.6500 ^{b}

Common treatments letters according to Duncan's multiple range test at least five percent are not significant.
Chase= C, Variety Sweet Corn= S, Salicylic Acid= A Variety

Table3) The mean interaction Cut off irrigation* Salicylic Acid On traits in Corn

Salicylic Acid * Cut off irrigation	Leaf area (mm^2)	Chlorophyll a ($mgg^{-1}fw$)	Chlorophyll b ($mgg^{-1}fw$)	Total Chlorophyll ($mgg^{-1}fw$)	Carotenoids ($mgg^{-1}fw$)	Proteins (%)
control * 0 A	1354.9500^{ab}	0.1300 ^{a}	0.1143 ^{a}	0.1782^{a}	0.0995 ^{ab}	12.3330^{bc}
control * 100 A	1017.9600^{b}	0.0993 ^{ab}	0.0728 ^{a}	0.1732 ^{a}	0.1173 ^{a}	11.9800 ^{bc}
control * 200 A	1273.1600 ^{ab}	0.0813 ^{b}	0.0708 ^{a}	0.2432 ^{a}	0.0478 ^{bc}	16.1035 ^{a}
0 A * BBCH51	1303.5300 ^{ab}	0.0638 ^{b}	0.0443 ^{a}	0.0887 ^{a}	0.0380 ^{c}	12.1800^{bc}
100 A * BBCH51	1271.8200 ^{ab}	0.0613 ^{b}	0.0418 ^{a}	0.1303 ^{a}	0.0588 ^{bc}	11.5417^{c}
200 A * BBCH51	1047.6000 ^{b}	0.0962 ^{ab}	0.0397 ^{a}	0.1367 ^{a}	0.0528 ^{bc}	13.4617 ^{abc}
0 A * BBCH61	1300.5900 ^{ab}	0.0640 ^{b}	0.0424 ^{a}	0.1225 ^{a}	0.0535 ^{bc}	13.4783 ^{abc}
100 A * BBCH61	1082.3700 ^{b}	0.0980 ^{ab}	0.0255 ^{a}	0.1030 ^{a}	0.0350 ^{c}	15.0400 ^{ab}
200 A * BBCH61	1567.6000 ^{a}	0.0798 ^{b}	0.0568 ^{a}	0.1355 ^{a}	0.0935 ^{abc}	14.0000^{abc}

Common treatments letters according to Duncan's multiple range test at least five percent are not significant.
Salicylic Acid= A

Volume : 4 | Issue : 8 | August 2014 | ISSN - 2249-555X

Table4) The mean interaction Cut off irrigation * Variety On traits in Corn

Cut off irrigation * Variety	Leaf area (mm^2)	Chlorophyll a (mgg^{-1}fw)	Chlorophyll b (mgg^{-1}fw)	Total Chlorophyll (mgg^{-1}fw)	Carotenoids (mgg^{-1}fw)	Proteins (%)
control *C	1313.8700 ^{a}	0.0921 ^{a}	0.0821 ^{a}	0.2134 ^{a}	0.1103 ^{a}	14.5276^a
control *S	1116.8400 ^{a}	0.1150 ^{a}	0.0899 ^{a}	0.1829 ^{a}	0.0661 ^{a}	12.4168 ^{a}
C * BBCH51	1178.4900 ^{a}	0.0683 ^{a}	0.0503 ^{a}	0.1238 ^{a}	0.0454 ^{a}	12.2689 ^{a}
S*BBCH51	1236.8100 ^{a}	0.0792 ^{a}	0.0336 ^{a}	0.1133 ^{a}	0.0543 ^{a}	12.5200 ^{a}
C * BBCH61	1287.7800 ^{a}	0.0974 ^{a}	0.0401 ^{a}	0.1172 ^{a}	0.0526 ^{a}	14.2478 ^{a}
S*BBCH61	1345.9300 ^{a}	0.0638 ^{a}	0.0430 ^{a}	0.1234 ^{a}	0.0688 ^{a}	14.0978 ^{a}
Common treatments letters according to Duncan's multiple range test at least five percent are not significant Chase= C, Variety Sweet Corn= S Variety						

