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Comparative performance of sole and intercrop of oat *(Avena sativa)* and Persian clover *(Trifolium resupinatum)* under alkali water irrigation

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ABSTRACT

A field experiment was conducted during the winter *(rabi)* seasons 2002–03 and 2003–04 to study the performance of sole and intercrop of oat *(Avena sativa* L.*)* and Persian clover or *shaftal (Trifolium resupinatum* L.*)* under alkali water irrigation. Application of gypsum 2 tonnes/ha significantly enhanced the green forage yield in all the cuts and total yield over no-gypsum treatment. Sole crop of Persian clover (95.7 tonnes/ha) gave significantly higher total green forage yield than oat (45.4 tonnes/ha). The yield of Persian clover was significantly improved in the first cut when grown in association with oat at different ratios. Higher green forage yield per day was obtained when oat was harvested for 1 cut only at 75 days than Persian clover and its mixtures. Application of gypsum improved the crude protein and calcium content of crops. Persian clover alone showed significantly higher concentration of N (crude protein), Na, Ca, Mg and P, while in oat only the K concentration was higher. Further, there was significant increase in the K content and decrease in Na content of Persian clover when grown in association with oat in different ratios.

Key words : Alkali water irrigation, Chemical composition, Forage yield, Gypsum, Oat, Persian clover

High exchangeable sodium in alkali soils or under alkali water irrigation conditions affects the crop growth adversely, which can be improved by adding amendments like gypsum to the soil. Amongst different forage crops, oat (Ashok Kumar, 2002) and Persian clover or *shaftal* (Ashok Kumar, 1987) were suitable for winter *(rabi)* season. Further, Persian clover is even more profitable as a fodder crop in *rabi* than wheat (Sharma *et al.,* 1983). Oat being a graminaceous crop gives 1 or 2 cuts, while Persian clover a leguminous crop gives 5–6 cuts. Being of different nature, the behaviour of the 2 crops was tested in pure and in mixed stand with each other at different ratios. Ashok Kumar (2004) observed significantly greater yield of berseem (Egyptian clover) + Indian mustard mixture compared to berseem + barely and berseem + oat combinations under alkali soils in conjunction with alkali water irrigation where only single recommended ratio of crop mixtures of the 2 crops was used. However, in the present study, effects on yield and chemical composition are elucidated when oat and Persian clover are grown in mixed stand with different ratios

MATERIALS AND METHODS

A field experiment in randomized block design with 4 replications was conducted at the Bhaini-Majra farm, Central Soil Salinity Research Institute, Kaithal, Haryana (N 29°47' 41.4" and E 76° 27' 30.0" in a flat terrain between 230 and 231 m above mean sea-level, during the winters *(rabi)* 2002–03 and 2003–04. Surrounding area of 50 km^2 is suffering from the groundwater problem of high residual sodium carbonate (RSC). The tube-well water used for irrigation had EC_{iw}=1.6 dS/m, RSC=8.6 me/litre, sodium absorption ratio (SAR) = 9.0 $(mmol/litre)^{0.5}$ and Ca + Mg 6.4 me/litre. The treatments comprised 2 gypsum levels, viz. 0 and 2 tonnes/ha, and 5 crop treatments, viz. oat alone, Persian clover alone, oat+Persian clover (1:1), oat+Persian clover (2:1) and oat+Persian clover (1:2). Initial soil pH of the experimental area in 0–15 cm and 15–30 cm depth was 9.2 and 9.08 respectively. The pH of soil was determined in 1: 2 soil water suspensions. Gypsum was mixed into shallow soil depth after applying pre-sowing irrigation with alkali water. Soil samples were collected at sowing and harvesting times during both the years.

During 2002–03 sowing was done on 19 October 2002. For oat alone, a seed rate of 100 kg/ha was used and the crop was sown in rows 25 cm apart, which received 80 kg N/ha, 40 kg P_2O_5/ha and 40 kg K_2O/ha. Further, Persian clover was sown in standing water keeping 15 kg seed/ha and fertilized with 20 kg N/ha, 80 kg P_2O_5/ha and 40 kg K_2O/ha. Different crop mixtures were also sown as per ratio of the seed rates of the 2 crops in standing water as in case of pure Persian

