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Effect of alkali water irrigation and gypsum doses on yield and chemical composition of oat (*Avena sativa*) varieties in an alkali soil

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ABSTRACT

A field experiment was conducted during the winter *(rabi)* seasons of 2002–2003 and 2003–2004 at Karnal, to study the effect of gypsum application on 5 varieties of oat *(Avena sativa* L.) in a moderately alkali soil (pH 9.3) using alkali water (RSC 8.6 me/litre) irrigation. The yield of oat was not significantly influenced owing to gypsum application; however, variation in yield was recorded amongst the varieties. Highest yield was observed in variety 'HJ 8' followed by 'OS 7'. On an average, 'HJ 8' and 'OS 7' varieties registered 16.2% and 8.3% higher yield, respectively, than 'Kent', a popular variety. Higher yield of 'HJ 8' may be attributed to its tall and broad leaves compared with remaining varieties. However, 'OS 6' variety showed the maximum tillers. Gypsum application did not influence chemical composition of oat. Varieties 'Kent', 'HJ 8' and 'OL 9' showed similar crude protein that was significantly greater than the remaining 2 varieties. 'Kent' and 'OL 9' varieties accumulated significantly lower sodium percentage than the other varieties evaluated. Application of gypsum at each level enhanced the chlorophyll content of oat. Varieties 'HJ 8' and 'OS 7' also showed significantly higher total chlorophyll content, indicating their better tissue tolerance inspite of their greater sodium content.

Key words : Oat, Varieties, Akali soil, RSC water irrigation, Growth, Yield, Chemical composition

Use of alkali waters having high residual sodium carbonate (RSC) adversely affects crop growth and the yield is further reduced if the soil is already alkaline. These adverse effects can be moderated through the use of gypsum. Oat *(Avena sativa* L.) is a graminaceous winter *(rabi)* season forage crop that has been found quite tolerant to alkaline soil and irrigation conditions (Ashok Kumar, 2002). Furthermore, Ashok Kumar (2002) reported that out of 6 winter *(rabi)* forage crops, tested on a moderately alkaline soil, oat showed the minimum yield reduction under alkali soil conditions when irrigated with alkali water compared with its yield in normal soil, demonstrating its tolerant nature. Since there is wide genetic variability amongst various cultivars, the present investigation was aimed to exploit the varietal differences to find out the most suitable variety/varieties of such situations.

MATERIALS AND METHODS

A field experiment was conducted during the winter *(rabi)* seasons of 2002–03 and 2003–04 to study the effect of gypsum application on 5 oat varieties in a moderately alkali soil using alkali water irrigation at Bhaini-Majra farm, Kaithal of the Central Soil Salinity Research Institute, Karnal. The alkali (RSC) water used from the tube-well had EC_{iw} =1.6 dS/m, RSC = 8.6 me/litre, SAR = 9.0 $(mmol/litre)^{0.5}$ and Ca + Mg 6.4 me/litre. The experiment having 3 replications was laid out in split-plot design with gypsum levels (0, 2 and 4 tonnes/ha) in the main plot and varieties ('Kent', 'OS 6', 'OS 7', 'HJ 8', 'OL 9') in the sub-plots. Gypsum was mixed into shallow soil depth at the pre-sowing irrigation with alkali water irrigation. Soil samples collected at the time of sowing in 0–15 cm soil depth at 0, 2 and 4 tonnes/ha gypsum levels had pH_2 of 9.26, 9.36 and 9.13 respectively. All the varieties were sown in rows 25 cm apart keeping a seed rate of 80 kg/ha and were fertilized with 80 kg N, 40 kg P_2O_5 and 40 kg/ha K_2O. During 2002–03, the oat varieties were sown on 18 October 2002 and harvested on 5 February 2003, while during 2003–04 these were sown on 5 October 2003 and harvested on 5 February 2004. Only 1 harvest was made on all the oat varieties when the crop reached approximately 50% bloom stage. Growth parameters were recorded a day before the harvesting. During rainy season *(kharif)* 2003, rice was grown as general crop with similar inputs in all the treatments. For chemical analysis of plant standard procedures were followed.

RESULTS AND DISCUSSION

Effect of gypsum

Application of gypsum did not significantly affect any

of the growth parameters (Table 1). Like the growth, the yield of oat was not influenced significantly owing to gypsum application during any of the 2 years. Similarly, gypsum application did not affect chemical composition but application of gypsum significantly increased the chlorophyll content of oat at each level.

Performance of varieties

'HJ 8' and 'OL 9' varieties showed significantly more height than the remaining varieties. 'Kent', 'OS 6' and 'OS 7' varieties were at par with each other (Table 1). Amongst different varieties, 'OS 6' gave significantly more number of tillers than others. In remaining varieties, the difference in tillers production was not significant. Number of leaves were not affected in different oat varieties. 'HJ 8' and 'Kent' varieties showed significantly more leaf length than rest of the varieties. Remaining varieties also differed significantly for leaf length. 'HJ 8' variety showed significantly broader leaves than other varieties, followed by 'OS 7', 'Kent' and 'OL 9' with no significant differences among each other. Further, minimum leaf width was recorded in variety 'OS 6'.

