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Effect of Soil Salinity on Grain Filling and Grain Development in Barley

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Abstract. Experiments were conducted with five barley cultivars with the aim of ascertaining the effect of salt stress on grain filling, grain development and biochemical composition of developing grains. Reduced grain yield under salt stress was found to be due to reduced efficiency per day to fill the grains and consequent more effective days and also due to disturbed starch-sugar balance.

Soil salinity not only delayed but also reduced flowering and yield of plants (HAYWARD and WADLEIGH 1949, BERNSTEIN and HAYWARD 1958, KOYAL SKAYA 1958). Reductions in yield under salinity have been reported also in wheat and barley (BHARDWAJ and RAO 1955, ASANA and KALE 1965, SARIN and NARAYANAN 1965, SARIN *et al.* 1975). Various research workers have attributed the adverse effect of salinity on growth, flowering and yield to either (a) osmotically reduced water availability to plant (b) specific ion effects and/or (c) disturbed metabolism of plants. As barley is one of the intensively cultivated crops under saline conditions, experiments were conducted with six barley cultivars with the aim of finding the physiology of salt stress effect on grain filling, grain development and on the biochemical composition of developing grains.

MATERIAL AND METHODS

Experiments were conducted with six cultivars of barley (IB-226, K-572/10, RS-6, C-138, T-4 and C-164). Plants were raised in plastic pots of 13 kg capacity. A normal soil having pH 8.6 and electrical conductivity of 0.5×10^{-3} Ω^{-1} cm^{-1} at 25 °C was artificially salinized using sodium chloride, calcium chloride and sodium sulphate in the ratio of Na : Ca = 3.1 and Cl : SO_4 = 3.1 (equivalent weight basis). Salinity level 12.5×10^{-3} Ω^{-1} cm^{-1} at 25 °C was maintained. Fourteen seeds per pot were sown in the middle of December, 1970, but finally only five plants per pot were kept after one month of sowing. N, P and K as ammonium sulphate, superphosphate, and muriate of potash (9g, 5g and 3g per pot, respectively) were added. Nitrogen was applied at

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TABLE 1
Comparison of yield, efficiency per day and effective filling period duration (EFPD) under normal and saline soils

Cultivar	Normal Soil			Saline Soil		
	Yield g/pot	Efficiency/ day	EFPD (days)	Yield g/pot	Efficiency/ day	EFPD (days)
RS-6	29.8	1.9	32.7	25.0	1.05	35.4
K-572/10	29.5	1.5	31.1	15.7	2.00	15.8
T-4	22.6	1.3	26.3	21.2	1.06	31.7
C-164	20.8	2.8	15.4	17.6	1.30	31.2
C-138	19.3	2.2	15.3	17.7	1.50	24.5
IB-226	18.2	2.6	15.2	16.6	1.70	21.7

sowing, tillering and flowering in three split doses. At 50% anthesis, ears were tagged and sampled at an interval of five days up to 20 days. Grains were taken out and fresh weight and dry weight at different intervals were recorded. Data were analysed using regression analysis. From the linear part of the quadratic regression analysis curve, maximum efficiency per day was calculated (DAYNARD *et al.* 1971). From the final weight of mature grain, the effective period of grain filling was calculated on the basis of maximum efficiency per day (DAYNARD *et al.* 1971). Starch and sugar content of developing grains were also determined following the method of SNELL and SNELL (1967).

RESULTS AND DISCUSSION

The yield of crop cultivars is adversely affected under salt stress. The lower yields may be attributed to reduced grain number and their individual grain weight. It was observed, in our experiments, that barley cultivars differed widely in yield attributes under normal as well as under saline conditions. Data on yield, efficiency per day as well as effective filling period duration (EFPD) suggested that irrespective of salt treatment, higher yields were accompanied by a higher number of effective days required for grain filling and by lower efficiency per day. Lower yields seemed to be associated with higher efficiency and less days (Table 1).

However, the decrease in yield due to saline conditions was followed by decreased efficiency and increased effective days. The only exception was formed by cultivar K-572/10 where the efficiency increased over control but effective days decreased. Lengthening the time required for grain filling under salt stress pushed the plants at grain filling and maturity to a higher temperature and water stress due to the coming of summer. The effect of both salt and water stress might lead to shrivelled grains and consequent lower yields. The relationship between yield and EFPD has been found to be statistically non-significant whereas yield and efficiency per day was significantly related ($P = 0.1$).