clover and applied with 40 kg N/ha, 40 kg P_2O_5/ha and 40 kg K_2O/ha. 'Kent' variety of oat and 'Local' seed was used for Persian clover during 2002–03 but 'SH 69' variety was grown during 2003–04. During 2002–03, two cuts from oat were obtained on 30 December 2002 and 24 March 2003 respectively; and 5 cuts each from Persian clover and oat + Persian clover mixtures on 30 December 2002, 14 February, 24 March, 10 April and 10 May 2003 respectively. During 2003–04, the sowing commenced on 15 October 2003 and only 1 cut from oat was taken on 28 December 2002, whereas 5 cuts each from Persian clover and oat + Persian clover mixtures on 28 December 2003, 4 February, 5 March, 26 March and 8 May 2004, respectively, were taken. In January, during 2002–03, total rainfall was 16.6 mm and mean relative humidity during 2 October – 3 March was 93.3% but during 2003–04, these values were 73.3 mm and 91.8% respectively. In the cuts in which oat was not available for harvesting, oat treatments were not considered for statistical analysis. Nitrogen in the plant samples was estimated by microkjeldhal's method, and crude protein was computed by multiplying with conversion factor 6.25. For remaining chemical analysis of plant samples, wet digestion method was followed. Sodium (Na) and potassium (K) were analyzed by flame photometer, whereas Ca, Mg and P were analyzed by atomic absorption spectrophotometer.

RESULTS AND DISCUSSION

Green forage yield

Application of gypsum @ 2 tonnes/ha increased the green forage yield in all the cuts and total yield over no-gypsum treatment (Table 1). In the first cut, oat alone recorded significantly greater yield compared with Persian clover alone. The yield of Persian clover was significantly improved by mixing oat at different ratios. However, among various oat : Persian clover mixtures, the difference was non-significant. In the second cut, Persian clover alone gave significantly greater yield than its various ratios with oat. However, mixture of 1:2 provided significantly greater yield than 1:1 and 2:1 ratios. In the third cut, Persian clover alone being at par with 1:2 ratio, gave significantly higher green forage yield over 1:1 and 2:1 ratios. In fourth and fifth cuts, the differences were non-significant.

Total yield of Persian clover alone was significantly greater than oat alone. However, there was no significant difference between Persian clover alone and its different ratios with oat. Oat + Persian clover mixtures gave significantly higher yield than oat pure.

Oat growth was non-significant after the first cut during 2003–04, mainly owing to the heavy rains (73.3. mm) spreading over 3 days in January and resultant higher humidity leading to non-regeneration of oat. On an average, Persian clover recorded higher yields in second year than with the first year. During the second year, an improved high-yielding variety 'SH 69' was taken compared to low-yielding 'Local' variety in the first year. Further, the broader leaves of 'SH 69' resulting into larger canopy of Persian clover per unit area in mixed plots may not have allowed oat to grow as vigorously as in the first year compared to 'Local' variety.

Since the growth period of oat and Persian clover is different, it was worthwhile to compare their yield on per day basis as well. Oat was harvested for the first cut 75 days after sowing. For treatments of Persian clover and of its mixtures with oat, the last harvest was made 205 days after sowing. Oat gave 5.07 q/ha/day green forage yield, whereas Persian clover alone 4.67 q/ha/day per day yield of different oat + Persian clover mixtures ranged from 4.29 to 4.62 q/ha/day. These results indicate that when

Table 1. Green forage yield (tonnes/ha) of oat and Persian clover alone and in association as affected by gypsum application under alkali water irrigation (pooled data of 2002–03 and 2003–04)

Treatment	Cuts					
	1st cut	2nd cut	3rd cut	4th cut	5th cut	Total
Gypsum (tonnes/ha)						
0	26.0	14.3	20.5	18.5	8.6	87.9
2	30.2	16.9	22.3	20.6	10.1	100.1
CD (P=0.05)	2.0	1.5	1.6	1.3	0.7	4.9
Crop mixture						
Oat alone	38.0		7.4			45.4
Persian clover (P.C.) alone	22.4	19.0	24.0	21.0	9.3	95.7
Oat + P.C. (1:1)	27.6	13.6	21.6	18.8	9.3	90.9
Oat + P.C (2:1)	26.7	13.3	20.1	18.7	9.1	87.9
Oat + P.C. (1:2)	26.0	16.6	22.2	19.9	10.1	94.8
CD (P=0.05)	3.0	2.2	2.0	NS	NS	7.8

oat is harvested only once at an early stage of about 75 days, it gives higher green forage per day yield than Persian clover and its mixtures.

