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[Reprinted from *Indian J. Agric. Sci.*, Vol. **47**, No. 4 pp. 204-209

Avena sativa

Indian J. agric. Sci. **47** (4) : 204–9, April 1977

Effect of levels of soil moisture and nitrogen on the fodder yield of oat on two types of soils

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Received : 24 January 1976

ABSTRACT

Experiments were conducted from 1968–69 to 1970–71, on a loam soil of medium fertility and a red gravelly sandy-loam soil of low fertility to study the effect of different levels of soil moisture and nitrogen on the yield, irrigation requirement and water-use efficiency of fodder oat (*Avena sativa* L.). The fodder yield of oat increased with an increase in the level of available soil moisture from 25% to 75% in the active root zone on both the soils. The yield of fodder also increased with an increase in the level of N from 30 to 90 kg/ha. There were positive interactions between the levels of soil moisture and N on the fodder production of oat on both the soils. The production potential and the water-use efficiency on red gravelly sandy-loam soil were only about 2/3 of that obtained on loam soil. The total amount of irrigation water required by the crop on the 2 soils did not vary much, but irrigations were required in smaller amounts and more frequently on light-textured soil (red gravelly sandy-loam than) on medium-textured soil (loam).

Oat (*Avena sativa* L.) is an important cereal fodder crop commonly grown in winter in northern India. It has been found to respond well to frequent supply of soil moisture through irrigations (Fulton, 1968; McNeil and Frey, 1969; Chang *et al.*, 1971). Oat has also been reported to respond well to the application of nitrogenous fertilizer, and N levels varying from 50 to 90 kg/ha have been recommended under different soil and climatic conditions (Tomar, 1970; Randhawa and Gill, 1971; Singh *et al.*, 1972; Srivastava and Varshney, 1974). The response to added fertilizer was more when moisture was adequate in the soil (McNeil and Frey, 1969). The management of soil moisture and the N level applied to fodder oats, therefore, needs careful considerations.

Studies were conducted at the Indian Grassland and Fodder Research Institute, Jhansi, to find out the effect of different levels of soil moisture and N and to find out the irrigation requirements of oat grown for fodder on 2 types of soils prevailing in the region.

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MATERIALS AND METHODS

Field studies were conducted in the winter seasons of 1968–69 to 1970–71, on Bhojla loam soils of medium fertility (0.062% total N and 26.3 kg available P/ha) and on Bharari red gravelly sandy-loam soils of low fertility (0.043% total N and 9.0 kg available P/ha). The former soil contained 24.2 cm and the latter 9.2 cm of available soil water per metre depth of soil. These 2 soils were situated within half a kilometre from each other on the same farm.

Both were well-drained soils free from salinity hazards. The water-table in both the situations was far below the root zone of the crop; hence its contribution towards the water needs of crops was regarded as negligible. The rainfall during the crop reason was 49.2 mm in 1968–69, 163.0 mm in 1969–70 and 36.0 mm in 1970–71. Of the 163 mm rain in 1969–70, 116 mm were received in the week following sowing, and thus it served as a common irrigation in that year. The maximum temperature ranged from 21°C to 35°C and the minimum from 4°C to 16°C in the crop seasons during the 3 years of study. The relative humidity ranged from 70 to 40%; it was higher in the second year because of more rainfall.

The treatments comprised all combinations of 3 levels of soil moisture, viz. irrigation at 25, 50 and 75% available soil moisture (ASM) measured gravimetrically at a soil depth of 15–30 cm, and 3 levels of N, viz. 30, 60 and 90 kg/ha. The treatments were laid out in a randomized-block design and replicated 4 times. The gross plot size was 5 m × 3 m and the net plot size was 3 m × 2 m. The experiments on both the soils were repeated for 3 years on changed sites within the same block.

After sowing, 2 irrigations of 5 cm each were given in common to all the treatments for establishment of the crop, except in the second year, when 1 irrigation was given. Irrigations thereafter were scheduled as per the treatments. The percentage moisture content (weight/weight) at a soil depth of 15–30 cm before irrigation in treatments with 25, 50 and 75% ASM in the loam soil were 10.0, 14.0 and 18.0% respectively (within ± 0.5% variation). The corresponding moisture contents in the red gravelly sandy-loam soil were 6.0, 7.5 and 9.0% respectively (within ± 0.5% variation). Soil samplings for moisture determination were taken on alternate days starting approximately from the fourth day to the sixth day, based on experience, before the possible time of irrigation. The amounts of irrigation water applied to make up the moisture deficit before irrigation as per the treatments in case of loam soil were 35–40, 50–55 and 60–65 mm in 75, 50 and 25% ASM treatments respectively. The corresponding values in the red gravelly sandy-loam soil were 30, 42–43 and 55 mm respectively. Irrigation water was measured with a 76-mm Parshall-flume. The information on number, amount and interval of irrigations is given in Table 1.