Table5) The mean interaction Salicylic Acid * Variety On traits in Corn

Variety * Salicylic Acid	Leaf area (mm^2)	Chlorophyll a (mgg^{-1}fw)	Chlorophyll b (mgg^{-1}fw)	Total Chlorophyll (mgg^{-1}fw)	Carotenoids (mgg^{-1}fw)	Proteins (%)
C * 0 A	1367.0100^a	0.0834 ^{a}	0.0706 ^{a}	0.1197 ^{b}	0.0639 ^{a}	12.5164^b
S * 0 A	1272.3700 ^{a}	0.0884 ^{a}	0.0634 ^{a}	0.1399^{ab}	0.0634 ^{a}	12.8111 ^{b}
C * 100 A	1146.9000 ^{a}	0.0832 ^{a}	0.0370 ^{a}	0.1257 ^{b}	0.0832 ^{a}	12.7500 ^{b}
S * 100 A	1101.1900 ^{a}	0.0892 ^{a}	0.0564 ^{a}	0.1453 ^{ab}	0.0576 ^{a}	12.9578 ^{b}
C * 200 A	1266.2200 ^{a}	0.0912 ^{a}	0.0650 ^{a}	0.2091 ^{a}	0.0612 ^{a}	15.7778 ^{a}
S * 200 A	1326.0200 ^{a}	0.0803 ^{a}	0.0466 ^{a}	0.1344 ^{b}	0.0682 ^{a}	13.2657 ^{b}
Common treatments letters according to Duncan's multiple range test at least five percent are not significant. Chase= C, Variety Sweet Corn= S, Salicylic Acid= A Variety						

Total Chlorophyll

The maximum total Chlorophyll content belongs to the treatment of cultivar Chase× irrigation cessation at the control stage× 200 ppm Salicylic acid application. Therefore, it can be said that the presence of the acid increases Chlorophyll content and irrigation cessation stress decrease it. These results are in accordance with the findings of other researchers. Mehrabian Moghaddam et al. (2011) reported that drought reduces Chlorophyll and relative water contents, decrease wet and dry fodder weight and increases ion leakage in corn, while Salicylic acid significantly increases Chlorophyll, relative water contents and dry fodder weight and significantly lowered ion leakage with the greatest effects observed in the treatment of soaking seeds before planting. Anjum et al. (2003) reported that drought stress increases Chlorophyll content in barley. They showed that drought stress reduces Chlorophyll a in barley but increases its stability. Delaney et al. (1994) reported that Salicylic acid increases Chlorophyll content in leaves entering into the senescence phase, raised the photosynthesis level, and, hence, increases growth. Plants treated with Salicylic acid usually had higher relative water content, dry weight, carboxylase activity of Rubisco, superoxide dismutase activity, and total Chlorophyll compared to seedlings not treated with Salicylic acid, irrespective of Salicylic acid concentration and the level of water stress (Singh and Yasha, 2003).

Chlorophyll a

The results of ANOVA indicated that the simple effect of irrigation cessation and the mutual effects of irrigation cessation and Salicylic acid on Chlorophyll a were significant at the five percent probability level. Comparison of the means showed that irrigation cessation at the control stage in the simple effects, and irrigation cessation at the BBCH51 stage and without Salicylic acid application in the mutual effects, leads to the highest Chlorophyll a contents. This result is in accordance with the results of some researchers. Under field conditions, plants may experience various degrees of water shortage during some growth stages which will directly influence on some important physiological indices such as leaf area index and Chlorophyll content (Dandas, 1998). Application of Salicylic acid for corn (Al-Khalil et al., 2009) increased Chlorophyll a and b contents. Sinha et al. (1993) reported that Salicylic acid increases Chlorophyll and Carotenoid contents of corn. It was also reported that Salicylic acid at low concentrations, significantly increases photosynthetic pigments in soybean (Kim et al., 2007) and in wheat (Iqbal and Ashraf, 2006). Mehrabian Moghaddam et al., (2013) reported that drought reduces Chlorophyll , relative water content and fodder wet and dry weight, and it increases ion leakage in corn, while Salicylic acid significantly increases Chlorophyll, relater water content, fodder dry weight and significantly reduces ion leakage, with the greatest effect observed in the treatment of soaked seeds. Anjum et al. (2003) reported that drought stress in barley reduces Chlorophyll a but it increases the stability of barely. Delany et al. (1994) stated that Salysilic acid increases Chlorophyll content in leaves entering into the senescence stage and could increases photosynthesis, thus it increases the growth. Urbi et al. (2010) conducted an experiment on cucumbers and found that application of Salicylic acid increases Chlorophyll but that there were no significant differences be-

