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Effect of irrigation schedule and nitrogen fertilization on growth, yield and quality of fodder oat (*Avena sativa* L.)

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Abstract
The present study was undertaken to evolutes the effect of irrigation schedule and nitrogen fertilizations on growth, yield and quality of multi cut fodder oat var. kent under Southern Rajasthan. A field experiment was conducted during *rabi* 2013-14 at Instructional Farm, Rajasthan College of Agriculture, Udaipur. The experiment comprised combinations of four irrigations and three nitrogen levels. Thus, 12 treatments; all were evaluated in split-plot design with three replications keeping irrigation in main and nitrogen in sub plots. The results indicated that application of irrigations did not significantly affect plant height and dry matter accumulation at 30 DAS while, five irrigations recorded significantly higher plant height, dry matter accumulation at 90 DAS whereas number of tillers m^{-1} row length at both first and second cuttings and total green and dry fodder yield. Five irrigations produced significantly higher crude protein, crude fat, mineral matter and total digestible nutrients but there was no significantly difference found in crude fibre, nitrogen free extract and total digestible nutrient content at first cutting whereas, minimum were noted with two irrigations in all the above parameters. In case of plant height, dry matter accumulation, number of tillers m^{-1} row length and total green and dry fodder yield significantly produced with an application 110 kg N ha^{-1} during year of experiment.

Keywords: Oat, irrigation, nitrogen, growth, yield, DMA, CP, CF, EE, MM, NFE, TDN

Introduction
India possesses a large bovine population which includes 200 million cattle and 92 million buffalo. This accounts for 19.5 per cent of the global cattle population. Despite this large bovine population, the scenario of milk production and productivity is far below the world average. The supply of nutritious fodder is a pre-requisite for the success of any dairy industry (Surje *et al*., 2015) [17]. The present availability of green fodder is about 400 million tonnes projecting a deficit of 63.50% and that of dry fodder is around 466 million tonnes against the requirement of 609 million tones therefore, the demand for fodder will keep on increasing. Therefore, there is urgent need to maximize the tonnage and quality of fodder within the existing farming systems. Being highly nutritious, palatable and energy rich with good regeneration ability cereal forage crop oat with high dry matter production has become a promising forage crop for livestock production. Multi cut nature of the crop ensures continuous supply of fodder (Jehangir *et al*., 2017) [8]. It can be grown on variety of soils as a winter annual in the north-western and central India and now extending to the eastern regions. In India, it is being grown in Punjab, Haryana, Jammu & Kashmir, Himachal Pradesh, Uttar Pradesh, Madhya Pradesh, Rajasthan, Maharashtra and West Bengal and in Gujarat where irrigation facilities are available. Oat ranks sixth in the world cereal area, production and productivity, followed by wheat, maize, rice, barley and sorghum (Joshi *et al*., 2015) [13]. Oat has assured considerable importance in India as fodder as well as grain for animal feed particularly calves and young stocks, horses, poultry and sheep. In dairy farms, oat as a fodder is inevitably adopted, as it can be fed green and surplus converted into silage or hay for use during the lean period. Despite the extensive worldwide use of oat for forage and fodder uses, very little of the world's research plant improvement resources are devoted to the development of the oat crop specifically for fodder uses (Godara *et al*., 2016) [6]. Vegetative growth of any crop depends upon the water and nutrient supply system and capacity of the soil to supply the nutrients to crop and capacity to take and use the water and nutrient is unit time.

Materials and methods
The field experiment was carried out during *rabi* 2013–14 at Instructional Farm, Rajasthan College of Agriculture, MPUAT, Udaipur. The soil of the experimental field was clay loam in texture, slightly alkaline in reaction pH (8.0), high in organic carbon (0.84), medium in available nitrogen (295.3 kg ha^{-1}), low in available phosphorus (16.60 kg ha^{-1}) and high in potassium (275.70 kg ha^{-1}). The experiment consisted of 12 treatment combinations, comprising four irrigation levels (Two-20 & 60 DAS, Three-20, 40 & 60 DAS, Four-20, 40,

60 & 80 DAS and Five-20, 40, 60, 80 & 100 DAS) and three nitrogen levels (70, 90 and 110 kg N ha^{-1}) tested in split-plot design with three replications keeping irrigation in main and nitrogen in sub plots. Nitrogen in form of urea was applied 1/3 at sowing time + 1/3 at 30 DAS + 1/3 after first cutting.

The samples of oat were taken for treatment evaluation from all the treatments and were sun-dried. Then they were dried in the oven at 70ºC for 40 hours till constant weight attained. The dried samples were then grinded and analyzed for nitrogen (Nesseler reagent method; Lindner, 1944) [11], crude protein and mineral matter (A.O.A.C., 1970) [1], Crude fat (EE) and nitrogen free extract (Knowles and Watkins, 1960) [9], crude fibre (Wright, 1939) [18], and total digestible nutrients by using the digestible coefficient of CP, CF, EE and NFE (Ranjhan, 1991) [15].