N in the form of urea was applied half at sowing below the seed level; the other half was broadcast at the time of the second common irrigation. P @ 35 kg/ha in the form of single superphosphate and K @ 35.5 kg/ha in the form of potassium sulphate were applied in common as a basal dose and were mixed by harrowing

Table 1. Irrigation requirement of fodder oat under different levels of soil-moisture supply on 2 soils

Treatment	Loam soil			Red gravelly sandy-loam soil		
	Irrigations after sowing	Irrigation water (mm)	Irrigation interval (days)	Irrigations after sowing	Irrigation water (mm)	Irrigation interval (days)
1968–69						
Levels of soil moisture						
I_1 = 25% ASM	5	275	26–28	6	300	18–21
I_2 = 50% ASM	7	370	17–20	8	335	13–15
I_3 = 75% ASM	12	440	9–12	14	440	7–9
1969–70						
Levels of soil moisture						
I_1 = 25% ASM	4	235	28–30	6	295	18–22
I_2 = 50% ASM	6	285	15–18	8	315	12–15
I_3 = 75% ASM	10	345	9–12	13	385	7–10
1970–71						
Levels of soil moisture						
I_1 = 25% ASM	5	285	27–28	*5	220	18–22
I_2 = 50% ASM	7	290	15–17	*7	280	12–14
I_3 = 75% ASM	10	370	8–11	*10	320	7–9

ASM, Available soil moisture before irrigation as measured at 15–30-cm depth of soil layer.
*Irrigation schedule on this soil could not be adhered to as per the treatments due to certain breakdowns in irrigation supply during regrowth period of the crop and hence the number of irrigations were reduced.

in both the soils.

'Kent' variety was sown around the middle of November in rows 25 cm apart after a pre-sowing irrigation, the seed rate was 100 kg/ha. Two cuts were taken, first at the initiation of flowering of the first growth (90–95 days after sowing) and the second at the 50% flowering stage of the regrowth (40–45 days after the first cut). The yield of fodder is reported as the total of 2 cuts both in terms of fresh and dry matter. The contribution of the second cut to the total yield was only 14–16% in terms of green fodder and 22–23% in terms of dry matter. The yield data (total of 2 cuts) of the 3 years were pooled and statistically analysed. The responses to N levels were worked out, based on green-fodder yield, under each level of soil-moisture supply since the 2 factors had shown positive interaction on yield. The optimum level of N was worked out where-ever the response was quadratic. For this the current price of green fodder was taken as Rs 7.50/q and N as Rs 4.50/kg of N.

RESULTS AND DISCUSSION

The data on the yield of fresh and dry fodder in each year and the data pooled over 3 years, as influenced by the levels of soil moistue and N, are given in Table 2. The yield on red gravelly sandy-loam soil, in general, was only about 2/3 of the yield obtained on loam soil.

Effect of soil moisture

On loam soil the fresh (green) fodder yield increased with an increase in the level of soil moisture up to 75% ASM (I_3), whereas the dry matter increased with an increase in soil moisture up to 50% ASM (I_2) only (Table 2). This differential effect of soil moisture on the yield of fresh and dry matter may be ascribed partly to the succulent growth (less dry matter %) at high level of soil-moisture supply. The

Table 2. Effect of levels of soil moisture and N on fodder production of oat on 2 soils