It has been observed that in developing grains dry weight per grain increased both under normal and saline conditions but less under salinity. Water content usually increased up to 15 days after anthesis and then decreased, the decrease being more under salinity. Starch content increased constantly under normal conditions; the increase after 15 days was at the

TABLE 2
Effect of soil salinity on dry weight, water, starch and sugar content per grain in developing grain in barley cultivars

Cultivars	Electrical conductivity [$\times 10^{-3} \Omega^{-1} cm^{-1}$]	Days after anthesis															
		5	10	15	20	5	10	15	20	5	10	15	20	5	10	15	20
		Dry weight [mg/grain]				Starch content [mg/grain]				Sugar content [mg/grain]				Water content [mg/grain]			
IB-226	0.5	6.3	18.3	25.3	27.7	1.7	12.4	14.5	17.3	1.62	2.51	6.24	4.50	17.3	28.4	14.6	14.8
	12.5	4.7	9.5	26.4	29.1	0.7	4.6	17.1	19.2	1.17	1.42	4.95	3.63	14.5	18.4	21.5	11.8
K-572/10	0.5	6.8	15.9	22.9	31.2	2.2	11.1	13.2	21.1	0.68	2.38	5.72	6.61	16.6	19.9	25.8	19.0
	12.5	6.2	17.5	20.8	26.0	1.7	14.0	18.7	18.2	0.85	2.62	5.72	3.25	16.5	18.7	19.5	10.2
RS-6	0.5	3.6	12.3	25.1	30.8	1.1	9.2	16.3	20.8	0.99	2.60	5.86	4.23	11.2	21.1	28.1	25.7
	12.5	7.2	15.7	23.4	26.8	1.3	10.7	21.1	18.1	1.98	2.14	4.97	4.35	20.3	24.2	31.3	33.1
C-164	0.5	3.6	19.1	24.7	27.8	0.6	12.0	17.3	22.2	0.70	4.75	5.85	4.99	14.6	16.8	28.4	26.8
	12.5	8.6	15.1	21.8	28.1	3.2	9.4	18.5	21.8	2.03	3.80	5.90	3.86	24.1	20.1	31.9	18.4
T-4	0.5	8.9	15.8	22.4	28.1	3.8	12.6	16.8	21.1	0.89	1.50	6.20	3.84	32.1	31.8	23.4	18.9
	12.5	7.6	14.5	18.4	26.6	2.9	8.7	14.2	19.9	1.04	2.71	5.98	3.32	17.5	14.7	19.7	20.1
C-138	0.5	5.7	17.4	28.4	31.8	2.2	11.1	21.3	22.3	0.78	3.04	7.81	6.67	14.3	9.9	28.0	21.4
	12.5	6.0	11.5	26.1	29.0	1.6	5.9	20.9	20.3	1.65	2.01	7.33	3.98	18.9	13.5	22.9	22.1
Average	0.5	5.8	16.3	24.9	29.6	1.9	11.4	16.5	20.8	0.94	2.73	6.28	5.14	15.3	18.3	24.7	21.1
	12.5	6.7	13.9	32.8	27.6	1.9	8.8	18.4	19.6	1.45	2.45	5.89	3.73	18.6	18.2	24.4	19.2

cost of decrease in sugar content. Decreased content of sugar under salinity did not correspond to starch formation, because in these grain starch content increased little or did not increase after 15 days.

This might ultimately lead to reduced grain weight under salinity and consequent lower yields. Variable behaviour of individual cultivars under salinity has been observed in respect of each factor (Table 2).

Thus it may be concluded that reduced yield under salt stress may be due to reduced efficiency per day to fill the developing grains, which may be due to disturbed starch-sugar balance. Delayed maturity due to salt stress pushes the plant also to desiccation stress causing shrivelled grains.

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REFERENCES

Asana, R. D., Kale, V. R.: A study of salt tolerance of four varieties of wheat. — Ind. J. Plant Physiol. **8** : 5—22, 1965.

Bernstein, L., Hayward, H. E.: Physiology of salt tolerance. — Annu. Rev. Plant Physiol. **9** : 25—46, 1958.

Bhardwaj, S. N., Rao, I. M.: Studies on the effect of Cl and SO_4 on germination and maturity of gram. — Agr. Univ. J. Res. (Sci.) 4 : 767, 1955.

Daynard, T. B., Tanner, J. W., Duncan, W. G.: Duration of grain filling period and its relation to grain yield in corn *Zea mays* L. — Crop Sci. **11** : 45, 1971.

Hayward, H. E., Wadleigh, C. H.: Plant growth in saline and alkaline soils. — Adv. Agron. **1** : 1—38, 1949.

Koyal Skaya, E. M.: Changes in salt resistance in plants during autogenesis. — Soviet Plant Physiol. 5 : 437—446, 1958.

Sarin, M. N., Joshi, Y. C., Gill, K. S.: Salt tolerance of wheat and barley varieties. Proc. Symposium New Developments in the Field of Salt Affected Soils. I.S.S.S. Cairo (1972). Pp. 647—652, 1975.

Sarin, M. N., Narayanan, A.: Influence of soil salinity on growth and yield of wheat. — Proceedings of Seminar on Sea, Salt and Plants held at Bhavnagar. Pp. 107—120, 1965.

Snell, F. D., Snell, C. T.: Colorimetric Methods of Analysis 4 (A) : 307—330. D. Van Nostrand Company. Inc. Princeton, New Jersy—Toronto—New York—London 1967.