Volume : 4 | Issue : 8 | August 2014 | ISSN - 2249-555X

tween solutions containing two millilmoles and four millilmoles of Salicylic acid. Destruction of Chlorophyll by active oxygen is one of the most important reasons for the reduction in Chlorophyll content (Ibon et al., 2000). Sho-a and Miri (2011) stated that application of Salicylic acid increases the number of inflorescences per square meter, the number of seeds per inflorescence, the 1000-seed weight, Chlorophyll a and b contents and yield of wheat under conditions of water and soil salinity.

Chlorophyll b

For Chlorophyll b, only irrigation cessation at the control stage had significantly different effects from those of other treatments. Application of Salicylic acid for corn increases Chlorophyll a and b contents (Al-Khalil et al., 2009). Sinha et al. (1993) reported that Salicylic acid increases Chlorophyll and Carotenoid contents in corn. Peter et al. (2012) conducted a four-year experiment and showed that Chlorophyll b content is increased comparing to the control when higher quantity of sulfur were applied. Sho-a and Miri (2011) reported that application of Salicylic acid increases the number of inflorescences per square meter, the number of seeds per inflorescence, the 1000-seed weight, Chlorophyll a and b contents, and yield of wheat under conditions of water and soil salinity.

Leaf area

In this research, the leaf area index of corn affected only by the mutual effects of irrigation cessation and Salicylic acid application. Comparison of the me[illegible]d that the maximum leaf area index (1567 $mm^2 mm^2$) was observed in the treatment of irrigation cessation at the BBCH61 stage and 200 ppm Salicylic acid concentration, which showed positive effects of the acid on leaf area index. These results are in accordance with the findings of other researchers. Khodary (2004) conducted an experiment on corn seedlings and reported that Salicylic acid application increases leaf surface area in seedlings under water stress. Gani et al. (2005), Khan et al. (2003), Eccodi et al. (2004), and Hayat et al. (2010) have reported similar results. Khan et al. (2003) reported application of Salicylic acid, acetyl Salicylic acid, gentisic acid, or other analogs of Salicylic acid on corn and soybean leaves increase leaf surface area and dry mass of these plants but had no effect on plant height or root length. It seems that reduction in leaf surface area is one of the first morphological responses to drought stress. Furthermore, it appears that plants use this mechanism in an attempt to maintain the water level in their tissues (Mardani et al., 2010). Martin, Max, Larko, and Sandra (2001) reported that in ornamental plants, such as gloxinia and violets, Salicylic acid increases the number of leaves so that leaf surface area in treated plants was 10 percent higher than control. Miarsadeghi et al. (2010) reported that Salicylic acid increases leaf fresh and dry weight, specific leaf weight and total dry weight in canola. Alsocanola dicotyledonous and real leaf area significantly increase by pretreatment with Salicylic acid under normal and water stress conditions. They also added that water shortage significantly reduces leaf surface area in canola but Salicylic acid application reduces these effects and increases leaf surface area. Drought stress reduces leaf surface area and dry matter in corn, and also water shortage during flowering reduces yield by up to 90 percent (Nesmith and Ritchie, 1992).

