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Fodder Yield and Quality of Oats Fodder (*Avena sativa*) as Influenced by Salinity of Irrigation Water and Applied Nitrogen Levels

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ABSTRACT

An experiment consisting of four irrigation water salinity levels (good quality water (0.69 dS/m), 2 EC, 4 EC and 6 EC water) and four N levels (0, 50, 100 and 125% recommended dose of N) was laid down in a factorial RBD to find out the effect on green fodder yield and quality of fodder oats. Salinity of irrigation water upto 4 EC did not influence fodder yield. The levels of proximate principles except those of total ash, organic matter and ether extract at 2nd cut were not affected significantly by irrigation salinity up to 6 EC compared to good quality water. Application of 100% recommended dose (150 kg ha^{-1}) of N (RDN) significantly increased the yield and quality of oats green fodder. N application did not significantly affect hemicellulose, neutral detergent fibre at 2nd cut and acid detergent fibre at 1st cut. The treatment involving 125% RDN decreased NDF content significantly while ADF and total carbohydrate content decreased significantly using 50% RDN. Crude protein content also increased significantly using 50% RDN.

Key words: Oats fodder, Fodder yield, Water salinity, Nitrogen application, Chemical composition

INTRODUCTION

India sustains about 15% of the world's livestock population and 17% of world human population from 2.3% of world geographical area and 4.2% of world's water resources (Kumar *et al*, 2012). Livestock production is backbone of Indian agriculture contributing 7% to national GDP and source of employment and livelihood for 70% population in rural areas. (IGFRI, 2011). India ranks first in terms of milk production (129.7 million tonnes), however, the productivity is quite low mainly because of scarcity of feeds and fodders. Recent reports clearly indicated that India faces a net deficit of green fodder by 61.1%, dry crop residues by 21.9% and for feeds as high as 64% (Kumar *et al*, 2012). This gap may be narrowed down by cultivating quick growing, high yielding and responsive fodder crops under assured supply of irrigation with adequate fertilisation. There is immense pressure on cultivated land and water resources due to increasing human population, which left us with very limited resources for fodder cultivation. The scarcity of good quality irrigation water is one of the major issues around the globe. In arid and semi-arid regions, farmers are compelled to use poor quality ground water to meet irrigation requirement of crops. The crops grown for grain production are more sensitive to irrigation water salinity in comparison to fodder crops. It is documented that oats showed the minimum yield reduction compared with its yield in normal soil, demonstrating its tolerant nature. Oats is the promising fodder crop due to its fast growing nature, nutritive value and tolerance to salinity. Further, nitrogen application has been reported to mitigate the adverse effect of salts on several crops (Leidi *et al.*, 1991). Therefore, present study was conducted to evaluate the effect of irrigation water salinity and level of nitrogen application on yield and quality of oats fodder.

MATERIALS AND METHODS

The experiment was conducted at Micro-plot research area, Central Soil Salinity Research Institute, Karnal, located at 29º45' N, 76º58' E and at an altitude of 245 m above mean sea level in north-western zone of Haryana. Experiment was laid out in Factorial Randomized Block Design consisting of sixteen treatment combinations, four irrigation water salinity levels (good quality water (0.69 dS/m), 2 EC, 4 EC and 6 EC water) and four N levels (0, 50, 100 and 125% recommended dose of N; RDN) with three replications.

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Irrigation water was prepared using salts of sodium, calcium and magnesium keeping Ca and Mg ratio 2: 1 and SAR at 5. Soil of the lysimeters was low to medium in available nitrogen, medium in available phosphorus and high in available potassium. Initial pH of the top 0-15 cm soil ranged between 7.5-7.7 and EC from 0.18-0.26 dS/m. All the recommended agronomical practices were followed during growing period and soil analysis was done (AOAC, 2005). A total three irrigations were given including pre-sowing irrigation using different treatments of saline water. Kent variety released by IGFRI, Jhansi was used for the study. Phosphorus and potassium were given at sowing time @ 60 kg P_2O_5 /ha and 40 kg K_2O/ha in all the plots through SSP (single super phosphate) and MOP (murate of potash), respectively. Nitrogen was applied in the form of urea as per the treatments in following manner: 1/3 at sowing, 1/3 at first irrigation and 1/3 at first cut. Sowing was done on 29 October, 2012 by *Kera* method. First cut of fodder was taken on January 2, 2013 at 65 DAS and second cut of fodder was taken on March 3, 2013 at booting to grain filling stage of crop. Fresh fodder yield was recorded and samples were collected. The samples were dried in hot air oven and ground to pass through 2 mm sieve for determination of proximate principles (AOAC, 2005) and cell wall constituents (Goering and Van Soest, 1970). Statistical analysis was done using standard procedures of analysis of variance in RBD using IRRISTAT software (IRRI, 1999) and statistical mean differences were found by Fisher's protected least significant difference test at P<0.05.