Treatment	Green-fodder yield (q/ha)				Dry-matter yield (q/ha)			
	1968–69	1969–70	1970–71	Pooled over 1968–71	1968–69	1969–70	1970–71	Pooled over 1968–71
			Loam soil					
Levels of soil moisture								
I_1 = 25% ASM	368	372	258	332	80.2	88.8	55.9	74.9
I_2 = 50% ASM	426	429	274	376	90.4	90.8	58.0	79.5
I_3 = 75% ASM	510	437	319	422	96.7	87.2	65.9	83.2
'F' test	Sig	Sig	Sig	Sig	Sig	NS	NS	Sig
Levels of N								
N_{30} = 30 kg N/ha	375	323	204	301	82.8	72.5	44.5	66.6
N_{60} = 60 kg N/ha	437	422	292	384	89.3	90.7	61.8	80.6
N_{90} = 90 kg N/ha	491	492	354	446	95.2	103.1	73.5	90.6
'F' test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
SEm±	15.8	117	10.5	7.4	2.37	2.34	2.21	1.40
CD at 5%	46.2	34.8	30.7	21.0	6.9	6.8	6.5	4.0
			Red gravelly sandy-loam soil					
Levels of soil moisture								
I_1 = 25% ASM	203	208	186	199	44.6	46.8	40.6	44.0
I_2 = 50% ASM	226	243	212	267	47.4	51.7	47.5	48.8
I_3 = 75% ASM	333	275	263	290	65.8	58.8	55.9	59.7
'F' test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
Levels of N								
N_{30} = 30 kg N/ha	182	152	162	165	39.1	35.6	36.1	36.9
N_{60} = 60 kg N/ha	238	239	234	237	49.5	51.0	50.9	50.0
N_{90} 90 kg N/ha	342	334	264	313	69.1	70.7	57.0	65.6
'F' test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
SEm±	7.8	12.0	8.7	5.6	5.12	3.61	1.87	1.23
CD at 5%	22.7	35.0	25.5	15.8	14.9	10.5	5.5	3.5

ASM = Available soil moisture measured gravimetrically at 15–30-cm depth of soil layer; Sig, significant, NS, non-significant.

year-to-year variation in the response to soil-moisture levels may be ascribed to the rainfall received in the crop season which might have evened out the effect due to differential irrigations.

The response to soil moisture was clearly marked on red gravelly sandy-loam soils. The fresh and dry matter of oats increased significantly with an increase in the level of soil moisture up to 75% ASM (I_3). The higher degree of response to soil-moisture levels on red gravelly sandy-loam soils may be ascribed to the limited capacity of these soils to hold available water in the root zone of the crop. In 1-m depth of soil layer, the loam soil contained 2½ times more available water than the gravelly sandy-loam soil. At each level of soil-moisture availability, therefore, much more water was available quantitatively on loam soils to meet the evapotranspiration demand over a prolonged period than on red gravelly sandy-loam soils. Hence the effect of water shortage is readily reflected on crops grown on lighter soils than on heavier soils under the same climate owing to an early exhaustion of the limited available water storage in lighter soils.

The efficiencies of the production of dry matter per unit amount of irrigation water (Table 3) were worked out from the data on dry matter (Table 2) and the amount of irrigation water (Table 1). The production efficiency of water decreased with an increase in the level of soil moisture on loam soils, but is was not much altered on red gravelly sandy-loam soils. This indicated that an increasing amount of water was used more efficiently on lighter soils because of their low water-holding capacities. These soils, however, were less productive and as such produced less dry matter per unit amount of water applied, about 2/3 of the dry matter produced per unit of water applied on loam soils.

Effect of N

The yield of fresh and dry fodder increased on both the soils with an increase in the level of N from 30 to 90 kg/ha (Table 2). The yield, both in terms of fresh and dry matter, for every kilogram of N was more on loam soil (276 kg green fodder and 46.6 kg dry matter) than on red gravelly sandy-loam soil (240 kg green fodder and 43.6 kg dry matter) when the level of N was increased from 30 to 60 kg/ha. However, with further increase in the level of N to 90 kg/ha, the fodder yield for every kilogram of N was more on red gravelly sandy loam (253 kg green fodder and 52.0 kg dry matter) than on loam soil (206 kg green fodder and 33.3 kg dry matter). This differential trend may be attributed to the difference in the initial fertility status of the 2 soils.

The production efficiency per unit of irrigation water was remarkably improved

Table 3. Fodder-production efficiency of oat per unit amount of irrigation water under various levels of soil moisture and N on 2 soils

Treatment	Dry matter production by oat/unit				Irrigation water (kg ha^{-1} mm^{-1})			
	Loam soil				Red gravelly sandy-loam soil			
	1968–69	1969–70	1970–71	Average	1968-69	1969–70	1970–71	Average
Levels of soil moisture								
I_1 = 25% ASM	29.2	37.8	19.6	28.9	14.9	15.9	18.5	16.9
I_2 = 50% ASM	24.4	31.9	20.0	25.4	14.1	16.4	17.0	15.8
I_3 = 75% ASM	22.0	25.3	17.0	21.4	14.9	15.3	17.5	15.9
Levels of N								
N_{30} = 30 kg N/ha	22.9	25.2	14.1	20.7	10.9	10.7	13.2	11.6
N_{60} = 60 kg N/ha	24.7	31.5	19.6	25.3	13.8	15.4	18.6	15.9
N_{90} = 90 kg N/ha	26.3	35.8	23.3	29.5	19.3	21.3	20.9	20.5
Average for soils				25.0				16.0

