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ELECTROLYTE LEAKAGE IN SEEDS, ROOTS AND LEAVES OF COTTON AND SOYBEAN AT OPTIMAL AND SUPEROPTIMAL TEMPERATURES

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Abstarct

Leaves, roots and seeds of soybean and cotton were subjected to a series of temperature stress of 30, 34, 38, 42, 46 and 50°C to measure the ion efflux from the cell. Soybean leaves leaked more electrolytes at 313 μS/cm than cotton leaves which recorded the electrical conductivity of 143 μS/cm at 50°C. Below the stress at 42°C relatively less ions were effluxed as compared to 42°C or above where severe damage to cell membrane occurred and more than 50% electrolytes leaked from leaves, seeds and roots of both crop plants.

Introduction

Crop plants are subjected to a large number of environmental and biological stresses throughout their growth period. These stresses may interfere with the normal growth and development of crop plants Under extreme stress conditions considerable amounts of electrolytes can be lost leading to cell damage and ultimately cell death (Cooper, 1985). Sullivan (1972); Raison *et al.*, (1980) and Quinn (1988) have reported that when the environmental conditions are altered beyond normal limits under which the plants grow, the cellular membranes undergo gross structural changes, cell membranes loose normal configuration and become more permeable. At normal growth temperatures, the lipids of the membranes are arranged in a fluid bilayer configuration at which membranes have low permeability to small molecules which disturb when the temperature is changed to either above (Burke *et al.*, 1985) or below the limits of growth (Lyons, 1973). The present study was undertaken to estimate the damage to the cell membranes of some summer crops by measurement of electrical conductivity.

Material and Methods

Seeds of Soybean cv. NARC-1 and Cotton cv. Rehmani were sown in 1.5' diam., earthen pots filled with silty loam soil and manure. Cotton seeds were acid delinted according the procedure described by Sethar (1993) and only sinker seeds were sown. Soybean seeds were sown without any treatment. The pots were kept in an open air pot house which was covered with iron net in order to protect the seeds/seedlings from demages by birds and rodents. Twenty five seeds were sown in each pot in May, 1995 and irrigated when required. After 27 days of sowing the plants were harvested and taken to the laboratory where the leaves were separated from the roots. The tissue

(leaves, roots and dry seeds) of both crops were washed with distilled water before analysis. The shaking water bath (model Grant, manufactured by Grant Instrument Co., U.K) was set at required temperature every time. Fifty ml of distilled water was taken in each flask and placed in a shaking water bath to maintain the required temperature. The tissue were put in respective conical flasks when the temperature of water in conical flask reached the required level. EC readings were recorded with EC meter (Jenway, Model 4070) by immersing the electrode in the medium after 15 and 30 min, during the stress in shaking water bath. The conical falsks were then transferred to an air incubator at 30°C and EC of the medium was recorded after 30, 60 min and 24 h. The effect of series of stress tempeatures i.e., 30, 34, 38, 42, 46 and 50°C were tested. The experiment was repeated three times. Statistical analysis was done in Systat programme. Data on EC and percent of the values of 50°C stress treatment recorded after 24h assuming that 100% electrolytes from the cells have been leaked out are presented (Table 1).

Results and Discussion

Soybean: Roots leaked more electrolytes than leaves and seeds either at stress or at incubation period where the EC values were 2 fold higher to leaves and 4 fold to seeds (Table 1). The final ion effluxes of leaves after 24 h incubation period were 28, 51, 77,

Table 1. Effect of temperature stress on the electrolyte efflux (μS/cm) from soybean.

Temp.	Leaves					Roots					Seeds				
Stress	Heat stress (min.)		Incubation at 30°C			Heat stress (min.)		Incubation at 30°C			Heat stress (min.)		Incubation at 30°C		
	15	30	30min	60min	24h	15	30	30min	60min	24h	15	30	30min	60min	24h
30	8	11	16	18	37	36	40	43	45	78	4	6	8	12	66
34	9	12	17	19	68	39	47	53	56	97	5	7	9	14	69
38	11	13	19	20	103	40	52	54	57	124	5	7	10	16	108
42	12	17	21	23	112	43	57	62	64	127	7	9	14	18	124
46	12	17	21	42	118	47	69	71	82	136	13	15	20	21	184
50	13	18	23	45	134	49	76	78	89	143	15	18	20	23	243
The EC values on single leaf/root/seed basis. Electrolyte efflux (%) of the total electrolyte efflux at 50°C after 24h incubation period															
30	6	8	11	13	28	25	28	30	31	55	2	3	4	5	27
34	7	9	13	14	51	27	33	37	39	68	2	3	4	6	28
38	8	10	14	15	77	28	36	38	40	87	2	3	4	7	44
42	9	13	16	17	84	30	40	43	45	89	3	4	6	7	51
46	9	13	16	31	88	33	48	50	57	95	5	6	8	9	76
50	10	13	17	34	100	34	53	54	62	100	6	7	8	9	100

84 and 88% of the total ion efflux (recorded at 50°C) for 30, 34, 38, 42 and 46°C stress temperatures respectively (Table 1). However, the leakage from roots was little higher which was 55, 68, 87, 89 and 95% at 30, 34, 38, 42 and 46°C, respectively. Final EC values from single soybean seed were 27, 28, 44, 51 and 76% for 30, 34, 38, 42 and 46°C, respectively, of the total ion efflux. The results were found highly significant ($P<0.01$).