Table 1. Effect of saline water irrigation and nitrogen application on green and dry fodder yield

Irrigation water quality (dS/m)	Green fodder yield (t/ha)			Dry matter content (%)			Dry matter yield (t/ha)		
	1st cut	2nd cut	Total	1st cut	2nd cut	Mean	1st cut	2nd cut	Total
Good quality water	30.3^{a}	57.2^{a}a	87.5^{a}	12.8	12.6	12.7	3.89	7.23	11.1^{a}
2 EC	30.1^{a}	55.8^{a}	85.9^{a}	12.6	12.6	12.6	3.80	7.07	10.8^{a}
4 EC	28.7^{a}	53.3^{ab}	82.0^{a}	12.3	12.9	12.7	3.53	6.87	10.4^{ab}
6 EC	24.9^{b}	50.2^{b}	75.1^{b}	12.1	13.0	12.6	3.00	6.51	9.51^{b}
SEm±	1.29	1.73	2.49	0.75	0.72	0.49	0.18	0.3	0.38
Recommended dose of N (%)									
0	24.8^{a}	48.5^{a}	73.3^{a}	12.2	13.1	12.7	3.02^{a}	6.34^{a}	9.37^{a}
50	27.7^{ab}	52.4^{ab}	80.6^{b}	11.9	13.4	12.8	3.29^{ab}	7.03^{ab}	10.32^{ab}
100	30.4^{b}	56.5^{b}	86.9^{bc}	11.7	13.0	12.5	3.55^{bc}	7.36^{bc}	10.84^{bc}
125	30.9^{b}	59.2^{bc}	90.1^{c}	12.1	12.9	12.6	3.74^{c}	7.62^{c}	11.37^{c}
SEm±	1.29	1.73	2.49	0.75	0.72	0.49	0.18	0.3	0.38

^{a,b,c} Values bearing different superscripts in a column differ significantly (P<0.05)

RESULTS AND DISCUSSION

Green fodder yield

Across N levels, green fodder yield of oats at both cuts was similar up to 4 EC salinity of irrigation water (Table1), thereafter, the decrease in green fodder yield was significant as compared to good quality water irrigation. Kumar and Sharma (1995) also reported that oats fodder can safely be irrigated with saline water up to 5 EC without significant yield reduction under Karnal conditions. The primary effect

Table 2: Effect of saline water irrigation and nitrogen on proximate composition and cell wall constituents (% DM basis)