Carotenoids

Results showed that only the mutual effects of irrigation cessation at the control stage and 100 ppm Salicylic acid application affects on the Carotenoid content. The experiment indicated that drought stress reduces the Carotenoid content but Salicylic acid application increases it. Some other researchers have also emphasized on these findings. Carotenoids are sensitive to environmental factors such as light, heat, oxygen and also materials like peroxides and acids. Oxidation, isomerization reactions, changes in molecular structure and changes in color are examples of Phenomenons that may be stimulated by aforementioned factors. Keeping Carotenoids in pure solvents, storing them in nitrogen under atmospheric pressure at low temperatures and in the dark, are useful methods that reduce decomposition of Carotenoides. Increasing the intensity of drought stress reduced concentrations of Carotenoids and various types of Chlorophyll in tea plants (Masoudian et al., 2005).

Proteins

The experiment showed that application of 200 ppm Salicylic acid caused maximum quantity in protein content. The highest protein content in treatments of mutual effects was achieved in the mutual effects of irrigation cessation at the control stage and 200 ppm Salicylic application. It also indicated that the highest protein content was observed in the treatment of Chase cultivar with irrigation cessation at the control stage and application of 200 pm Salicylic acid. Some other researchers have also shown that applying stress at seed filling stage increases seed protein content. Under conditions of drought stress, absorption and fixation of CO_2 isdecreased because stomata are partially closed and, hence, total photosynthetic products for filling seeds declines. However, as de Souza et al. (1997) reported on soybean, drought stress does not reduce the retransfer of nitrogen from leaves to seeds. Cell expansion, cell wall synthesis and protein synthesis in rapidly growing tissues, are the most sensitive processes to water shortage (Sidiras et al., 1996). Tolera and Sundstol (1999) studied on the nutritional values of different parts of corn plant at various stages of seed maturity. They reported that when seed moisture content dropped from 30 to 10 percent, leaf blades were more digestible and had higher protein content compared to stems. Also, while stems had more lignin, had the least digestible and had the lowest protein content. Like high temperatures, water shortage stress at maturity, increases protein percentage (Kafi et al., 2000). Another reason for increasing in seed protein content under stress conditions is the heat shock in growing and maturing seeds (Giomini and Gallia, 1991). Tahir et al. (2006) concluded that heat stress simultaneously increased soluble and insoluble proteins. Some researchers have reported that seed protein content is increased under stress conditions and this increasing helps to achieve osmotic regulation and balance under water stress conditions. There are reports that protein decomposition in mature leaves reduces their concentration and, hence, increases free amino acids including proline. Increased proline concentration in the sensitive cultivar Marvdasht under conditions of drought stress can be attributed to higher levels of protein decomposition, which explains the sensitivity of this cultivar to drought. Decrease in protein percentage under drought conditions was reported by Misra (1994). This decreasing can be attributed to the decomposition of some proteins under conditions of drought stress and to the lack of their resynthesis under these conditions. Donald, M. S. (1992) reported that seed protein content is increased under stress conditions resulting from the decreased level of starch in seeds and rather than the absolute increase in the amount of protein.

General Conclusions

The results of ANOVA showed that the highest protein content (20.24 percent) was achieved in the interaction of three factors including cultivar (Chase), irrigation cessation (at the control stage) and Salicylic acid application (200 ppm). The mutual effects of Salicylic acid application and irrigation cessation on the characteristics of leaf surface area, Carotenoid content (0.11 milligram per gram fresh weight of plant), and Chlorophyll a content (0.13 milligram per gram of fresh plant weight) were significant at the five percent probability level. As for Chlorophyll b, only the simple effect of irrigation cessation stress exhibited significant differences at one percent probability level and increased Chlorophyll b concentration to 0.086 milligram per gram fresh weight of the plant. Furthermore, the maximum total protein content (0.349 milligram per gram fresh weight of the plant) was achieved in the interaction of three factors of cultivar (Chase), irrigation cessation (at the control stage) and Salicylic acid application (200 ppm). Therefore, we can conclude that Salicylic acid has tangible effects on improving growth and on increasing yield both under stress conditions and under normal conditions. increasing on the evaluated characteristics play a Significant role in removing the stress at both100 and especially at 200 ppm concentrations and caneffectively increase corn yield.

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