Results and discussion

Growth characters

The data presented (Table1) shows that the irrigation levels did not significantly influence plant height at 30 DAS while five irrigations recorded significantly higher plant height over two and three irrigations but it was statistically at par with four irrigations at 90 DAS. The per cent increase with five irrigations in plant height at 90 DAS was 31.8 and 12.5 over two and three irrigations, respectively. This increase may be due to increased uptake of nutrients with increased availability of moisture for plant uptake. These results are supported by (Gangaiah, 2005) [5]. Application of 110 kg N ha^{-1} found significantly superior over 70 and 90 kg N ha^{-1} at 30 DAS but statistically at par with 90 kg N ha^{-1} at 90 DAS. The per cent increase in plant height by 90 and 110 kg N ha^{-1} was 10.8 and 24.6 over 70 kg N ha^{-1}at 90 DAS, respectively. This increase in plant height may be attributed to synthesis of food materials, resulting in greater cell division and cell elongation. Therefore, elongation in plant increased with increasing nitrogen application (Dubey *et al*., 2013) [4].

The dry matter accumulation was did not significantly influence by irrigations at 30 DAS. Four irrigations gave significantly highest dry matter accumulation (34.2 g 0.5 m^{-1}) over rest of treatments except five irrigations were found statistically at par at 90 DAS. The per cent increase in dry matter accumulation by four irrigations was 24.4 over two irrigations, respectively. The dry matter accumulation under different nitrogen levels varied between 24.3 and 28.5 g 0.5 m^{-1}. Application of 110 kg N ha^{-1} was recorded significantly superior over 70 and 90 kg N ha^{-1} at 30 DAS. The per cent increase in dry matter accumulation by 110 and 90 kg N ha^{-1} was 17.3 and 5.9 over 70 kg N ha^{-1}, respectively. The maximum dry matter accumulation (34.1 g 0.5 m^{-1}) was recorded with 110 kg N ha^{-1} closely followed by 90 kg N ha^{-1} at 90 DAS. The per cent increase in dry matter accumulation by 110 kg N ha^{-1} was 23.1 over 70 kg N ha^{-1}. This might be due to better plant growth in terms of plant height and secondly continuous vertical growth of the crop ultimately reflected in higher dry-matter production. Malik *et al*. (2015) [12] also reported similar findings.

The irrigations had significantly affect on number of tillers m^{-1} row length at both first and second cuttings. The five irrigations gave maximum (157.4 and 196.6) number of tillers m^{-1} row length closely followed by four irrigations (156.4 and 187.9) number of tillers m^{-1} row length at both first and second cuttings, respectively. This can be ascribed to greater availability of photosynthates and its translocation towards the formation of sink organs that resulted in formation of significantly more no. of tillers m^{-1} row length. Nitrogen levels had significantly affect on number of tillers m^{-1} row length at both first and second cuttings. Application of 110 kg N ha^{-1} gave significantly higher (165.6 and 191.7) number of tillers m^{-1} row length over 70 kg N ha^{-1} but statistically at par with rest of treatment, respectively. The improvement in nutritional status of plant might have resulted in greater synthesis of amino acids, proteins and other growth promoting substances which seems to have enhanced the meristematic activity and increased cell division and enlargement and their elongation resulted in more number of tillers.

Yield

It is evident from the data (Table1) that the irrigations had significantly affect on total green and dry fodder yield. It was observed that five irrigations gave significantly higher total green and dry fodder yield over two, three and four irrigations. The maximum green and dry fodder yield recorded in five irrigations were (60.03 and 19.56 t ha^{-1}) followed by four irrigations (55.20 and 18.12 t ha^{-1}) and three irrigations (50.41 and 16.68 t ha^{-1}), respectively. The higher green fodder yield with increasing levels of irrigation and nitrogen might be attributed to the significant enhancement in performance of yield is well linked with corresponding significant higher performance of growth parameters (plant height, dry matter accumulation and crop growth rate or relative growth rate) and also due to higher availability of metabolites. Such improvement in various growth attributes ultimately resulted in higher fodder yield. Similar effect of irrigation and nitrogen on fodder yield was also reported by Gangaiah (2005) [5], Jat *et al*. (2015) [7] and Satpal *et al*. (2016) [16].

Quality parameters production

It was found that irrigation levels had significantly affect on quality parameters production of fodder oat (Table 2). Five irrigations produced significantly higher crude protein, crude fat, mineral matter and total digestible nutrients but there was no significantly difference found in crude fibre, nitrogen free extract and total digestible nutrients at first cutting whereas, minimum were noted with two irrigations in all the above parameters production. Application of five irrigations resulted in crude protein production 939.88 and 994.03 kg ha^{-1} crude fat production 147.00 and 158.95 kg ha^{-1} mineral matter production 631.95 and 658.41 kg ha^{-1} and nitrogen production 150.38 and 159.04 kg ha^{-1} at first and second cuttings, respectively.