Cotton: The pattern of ion efflux was same as in soybean i.e., EC increase with the passage of time. However, quantitatively there was fairly large difference in ion efflux between crops. Contrary to soybean, the cotton leaves leaked highest ion efflux than roots and seeds. In leaves and roots the EC values were almost same upto 60 min. incubation period and 46°C stress temperature.

At 50°C stress the difference was more obvious when the tissue were left for 24h period at 30°C. In leaves, there was a huge ion leakage which reached upto 313 μS/cm after 24h as compared to 52 μS/cm after 60 min incubation in 50°C stress treatment. The ion efflux in leaves after 24h period was 8 to 9 fold higher than roots and seeds. The results were highly significant ($P<0.01$). EC values in cotton leaves after 24h were 23, 39, 51, 75 and 86% at 30, 34, 38, 42 and 46°C stress, respectively, to that of value recorded at 50°C stress (Table 2).

The plasmamembrane and tonoplast control the ion transport in or out of the cell and between the cytoplasm and vacuole. The bulk of the accumulated salts are found in

Table 2. Effect of temperature stress on the electrolyte efflux (μS/cm) from cotton.

Temp.	Leaves					Roots					Seeds				
Stress	Heat stress (min.)		Incubation at 30°C			Heat stress (min.)		Incubation at 30°C			Heat stress (min.)		Incubation at 30°C		
	15	30	30min	60min	24h	15	30	30min	60min	24h	15	30	30min	60min	24h
30	8	11	14	18	73	6	7	7	8	11	3	4	5	7	24
34	9	13	16	19	123	10	11	12	12	19	5	5	7	8	25
38	9	15	18	21	155	12	15	16	17	30	6	7	9	10	25
42	15	17	23	27	234	15	17	19	20	34	8	8	10	11	31
46	16	19	24	29	268	16	19	20	22	38	8	9	11	12	36
50	24	28	41	52	313	19	20	24	25	41	9	9	12	13	38
The EC values on single leaf/root/seed basis. Electrolyte efflux (%) of the total electrolyte efflux at 50°C after 24h incubation period															
30	3	4	5	6	23	15	17	17	20	27	8	11	13	18	63
34	3	4	5	6	39	24	27	32	32	46	13	13	18	21	66
38	3	5	6	7	50	32	37	39	41	73	16	18	24	26	66
42	5	5	7	9	75	37	41	46	49	83	21	21	26	29	82
46	5	6	8	9	86	39	46	49	54	93	21	24	29	32	95
50	8	9	13	17	100	46	49	59	61	100	24	24	32	34	100

the largest compartment ie vacuole (Pierce & Hinginbotham, 1970; Cram, 1973). Thus, for the purpose of electrolyte efflux study, all three major compartments must be considered.

Total electrolytes released at various temperatures were not the same in the tissue of both the species. Soybean roots and seeds leaked higher quantity of ions than cotton, while the cotton leaves affluxed double the quantity of electrolytes than soybean leaves. Luo *et al.*, (1983) reported that physical and physiological status of the seeds can play an important role in the electrolyte efflux. In most conditions more than 50% electrolytes were released into the medium when the tissue were stressed even for 30 min at 42°C or above. The EC was 95% at 46°C of the highest or lethal temperature (50°C) in soybean. The results are similar to the findings of Sethar (1993) who worked with cotton genotypes (root radicles only) and found that in the cotton cultivars, severe damage occurred to the cell membranes above stress temperature of 40°C. Similarly, Ashraf *et al.*, (1994) reported in cotton cultivars that no germination was observed above 45°C.

Quantification of membrane permeability and damage to cell membranes can provide valuable information about several aspects of plant performance including the viability of seeds and heat tolerance in plants. In soybean the best germination took place at 25-35°C but was significantly inhibited at 40°C and severely affected at 42.5°C with no germination at 45°C and above (Aquino & Bekendam, 1969; Tyagi & Tripathi, 1983; Keerio, 1996). The greater amount of ion efflux at or above 40°C in our results show that there could be tremendous loss to the plant tissue in seeds, roots or leaves.

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