Irrigation water quality (dS/m)	CP		EE		Total ash		Total carbohydrate		OM		NDF		ADF		Hemicellulose	
	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut
Good quality water	12.3	11.6	2.45	2.1^{a}	9.41^{a}	7.44^{a}	75.8	78.9	90.6^{a}	92.5^{a}	55.6	60.7	34.1	36.1	21.5	24.6
2EC	12.2	11.5	2.40	1.95^{a}	9.42^{a}	7.49^{a}	75.9	79.0	90.5^{ab}	92.4^{a}	56.1	60.7	34.5	36.2	21.6	24.5
4EC	11.9	11.2	2.27	1.87^{a}	9.72^{ab}	8.01^{a}	76.2	79.2	90.3^{ab}	91.9^{a}	56.7	60.8	34.9	36.3	21.8	24.5
6EC	11.1	10.1	2.05	1.57^{b}	10.40^{b}	9.27^{b}	77.3	79.6	89.6^{b}	90.7^{b}	57.8	61.7	36.0	36.8	21.8	24.9
SEm±	0.51	0.67	0.15	0.10	0.32	0.27	0.62	0.75	0.32	0.27	0.90	1.40	1.04	0.40	1.21	1.36
Recommended dose of N (%)																
0	9.48^{a}	9.23^{a}	1.78^{a}	1.64^{a}	8.92^{a}	7.99^{a}	79.8^{a}	81.1^{a}	91.1^{a}	92.0^{a}	57.7^{a}	63.7	35.6	38.0	22.1	25.7
50	11.4^{b}	10.3^{ab}	2.11^{ab}	1.85^{ab}	9.77^{ab}	8.72^{ab}	77.3^{b}	79.4^{b}	90.2^{ab}	91.3^{ab}	56.1^{ab}	61.0	34.5	36.0	21.6	25.0
100	12.7^{bc}	11.3^{b}	2.43^{bc}	2.02^{b}	10.0^{b}	9.29^{b}	75.0^{c}	77.9^{bc}	89.9^{b}	90.7^{b}	55.2^{b}	60.1	33.8	35.5	21.4	24.6
125	13.1^{c}	11.9^{b}	2.62^{c}	2.02^{b}	10.2^{b}	9.40^{b}	74.0^{c}	76.6^{c}	89.7^{b}	90.6^{b}	55.1^{b}	59.7	33.8	35.3	21.3	24.4
SEm±	0.51	0.67	0.15	0.10	0.32	0.27	0.62	0.75	0.32	0.27	0.90	1.40	1.04	0.40	1.21	1.36

^{a,b,c} Values bearing different superscripts in a column differ significantly ($P<0.05$)

of high irrigation water salinity renders less water available to plants inspite of the fact that some water is still present in the root zone. This is because of osmotic pressure of the soil solution become more negative as the salt concentration increases. Apart from the osmotic effect of salts in the soil solution, excessive concentration and absorption of individual ions may also prove toxic to the plants and/or may retard the absorption of other essential plant nutrients (Qadar, 2009). Lower osmotic potential of soil resulting from the good rainfall received after 1st cut encouraged the profuse growth of fodder which ultimately increased the green fodder yield appreciably in 2nd cut. Increasing N levels, increased the green fodder yield significantly up to 125% RDN, however, increase was significant only upto 100% RDN for the second cut. Significant increase in green fodder yield can be attributed to greater plant height, more number of leaves per plant and leaf area index. The abundant supply of nitrogen may have increased protoplasmic constituents and accelerated the process of cell division and elongation which might have resulted in luxuriant vegetative growth in terms of plant height, thereby, higher biomass and dry matter yield. Ahmad *et al*. (2011) also reported 74.67 t/ha total green fodder yield of oat by application of 150 kg N/ha.

Dry matter content and yield

DM content was not affected significantly by both nitrogen levels as well as water salinity (Table 1). Dry matter yield at 1st cut and total yield was reduced by 6 EC salinity level, whereas at 2nd cut, the effect was non-significant which could be ascribed to the fact that rainfall (18 cm) received after 1st cut leached down the salts below the root zone. 100% RDN significantly increased the DM yield by 17.5 and 16.1 % at 1st and 2nd cut, respectively. Jehangir *et al*. (2013) also reported that the fertility level of 150: 70: 40 kg N: P_2O_5: K_2O /ha for oats fodder increased both green and dry fodder yield.

Chemical composition of oats fodder under different treatments

The chemical composition of oats fodder has been given in Table 2. CP content of oats was not affected due to water salinity at both the cuts, though good quality water recorded 10.8% higher crude protein content at first cut and 14.8% at second cut compared to 6 EC saline water irrigation. A significant decrease in the N content was also noted in plants irrigated with saline water in maize (Irshad *et al.,* 2009). 100% RDN increased CP content by 33.97 and 22.43% at 1st and 2nd cut, respectively, but significant increase at 1st cut was for 50% RDN whereas at 2nd cut for 100% RDN. These results are in line with those reported earlier (Bhilare and Joshil, 2007) in oats fodder. It has been reported that N supply increased the formation of nucleotides and coenzyme to which nitrogen is a constituent and this facilitates cell elongation (Epstein, 1972). Moreover, acceleration of meristematic activity and encouragement of vegetative growth are some of the recognized effects of N fertilization. The increase in CP content with increased N levels might be due to rapid synthesis of carbohydrates and their conversion to protein and protoplasm, leaving only a smaller portion for cell wall synthesis because carbohydrates and nitrogen provide skeleton for protein synthesis (Russell, 1973).