Chemical composition

Application of gypsum enhanced the crude protein and Ca content of crops significantly compared with no-gypsum treatment (Table 2), but other constituents were not affected due to gypsum application. Persian clover alone showed higher crude protein content than oat alone. Average crude protein of various oat mixtures was also higher than oat alone. Significantly higher crude protein was observed only in mixture ratio of 1:1 than 2:1, though the difference with 1:2 ratio was non-significant. Significantly higher sodium and lower potassium accumulation in Persian clover alone compared to oat alone might have caused yield reduction. Further, lower Na accumulation in different mixtures of Persian clover with oat might have helped in their improved yield compared to Persian clover alone. Amongst the mixtures, the differences were non-significant for Na accumulation. Gypsum (2 tonnes/ha) application significantly increased the Ca content of crops compared with the control, whereas non-significant differences were recorded for Na, K, Mg and P accumulation. Amongst the 2 crops, Persian clover alone and its mixtures with oat accumulated significantly higher Ca than oat alone. Of the different mixtures, 1:2 ratio showed significantly greater Ca than remaining mixtures. Though Mg accumulation was also significantly higher in Persian clover alone compared to oat alone, their differences amongst oat and its mixtures with Persian clover were non-significant. Further, Persian clover alone and its mixture of 1:2 with oat showed significantly higher concentration of P compared to oat alone.

Significantly greater concentration of N (crude protein), Na, Ca, Mg and P were obtained from Persian clover, while K concentration was highest in oat alone. There was a significant increase in the K content and decrease in Na content of forage when both crops were mixed in different ratios. From quality point of view, forage should have

Table 2. Effect of gypsum application and crop mixtures on chemical composition (%) (pooled data of 2002–03 and 2003–04)

Treatment	Dry matter	Crude protein	Na	K	Ca	Mg	P
Gypsum (tonnes/ha)							
0	10.87	17.6	2.33	2.85	0.68	0.66	0.40
2	10.70	18.7	2.24	2.86	0.71	0.67	0.41
CD (P=0.05)	NS	1.0	NS	NS	0.03	NS	NS
Crop mixture							
Oat alone	10.63	15.4	2.33	3.27	0.51	0.65	0.38
Persian clover (P.C.) alone	10.75	23.4	2.68	1.84	0.99	0.73	0.44
Oat + P. C. (1:1)	11.02	18.4	2.10	2.98	0.65	0.65	0.40
Oat + P.C (2:1)	10.99	16.5	2.10	2.93	0.62	0.65	0.40
Oat + P.C. (1:2)	10.90	17.5	2.13	2.83	0.69	0.66	0.42
CD (P=0.05)	NS	1.4	0.11	0.21	0.04	0.02	0.02

P.C., Persian clover

Table 3. Effect of gypsum levels and crop mixtures on soil pH in different soil depth

Treatment	pH 0–15 cm				pH 15–30			
	Sowing		Harvesting		Sowing		Harvesting	
	2 Oct.	3 Oct.	3 Jun	4 May	2 Oct.	3 Oct.	3 June	4 May
Gypsum (tonnes/ha)								
0	9.18	9.15	9.24	9.25	9.06	9.02	9.19	9.28
2	9.07	9.06	9.15	9.14	9.03	9.01	9.06	9.14
CD (P=0.05)	0.06	0.05	0.05	0.05	NS	NS	0.08	0.04
Crop mixture								
Oat alone	9.19	9.16	9.18	9.21	9.06	9.04	9.16	9.24
Persian clover (P.C.) alone	9.12	9.10	9.22	9.20	9.04	9.01	9.14	9.20
Oat + P.C. (1:1)	9.12	9.11	9.17	9.19	9.02	9.00	9.09	9.20
Oat + P.C. (2:1)	9.09	9.08	9.22	9.18	9.07	9.04	9.12	9.21
Oat + P.C. (1:2)	9.12	9.10	9.18	9.20	9.06	9.03	9.13	9.21
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

higher K and lower Na. Irrigation with saline-sodic water influences several forage quality parameters (Robinson *et al.* 2004). Irrigating with such waters increased sodium accumulation, while potassium accumulation was maintained in ryegrass, presumably to adjust the osmotic gradient (Ben-Ghedalia *et al.,* 2001), indicating that salinity may have appreciable effect on forage quality and ultimately forage intake.

Soil changes

During both the years, on mean basis, pH of soil in 0–15 cm soil depth was significantly lower in gypsum-applied plots compared to no-gypsum plots (Table 3). However, various crop mixtures did not significantly affect pH. In 15 – 30 cm soil depth, pH at the time of sowing was not affected significantly by gypsum application or by crop mixtures during both the years. However, pH at harvesting was significantly reduced owing to gypsum application.

Under alkali water irrigation, application of gypsum at 2 tonnes/ha is essential to improve the green forage yield and its quality. Soil crop of Persian clover gave significantly greater yield than oat. The yield of Persian clover is enhanced in the first cut when grown in association with oat at different ratios. Persian clover showed significantly higher nutrients than oat except K, which was higher in oat.

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