

## Fodder quality and nitrate estimation of oats grown under different nutrient management options

Dinesh Kumar, Magan Singh, Sanjeev Kumar, Rajesh Kumar Meena and Rakesh Kumar

Received: 09 April 2021 / Accepted: 15 April 2021 / Published online: 07 September 2021  
© Indian Dairy Association (India) 2021

**Abstract:** Fodder insufficiency and its poor-quality leads to lower productivity of Indian cattle. To improve productivity and quality of fodder oats, the present study was undertaken with residual effect of three maize cultivars ( $V_1$ : African Tall,  $V_2$ : J-1006;  $V_3$ : P-3396) on oats cv. Kent and four nutrient management options ( $N_0$ : Control;  $N_1$ : 100% RDF;  $N_2$ : 75% RDF + PGPR + Panchagavya;  $N_3$ : 50% RDF + 25% FYM + PGPR + Panchagavya) using Split Plot Design. Results showed that residual effect of maize cultivars did not cause significant variations on quality traits as well as economics of fodder oats. The use of 75% RDF + PGPR + Panchagavya ( $N_2$ ) showed significantly higher dry fodder, crude protein, ether extract and total ash yields and it followed by 50% RDF + 25% FYM + PGPR + Panchagavya ( $N_3$ ). The fibre fractions as well as nitrate concentrations were significantly lowered with the application of  $N_2$  and  $N_3$  options. The highest benefit in terms of net returns was also obtained with  $N_2$  option. Our results suggested that application of 75% RDF + PGPR + Panchagavya enhances the fodder quality, productivity, profitability and reduces the nitrate concentration in oats grown after maize besides replacing 25% chemical fertilizers.

**Keywords:** Fodder oats, Nitrate, Panchagavya, Profitability, Quality

### Introduction

Livestock is the main source of livelihood for a majority of the rural population. But, the productivity of Indian cattle is lower than global average (Anonymous 2020a), apart from largest milk producer in world (Anonymous 2020b). Fodder insufficiency and its poor-quality leads to lower productivity of Indian cattle. At present, India faces a net deficit of 30.7% dry fodder and this value will be around 24.6 and 18.4% during 2030 and 2050, respectively (Anonymous 2020a). Fodder quality which is the potential of any fodder to produce a desired animal response, also as much important as fodder production because about 80-90% of nutrients requirements of livestock are met from the fodder crops. Both fodder availability and quality influences livestock performance *viz.* growth rates, milk production and body condition (Singh et al. 2012). Further, the performance of animals and economics of milk production is heavily dependent on the quantity of nutritious forage fed to milch animals. Therefore, the production of nutritious fodder needs to be enhanced. Increment in land area may not be possible due to human pressure for food crops and more probably cereal-cereal system dominated in NW-Indo Gangetic Plain regions due to higher net returns; therefore, the increment in fodder productivity is the way to meet the present as well as future needs of nutritious fodder. Cereal crops are well known for higher productivity in terms of green biomass. In India, oats (*Avena sativa* L.) is one of the most popular cereal fodders of *Rabi* season which is sown in North, Central and Western zone. Its fodder is a good source of protein, fibre and minerals. It is widely grown for green fodder because of its luxuriant growth, good palatability, highly nutritious nature and rich in soluble carbohydrates. It is relished by all animals owing to its higher palatability and softness than wheat and barley (Hameed et al. 2014).

Being cereal, the nutrient management in oats is an important aspect under Indian soil. In NW-Indo Gangetic Plains of India where intensive cereal – cereal cropping system dominates; the shrewd use of organic and inorganic nutrient sources is necessitated for sustainable fodder production. Indiscriminate

---

Agronomy Section, ICAR-National Dairy Research Institute, Karnal – 132 001, Haryana, India

Magan Singh (✉)  
Agronomy Section, ICAR-National Dairy Research Institute, Karnal – 132001, Haryana, India  
Email: [magansingh07@gmail.com](mailto:magansingh07@gmail.com)

and continual application of higher dose of chemical fertilizers creates harmful effect and use of only organic sources may not be sufficient to meet the nutrient requirements for cereals. Hence, the integrated use of organic and inorganic nutrient sources may be a better approach for sustainable fodder production under Indian condition. Inclusion of organic nutrient sources significantly increases the crop productivity (Bandyopadhyay et al. 2010). Plant growth-promoting rhizobacteria (PGPR) colonizes the plant roots and augments the growth (Beneduzi et al. 2012) and improves the crop yields by regulating hormonal and nutritional balance in soil (Vejan et al. 2016). Panchagavya which is made up of five cow byproducts along with certain other ingredients, has capacity to promote the plant growth and provide immunity in the plant systems. In view of above facts, we prepared a nutrient source (Panchagavya), integrated it with reduced dose of chemical fertilizers along with other nutrient sources (FYM, PGPR) and undertaken the present study.