ASM = Available soil moisture measured at 15-30-cm soil layer.

on both the soils with the application of increased amount of N fertilizer (Table 3). This resulted in a positive interaction between the levels of soil moisture and N on the yield of green fodder on both the soils (Table 4). In terms of dry matter, however, the interaction effect was obtained only on red gravelly sandy-loam soils poor in fertility and moisture retentivity. The interaction effect revealed that the response to N was considerably boosted under higher levels of soil-moisture supply (Fig. 1). The response to the application of N was linear under all levels of soil mois-

Table 4. Interaction of irrigation and N levels on the fodder yield of oats on 2 soils (pooled data)

Treatment	Levels of soil moisture			SEm± q/ha	CD at 5% q/ha
	I_1 = 25%ASM	I_2 = 50% ASM	I_3=75% ASM		
Loam soil					
	Green fodder yield (q/ha)				
N_{30} = 30 kg N/ha	257	310	335	12.9	36.3
N_{60} = 60 hg N/ha	355	383	412		
N_{90} = 90 kg N/ha	384	435	518		
(N_{60}–N_{30})	98	73	77		
(N_{90}–N_{30})	127	125	183		
Red gravelly sandy-loam soil					
	Green fodder yield (q/ha)				
N_{30} = 30 kg N/ha	142	160	193	3.1	8.6
N_{60} = 60 kg N/ha	184	238	270		
N_{90} = 90 kg N/ha	270	282	388		
(N_{60}–N_{50})	42	78	97		
(N_{90}–N_{30})	128	122	195		
	Dry matter yield (q/ha)				
N_{30} = 30 kg N/ha	34.4	34.6	41.7	2.14	6.0
N_{60} = 60 kg N/ha	39.6	51.7	58.7		
N_{90} = 70 kg N/ha	57.9	60.7	78.8		
(N_{90}–N_{30})	5.2	17.1	17.0		
(N_{90}–N_{30})	23.5	26.1	37.1		

ASM = Available soil moisture measured at 15–30-cm soil depth.

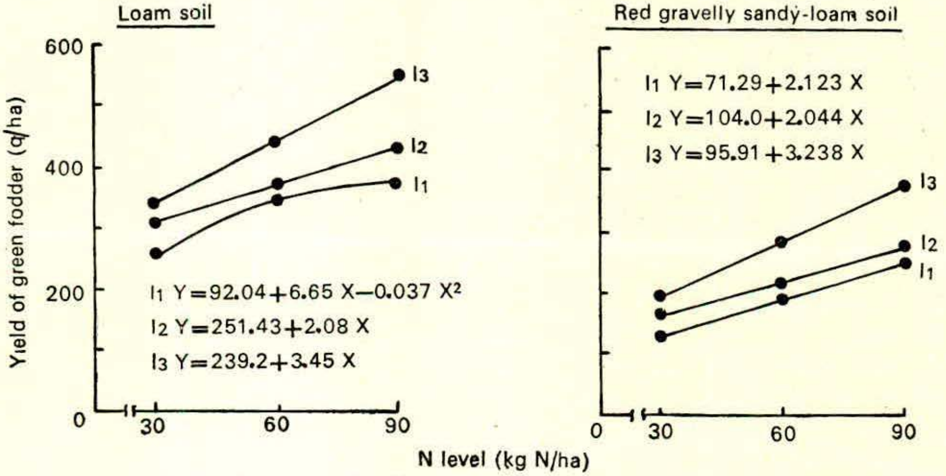

Fig. 1. Response of fodder oat to nitrogen on two types of soils.

ture on both the soils except under I_1 level (low moisture supply) on loam soils, where the response was quadratic and the optimum dose of N was 80.07 kg. Owing to the linear nature of response in the rest of the cases, the optimum dose of N could not be worked out; apparently, still higher levels of N application are required to be tried.

ACKNOWLEDGEMENTS

We are thankful to the Director, Indian Grassland and Fodder Research Institute, Jhansi, for providing facilities. and to Mr P. R. Sreenath, Mr A. G. Kavitkar and Mr Mahabir Prasad for help in statistical analyses.

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