There was decrease in EE content with increasing levels of irrigation water salinity for both the cuts, but decrease at first cut was non-significant and at 2nd cut 6 EC water significantly reduced EE content. The reduction in EE content was 19.5% at first cut, whereas, it was 33.7% at second cut. Increasing N levels increased the ether extract content at both cuts of fodder oats, but the significant increase in ether extract content was observed only up to 100% RDN for both the fodder cuts. Abichandani *et al.* (1970) also reported similar findings in fodder teosinte.

Irrigation (6 EC) significantly increased the total ash content by 10.52% at 1st cut and 24.60% at 2nd cut. Accumulation of high salt concentrations in organs of grasses usually serves to achieve osmotic balance under saline conditions by adjusting the water potential of plants to more negative levels than that of the growth medium. N application successively increased total ash content but the increase was non-significant at first cut and at 2nd cut, a significant increase was observed up to 100% RDN which might be attributed to the increased availability of N to the plants. Ayub *et al*. (2002) also reported similar findings in fodder sorghum.

There was no significant effect on OM content due to levels of irrigation water salinity at both the cuts. Increased irrigation water salinity increased the total ash content of fodder due to higher uptake of salts from soil solution to adjust osmotic potential, so fraction of OM decreased simultaneously at higher EC. N levels decreased the OM content at both cuts of oats fodder. Significant decrease in OM for 1st cut was at 50% RDN, whereas for 2nd cut decrease was non-significant. The decrease in OM content with increase in the levels of N application is due to the increase in total ash content with N application.

Total carbohydrate contents were similar at both cuts irrespective of levels of irrigation water salinity. 6 EC irrigation water adversely affected crude protein, ether extract and yield due to higher concentration of soluble salts, so fraction of total carbohydrates increased simultaneously. Increasing N levels decreased the total carbohydrate content significantly at both cuts of oats fodder, but the significant decrease was observed in total carbohydrate content by 6.02 and 3.95% up to 100% RDN for 1st and 2nd cut, respectively. Higher N dose decreased total carbohydrate content because of higher availability of N directly increased the CP, ash and EE of plants.

NDF content increased slightly with increasing levels of irrigation water salinity at both the cuts. Maximum NDF content was recorded with 6 EC irrigation water for both 1st (57.8 %) and 2nd cut (61.7 %) but these values were statistically similar. Higher NDF content with saline water irrigation may be ascribed to the fact that higher concentration of soluble salts might have deposited in cell wall making it more rigid and hard. Ben-Ghedalia *et al.* (2001) also reported that NDF content responded positively to increased water salinity. 125% RDN decreased NDF content by

2.46 and 6.70 % at 1st and 2nd cut of oats fodder but the decrease was non-significant for 2nd cut. Kering *et al.* (2011) reported that NDF decreased up to 25% with the greatest N application rate in Bermuda grass.

The content of ADF increased with 6 EC irrigation water by 5.57% at first cut and 1.95% at second cut compared to good quality water irrigation, but differences were non-significant. Higher concentration of soluble salts might have deposited in cell wall making it more rigid and hard so ADF content increased at higher EC of irrigation water. ADF content decreased with increasing N levels by 5.32 and 7.64% at first and second cut, respectively with 125% RDN compared to control treatment. The significant decrease ($P<0.05$) in ADF was observed up to 50% RDN at second cut whereas at first cut decrease was non-significant due to N application. Increased uptake of N imparts succulence to green plants by reducing fibre content of it. Similar results have been reported (Kering *et al.,* 2011) for bermuda grass. The chemical composition of oats fodder was comparable as reported by Chander Datt *et al.* (2009). From high yielding animal feeding point of view, fodder with low NDF as well as ADF is always preferred. Hemicellulose was not affected statistically by both EC level as well as N application.

CONCLUSIONS

Oats fodder may be successfully grown using saline water irrigation up to 4 EC with 125% recommended dose of N (188 kg/ha). Fodder quality parameters like CP, EE, ash, NDF and total carbohydrate contents were at par when good quality water or 2 EC salinity irrigation water was used. These results are indicative and require further experimentation.

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