## Materials and Methods

### Location description

The experiment was carried out during *Rabi* season of 2018-19 and 2019-20 at Research Farm of Agronomy Section, ICAR – National Dairy Research Institute, Karnal, Haryana (India). Karnal falls under Indo-Gangetic plains of NW India which is located at an elevation of 245 meters above mean sea level with a latitude of 29°43' North and longitude of 76°58' East. The soil of the experimental field was near neutral to slightly alkaline having 7.61 pH and 0.312 dS m<sup>-1</sup> electrical conductivity. Organic carbon, available N, P and K content of soil were 0.63%, 192.4, 29.71 and 195.7 kg ha<sup>-1</sup>, respectively. The climate of this region was semi-arid and annual rainfall varies from 690-720 mm. The weather conditions during both years of experimentation were congenial to oats growth (supplementary file).

### Experimental treatments and crop management

The experiment was laid out in split plot design with three replications. In main plot, residual effect of maize cultivars on oats (V<sub>1</sub>: African Tall; V<sub>2</sub>: J-1006; V<sub>3</sub>: P-3396) and in sub-plot, four nutrient management options (N<sub>0</sub>: Control; N<sub>1</sub>: 100% RDF; N<sub>2</sub>: 75% RDF + PGPR + Panchagavya spray; N<sub>3</sub>: 50% RDF + 25% FYM + PGPR + Panchagavya spray) were taken. Recommended dose of well decomposed FYM (Table 1) was applied @ 10.0 t ha<sup>-1</sup> at the time of sowing (as respective per treatment). Urea, single super phosphate and muriate of potash were used to supply the recommended dose of N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O (120, 40 and 40 kg ha<sup>-1</sup>). One third of N and full dose of P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O was applied as basal and remaining two third of N was applied in two equal amounts at 32 DAS and three days after first cut. Panchagavya was prepared using five by products of cow along with some other ingredients (Table 1) and applied at 25, 40 and 85 DAS through foliar spray. Seed rate of oats cv. Kent @ 80 kg ha<sup>-1</sup> was taken and

treated with Bavistin 50% WP @ 2 g a.i. kg<sup>-1</sup> seeds followed by PGPR (as per treatment) @ 120 ml ha<sup>-1</sup> seeds. After shade drying around half an hour, the seeds were sown using *Pora* method.

### Fodder sample collection and their quality analyses

Green fodder samples collected at first and second cut were dried in hot air oven at 65±5°C till constant weight attained. The loss in moisture content after drying was estimated and dry fodder yield was calculated. The dried samples were grounded (Wiley mill) to pass through one mm screen for quality analysis. Crude protein (CP), ether extract (EE) and total ash (TA) yields were calculated by multiplying their content (AOAC 2005) with dry fodder yield. The fibre fraction such as neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were estimated using Van Soest et al. (1991) method. Nitrate (NO<sub>3</sub>) concentration in fodder oats were determined spectrophotometrically using the powder mixture (Bray's indicator) as described by Woolley et al. (1960).

### Economic analyses

Economics for different treatments were worked out by taking into account the cost of inputs, operations and price of output prevailed at the time of experimentation (supplementary file). The prevailing price of the inputs and operations was taken into consideration for calculating the cost of cultivation, green fodder yield and its price for gross returns and differences between gross returns and cost of cultivation for net returns which were expressed in terms of Indian rupee per ha (INR ha<sup>-1</sup>). The returns per rupee invested (RPRI) and economic efficiency were computed using following equations:

$$\text{RPRI} = \frac{\text{Gross returns (INR ha}^{-1}\text{)}}{\text{Cost of cultivation (INR ha}^{-1}\text{)}}$$

$$\text{Economic efficiency (INR ha}^{-1}\text{ day}^{-1}\text{)} = \frac{\text{Gross returns (INR ha}^{-1}\text{)}}{\text{Crop duration (days)}}$$

### Statistical data analysis

Experimental data were analyzed with the help of analysis of variance technique for split plot design using statistical analysis system (SAS) software at ICAR-Indian Agricultural Statistics Research Institute (IASRI) server. Significance among treatments mean differences for various parameters were analyzed by least significant differences (LSD) at 0.05 probability level. Pearson correlation (two tailed) were determined using SPSS software and significance of differences between means were determined at  $P=0.05$  and  $0.01$ .