Data further reflect that nitrogen levels had significant influence on production of quality parameters during first and second cuttings. Enriching fertility levels up to 110 kg N ha^{-1} produced significantly higher crude protein, crude fibre, crude fat, mineral matter, nitrogen free extract and total digestible nutrient production over 70 and 90 kg N ha^{-1} whereas, crude fibre production did not influence by nitrogen levels at first cutting. Application of 110 kg N ha^{-1} resulted in crude protein production 956.75 and 982.54 kg ha^{-1} crude fat production 151.78 and 153.46 kg ha^{-1} mineral matter production 647.58 and 639.62 kg ha^{-1}; nitrogen free extract production 4451.71 and 4465.44 kg ha^{-1} total digestible nutrient production 6277.45 and 6315.02 kg ha^{-1} nitrogen production 153.08 and 157.21 kg ha^{-1} at first and second cuttings, respectively. The results of present study showed that the irrigation and nitrogen caused significant variation in production of quality parameters (Table 2). The significant variation in production of quality parameters might be due to the fact that production is primarily a function of total biomass production (dry fodder yield) and their respective contents. Therefore, higher biomass production of fodder was recorded under five irrigation and 90 and 110 kg N ha^{-1} treatments, ultimately resulted in higher quality nutrients production of fodder in respective treatments. Similar finding was reported by Amandeep *et al.* (2010) [2], Bhilare and Joshi (2007) [3], Rana *et al.* (2013) [14] and Malik *et al.* (2015) [12].

Table 1: Effect of irrigation schedules and nitrogen fertilization on growth and total fodder yield of oat

Treatments	Plant height (cm)		Dry Matter Accumulation (g 0.5 m^{-1})		Number of tillers m^{-1} row length		Total fodder yield (t ha^{-1})	
	30 DAS	90 DAS	30 DAS	90 DAS	60 DAS	120 DAS	Green	Dry
Irrigation levels								
Two	26.5	45.0	26.4	27.5	131.6	142.4	34.81	14.31
Three	26.9	52.7	26.9	29.9	155.9	172.2	50.41	16.68
Four	26.8	58.0	26.5	34.2	156.4	187.9	55.20	18.12
Five	26.2	59.3	26.4	32.1	157.4	196.6	60.03	19.56
S.Em.±	1.0	1.8	1.0	1.2	5.1	6.3	1.40	4.14
C.D. (P=0.05)	NS	6.3	NS	4.1	17.6	21.8	4.83	1.43
Nitrogen levels (kg ha^{-1})								
70	24.0	49.9	24.3	27.7	131.2	157.6	45.89	15.73
90	26.6	54.4	26.9	31.1	154.2	175.0	50.69	17.44
110	29.9	56.9	28.5	34.1	165.6	191.7	53.77	18.33
S.Em.±	0.6	0.9	0.4	1.0	4.2	4.1	0.95	0.37
C.D. (P=0.05)	1.9	2.7	1.3	2.9	12.5	12.2	2.85	1.10

Table 2: Effect of irrigation schedules and nitrogen fertilization on quality parameters production of fodder oat (kg ha^{-1})

Treatments	1st cutting							2nd cutting						
	N	CP	CF	EE	MM	NFE	TDN	N	CP	CF	EE	MM	NFE	TDN
Irrigation levels														
Two	113.79	711.16	2187.92	115.83	487.89	3709.73	5235.86	119.51	746.92	2130.22	117.29	492.15	3611.55	5141.82
Three	148.32	927.00	2524.94	145.47	614.52	4213.59	6078.79	144.65	904.08	2442.66	139.92	594.01	4171.55	5960.29
Four	149.22	932.63	2459.29	145.98	619.14	4259.27	6069.61	149.05	931.55	2443.74	146.32	610.11	4319.35	6104.85
Five	150.38	939.88	2364.44	147.00	631.95	4321.77	6053.26	159.04	994.03	2525.52	158.95	658.41	4578.89	6431.23
S.Em.±	5.02	31.37	77.92	4.02	24.57	144.67	192.96	4.13	25.81	70.01	3.20	15.55	148.69	186.72
C.D. (P=0.05)	17.37	108.56	NS	13.91	85.01	NS	NS	14.29	89.33	242.25	11.08	53.80	514.55	646.14
Nitrogen levels (kg ha^{-1})														
70	123.66	772.86	2243.08	123.00	518.78	3748.12	5360.59	124.73	779.59	2212.12	124.54	521.27	3816.96	5398.02
90	144.54	903.40	2408.07	140.92	598.77	4178.44	5940.09	147.25	920.31	2434.93	143.85	605.13	4228.61	6015.60
110	153.08	956.75	2501.30	151.78	647.58	4451.71	6277.45	157.21	982.54	2509.55	153.46	639.62	4465.44	6315.02
S.Em.±	4.07	25.42	70.03	3.47	17.11	95.43	148.17	3.63	22.68	68.33	4.06	15.29	105.48	153.39
C.D.. (P=0.05)	12.19	76.21	NS	10.39	51.29	286.11	444.20	10.88	67.99	204.86	12.18	45.83	316.22	459.85

N-Nitrogen, CP–Crude protein, CF–Crude fibre, EE–Ether extract, MM–Mineral matter, NFE–Nitrogen free extract and TDN–Total digestible nutrient.

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