During 2002–03, 'HJ 8' variety gave significantly higher yield than remaining varieties except 'OS 7' variety with which it was on a par (Table 1). Similarly, the difference between 'OS 7' and 'OL 9' varieties was not significant. The 'OL 9', 'OS 6' and 'Kent' varieties were at par with each other. 'HJ 8' and 'OS 7' varieties recorded higher yield by 11.2 and 8.5% over the 'Kent' variety. As in 2002–03, 'HJ 8' variety outyielded the remaining varieties in 2003–04 also, followed by 'OS 7' variety, which gave significantly greater yield than 'Kent' variety. However, 'OS 7', 'OL 9' and 'OS 6' varieties did not differ significantly amongst each other. Similarly, 'OL 9', 'OS 6'

Table 1. Effect of gypsum levels on growth and green forage yield of oat varieties when irrigated with sodic water

Treatment	Plant height (cm)	Tillers/30 cm row length	Leaves/ plant	Leaf length (cm)	Leaf width (cm)	Green forage yield (tonnes/ha)		
						2002–03	2003–04	Mean
Gypsum (tonnes/ha)								
0	134.5	41.1	5.0	36.8	2.0	61.3	50.7	56.0
2	124.6	41.9	5.4	35.0	1.9	58.7	52.2	55.5
4	139.2	40.3	5.5	38.2	2.1	62.3	51.4	56.9
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Variety								
'Kent'	127.3	42.1	5.4	39.2	1.9	57.9	47.9	52.9
'OS 6'	126.3	52.7	4.9	33.8	1.5	58.2	48.8	53.5
'OS 7'	129.0	38.1	5.4	34.8	2.0	62.8	51.8	57.3
'HJ 8'	143.6	36.0	5.4	41.4	2.7	64.4	58.6	61.5
'OL 9'	137.7	43.3	5.3	34.1	1.9	60.5	50.0	55.2
CD (P=0.05)	8.5	8.0	NS	4.6	0.3	3.7	3.5	3.6

Table 2. Effect of gypsum level on chemical composition of oat varieties when irrigated with sodic water

Treatment	Dry matter (%)	Crude protein (%)	Na (%)	K (%)	Ca (%)	Mg (%)	P (%)	Na : K	Na : Ca	Chl *a* (mg/g weight)	Chl *B* (mg/g weight)	Total Chl (mg/g weight)
Gypsum (tonnes/ha)												
0	14.7	9.4	1.8	1.8	0.08	0.20	0.26	1.00	22.50	3.17	1.62	4.78
2	15.7	9.4	1.6	1.8	0.08	0.20	0.25	0.89	20.00	3.37	1.69	5.11
4	15.1	9.4	1.7	2.0	0.09	0.22	0.26	0.85	18.88	3.58	1.85	5.14
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS			0.09	0.06	0.15
Variety												
'Kent'	15.1	10.0	1.6	2.0	0.08	0.19	0.25	0.80	20.00	1.68	1.09	3.07
'OS 6'	16.3	8.1	1.7	1.7	0.09	0.21	0.26	1.00	18.88	2.40	1.18	3.39
'OS 7'	14.6	8.8	1.8	1.8	0.08	0.22	0.26	1.00	22.50	4.40	2.14	6.26
'HJ 8'	14.7	10.0	1.8	2.0	0.08	0.22	0.25	0.90	22.50	5.02	2.62	7.48
'OL 9'	15.0	10.0	1.6	1.9	0.09	0.21	0.26	0.84	17.77	3.35	1.56	4.83
CD (P=0.05)	NS	0.6	0.1	NS	NS	0.02	NS			0.06	0.09	0.14

Chl, Chlorophyll

and 'Kent' varieties were at par amongst themselves. 'HJ 8' recorded 22.3% increased yield over the 'Kent'.

On an average of 2 years, 'HJ 8' outyielded the remaining varieties evaluated. 'OS 7' variety was the next best but was on a par with 'OL 9'. It gave significantly greater yield than the remaining 2 varieties. Tripathi (1993) reported that amongst the 5 cultivars (including 'OS 6'), 'OS 7' was the highest yielding under normal soil conditions, giving mean green fodder and dry-matter yields of 46.32 and 10.31 tonnes/ha respectively. Further, Agrawal *et al.* (1995) observed highest green fodder yield of 'OS 6' cultivar with the application of 120 kg N/ha again under normal soil conditions. However, in the present experiment conducted under alkali water irrigation, 'OL 9', 'OS 6' and 'Kent' varieties were at par with each other. Overall, 'HJ 8' and 'OS 7' registered 16.2% and 8.3% higher yield, respectively, than 'Kent' variety. Higher yield of 'HJ 8' variety may be attributed to its greater height and broad leaf compared with remaining varieties of oat. However, 'OS 6' variety showed the maximum tillers.

Crude protein content, sodium and magnesium concentration differed significantly amongst varieties (Table 2). 'Kent', 'HJ 8' and 'OL 9' varieties showed significantly more crude protein content than the other varieties. 'Kent' and 'OL 9' varieties also showed significantly lower sodium percentage than the other varieties. 'Kent' also showed significantly lower magnesium content than the others. Further, 'Kent' and 'OL 9' varieties also showed lower Na : K ratio compared to remaining varieties evaluated. However, high-yielding variety 'HJ 8' and 'OS 7' recorded higher accumulation of Na : K and Na : Ca compared to other varieties. Along with this, 'HJ 8' also accumulated higher K amongst different varieties. Significant differences were recorded amongst different oat varieties for chlorophyll *a*, chlorophyll *b* and total chlorophyll content (Table 2). Variety 'HJ 8' showed the highest chlorophyll content followed by 'OS 7'. Minimum chlorophyll was recorded in variety 'Kent'. This also showed better tissue tolerance of these 2 varieties where higher chlorophyll was produced in spite of higher Na accumulation. There were non-significant differences for potassium, calcium and phosphorus concentration amongst different oat varieties.

Based on the results of individual years and of pooled data, it could be inferred that oat has the capability to tolerate high pH, as the gypsum levels applied on moderately high pH soil did not affect its yields. While summarizing the review of literature on forage crops Ayers and Westcot (1985) also reported that oat is moderately tolerant to exchangeable sodium. The results also indicate that 'HJ 8' and 'OS 7' varieties of oat are more suitable for high alkalinity of soil even with using high RSC (alkali) water.

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