## Results and Discussion

### Fodder productivity

Results revealed that residual effect of maize cultivars did not cause significant variations on dry fodder yield (DFY) of oats (Table 2). Though, nutrient management options brought significant effect on DFY. Significantly highest DFY at first cut, second cut and their total were recorded with application of 75%

RDF + PGPR + Panchagavya spray (N<sub>2</sub>) compared amongst all nutrient management options. However, at second cut, the N<sub>2</sub> remained at par with N<sub>3</sub> option.

In present study, different maize cultivars were failed to exert significant residual effects on yield, quality traits and economics of oats which may be due to alike rhizosphere conditions under all the three maize cultivars *fb* oats (Table 2 to 3 and Figure 1 to 2). Nutrient management options caused significantly positive

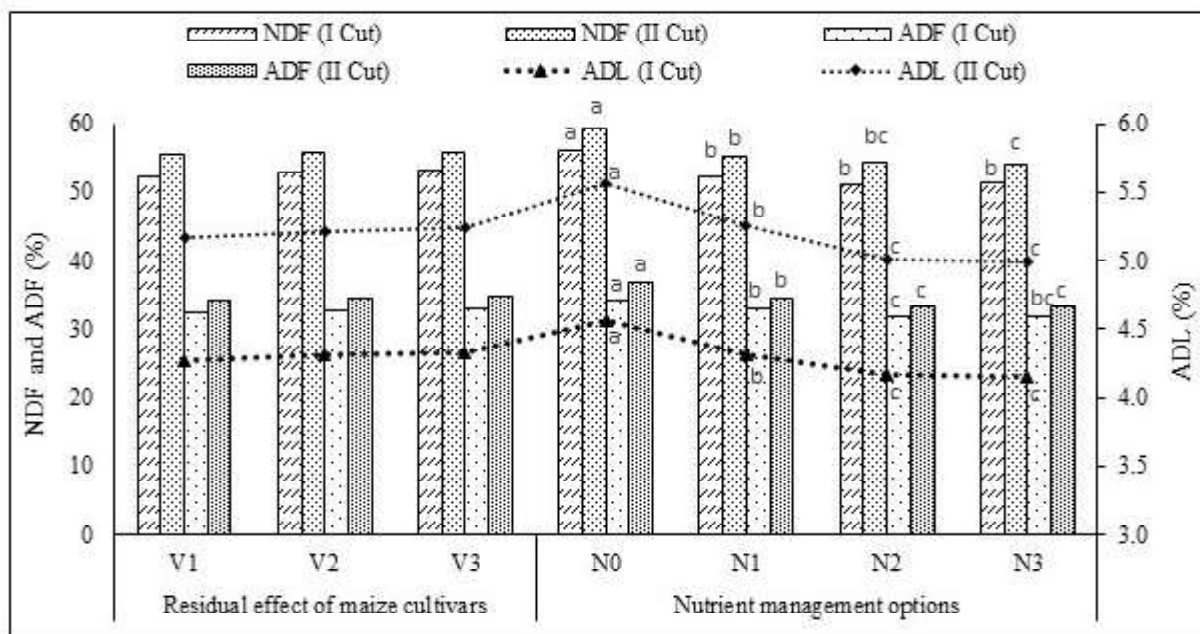
**Table 1** Characteristics of FYM and Panchagavya used for experimentation during 2018-19 and 2019-20

Parameters	FYM		Panchagavya	
	2018-19	2019-20	2018-19	2019-20
pH <sub>1:5</sub>	8.25 ± 0.01	8.31 ± 0.01	4.35 ± 0.04	4.28 ± 0.05
EC <sub>1:5</sub> (dS m <sup>-1</sup> )	3.40 ± 0.08	3.36 ± 0.12	6.14 ± 0.06	6.21 ± 0.05
Oxidizable OC (%)	11.25 ± 0.09	11.72 ± 0.07	–	–
Total carbon (%)	20.78 ± 0.28	20.85 ± 0.19	–	–
Total N (%)	0.62 ± 0.07	0.69 ± 0.08	0.64 ± 0.01	0.65 ± 0.02
Total P (%)	0.45 ± 0.01	0.46 ± 0.02	0.10 ± 0.01	0.10 ± 0.01
Total K (%)	0.82 ± 0.02	0.85 ± 0.03	0.47 ± 0.03	0.46 ± 0.02
Ca (g kg <sup>-1</sup> )	27.35 ± 0.15	27.57 ± 0.13	121 ± 4.85	127 ± 5.95
Mg (g kg <sup>-1</sup> )	11.79 ± 0.34	12.02 ± 0.42	42 ± 2.54	45 ± 2.35
Fe (g kg <sup>-1</sup> )	3.21 ± 0.02	3.28 ± 0.03	8.75 ± 0.12	8.83 ± 0.10
Zn (mg kg <sup>-1</sup> )	205.3 ± 8.34	221.4 ± 10.24	1.05 ± 0.02	1.04 ± 0.01
Mn (mg kg <sup>-1</sup> )	323.0 ± 6.05	332.7 ± 6.38	1.48 ± 0.02	1.52 ± 0.04
Cu (mg kg <sup>-1</sup> )	52.6 ± 1.35	57.3 ± 1.51	0.62 ± 0.01	0.59 ± 0.01
Total Bacteria (×10 <sup>5</sup> CFU ml <sup>-1</sup> )	–	–	38.2 ± 1.45	40.6 ± 2.18
Total Fungi (×10 <sup>3</sup> CFU ml <sup>-1</sup> )	–	–	25.6 ± 1.52	26.8 ± 1.05
Total Actinomycetes (×10 <sup>2</sup> CFU ml <sup>-1</sup> )	–	–	18.8 ± 1.12	19.0 ± 1.39
Azotobacter (×10 <sup>2</sup> CFU ml <sup>-1</sup> )	–	–	7.0 ± 0.65	7.4 ± 0.42
P solubilizers (×10 <sup>2</sup> CFU ml <sup>-1</sup> )	–	–	8.2 ± 0.38	8.0 ± 0.56

**Table 2** Dry fodder, crude protein, ether extract and total ash yields of oats as influenced by residual effect of maize cultivars and nutrient management options (mean of two years)

Treatments	Dry fodder yield (t ha <sup>-1</sup> )			Crude protein yield (q ha <sup>-1</sup> )			Ether extract yield (q ha <sup>-1</sup> )			Total ash yield (q ha <sup>-1</sup> )		
	I Cut	II Cut	Total	I Cut	II Cut	Total	I Cut	II Cut	Total	I Cut	II Cut	Total
Residual effect of maize cultivars on oats cv. Kent												
African Tall	5.59	3.90	9.49	6.72	4.20	10.92	1.70 <sup>A</sup>	1.09	2.78	5.30	3.36	8.66
J-1006	5.32	3.67	8.99	6.35	3.95	10.31	1.61 <sup>B</sup>	1.03	2.63	5.03	3.14	8.17
P-3396	5.28	3.66	8.94	6.09	3.77	9.86	1.54 <sup>B</sup>	0.99	2.53	4.91	3.08	7.99
SEd(±)	0.20	0.17	0.34	0.35	0.22	0.50	0.03	0.05	0.07	0.15	0.17	0.26
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	0.08	NS	NS	NS	NS	NS
Nutrient management options												
N <sub>0</sub>	3.73 <sup>C</sup>	2.73 <sup>C</sup>	6.45 <sup>C</sup>	4.03 <sup>C</sup>	2.64 <sup>C</sup>	6.67 <sup>D</sup>	1.02 <sup>D</sup>	0.69 <sup>C</sup>	1.71 <sup>D</sup>	3.18 <sup>C</sup>	2.09 <sup>C</sup>	5.28 <sup>D</sup>
N <sub>1</sub>	5.81 <sup>B</sup>	3.89 <sup>B</sup>	9.70 <sup>B</sup>	6.77 <sup>B</sup>	4.11 <sup>B</sup>	10.88 <sup>C</sup>	1.70 <sup>C</sup>	1.05 <sup>B</sup>	2.75 <sup>C</sup>	5.46 <sup>B</sup>	3.31 <sup>B</sup>	8.77 <sup>C</sup>
N <sub>2</sub>	6.22 <sup>A</sup>	4.26 <sup>A</sup>	10.48 <sup>A</sup>	7.69 <sup>A</sup>	4.71 <sup>A</sup>	12.40 <sup>A</sup>	1.94 <sup>A</sup>	1.23 <sup>A</sup>	3.16 <sup>A</sup>	6.05 <sup>A</sup>	3.77 <sup>A</sup>	9.82 <sup>A</sup>
N <sub>3</sub>	5.83 <sup>B</sup>	4.09 <sup>AB</sup>	9.92 <sup>B</sup>	7.06 <sup>B</sup>	4.44 <sup>A</sup>	11.50 <sup>B</sup>	1.80 <sup>B</sup>	1.17 <sup>A</sup>	2.98 <sup>B</sup>	5.63 <sup>B</sup>	3.60 <sup>A</sup>	9.23 <sup>B</sup>
SEd(±)	0.17	0.12	0.19	0.20	0.13	0.21	0.05	0.04	0.05	0.17	0.12	0.19
LSD (P=0.05)	0.36	0.25	0.39	0.41	0.27	0.44	0.10	0.08	0.11	0.36	0.25	0.40

**Note:** N<sub>0</sub>: Control; N<sub>1</sub>: 100% RDF; N<sub>2</sub>: 75% RDF + PGPR + Panchagavya spray; N<sub>3</sub>: 50% RDF + 25% FYM + PGPR + Panchagavya spray; Same letter within each column indicate non-significant difference among the treatments using LSD test (P<0.05).



**Fig 1.** Residual effect of maize cultivars and nutrient management options on fibre fractions of fodder oats (mean of two years)

**Note:** V<sub>1</sub>: African Tall; V<sub>2</sub>: J-1006; V<sub>3</sub>: P-3396; N<sub>0</sub>: Control; N<sub>1</sub>: 100% RDF; N<sub>2</sub>: 75% RDF + PGPR + Panchagavya spray; N<sub>3</sub>: 50% RDF + 25% FYM + PGPR + Panchagavya spray; NDF: Neutral detergent fibre; ADF: Acid detergent fibre; ADL: Acid detergent lignin; Vertical bars/ lines labelled with different lower-case letters shows significant variations among nutrient management options using LSD ( $P=0.05$ ).

influence on first, second cut and total DFY over control (Table 2). Significantly higher DFY with 75% RDF + PGPR + Panchagavya might be associated with increased green fodder yield (GFY) and DM content, thus DFY. PGPR activates certain growth promoting enzymes which might have played vital role in boosting green fodder yield (Saleem et al. 2015). Further, the higher NPK fertilization either from chemical fertilizers or panchagavya enhanced the chlorophyll content which leads to increased photosynthates, protoplasmic constituents and accelerated cell division and elongation which ultimately resulted into luxuriant vegetative growth as well as GFY. Higher GFY and their content led to increased DFY. Similar results in dry forage yield of oats due to integrated use of organic and inorganic sources of nutrients were also reported by Bilal et al. (2017).

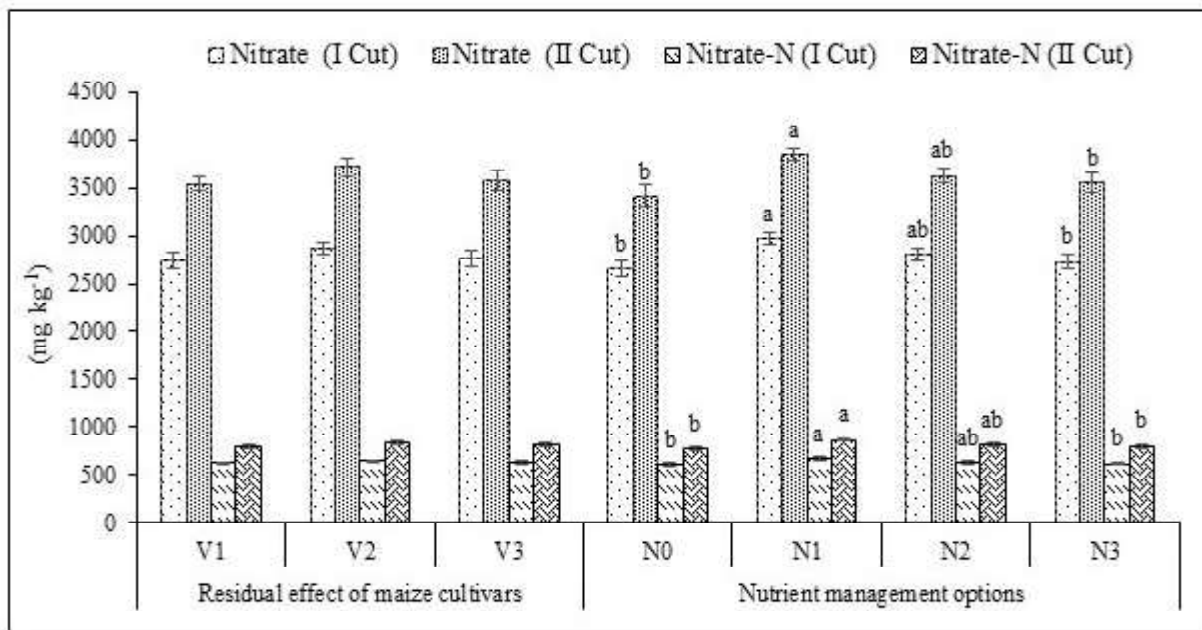
#### Crude protein, ether extract and total ash yield

Data presented in Table 2 indicated that residual effect of maize cultivars did not exert any significant effect on crude protein (CP) ether extract (EE) and total ash (TA) yield of oats. With respect to nutrient management options, the significant variations were observed on all the quality parameters at first cut, second cut as well as their total. At first cut, the use of N<sub>2</sub> option recorded significantly higher CP yield compared to rest of nutrient management options. While at second cut, application of N<sub>2</sub> and N<sub>3</sub> options showed significantly higher CP yield compared to N<sub>0</sub>

and N<sub>1</sub>. In case of total CP yield, the use of N<sub>2</sub> nutrient management option showed superiority over N<sub>0</sub>, N<sub>1</sub> and N<sub>3</sub>. Similarly, the application of N<sub>2</sub> option resulted in considerably higher EE yield at first cut as well as total of both cuts compared to remaining treatments. While at second cut, the use of N<sub>2</sub> and N<sub>3</sub> options recorded significantly higher EE yield compared to N<sub>0</sub> and N<sub>1</sub>. Alike CP and EE yields, significantly higher TA yield at first cut was noted under N<sub>2</sub> option amongst all. While at second cut, the use of N<sub>2</sub> and N<sub>3</sub> options recorded significantly highest TA yield compared to N<sub>0</sub> and N<sub>1</sub>. In case of total TA yield, the use of N<sub>2</sub> produced significantly higher yield compared to remaining treatments.

#### Fibre fractions

Data (Figure 1) indicated that residual effect of maize cultivars did not show significant differences on fibre fractions viz. NDF, ADF and ADL content of oats. Though, nutrient management options caused significant variations on fibre fractions. At first cut, the nutrient applied treatments (N<sub>1</sub>, N<sub>2</sub> and N<sub>3</sub>) showed significant reductions in fibre fractions compared to control and the lowest values were noted under N<sub>2</sub> option. While at second cut, the application of N<sub>2</sub> and N<sub>3</sub> options showed remarkably lower values of fibre fraction compared to control and N<sub>1</sub>.



**Fig 2.** Residual effect of maize cultivars and nutrient management options on nitrate and nitrate-N content of fodder oats (mean of two years)

**Note:** V<sub>1</sub>: African Tall; V<sub>2</sub>: J-1006; V<sub>3</sub>: P-3396; N<sub>0</sub>: Control; N<sub>1</sub>: 100% RDF; N<sub>2</sub>: 75% RDF + PGPR + Panchagavya spray; N<sub>3</sub>: 50% RDF + 25% FYM + PGPR + Panchagavya spray; Vertical bars labelled with different lower-case letters shows significant variations among nutrient management options using LSD (*P*=0.05); Capped lines indicate the standard error of mean.

The better quality of fodder is vital for milk production, because the higher supply of crude protein and other nutrients from nutritious fodder to the small intestine and thus, improves the overall N balance of the livestock (Sarabia-Salgado et al. 2020). The deficit of nutritious feeds/ fodder availability causes the poor animal health and thus, lower dairy production (Hernández-Castellano et al. 2019). In the present experiment, the combined use of organic and inorganic nutrient sources appreciably enhanced the qualitative characters of fodder oats i.e. higher CPY, EEY and TAY; and lower NDF, ADF, ADL, nitrate concentration (Table 2 and Figure 1). Apart from essential plant nutrient, the nitrogen is an indispensable content of amino acids which is a basic unit of proteins. Addition of organic nutrient sources to soil (FYM and PGPR) along with reduced dose of chemical fertilizers could have provided essential nutrients to crop throughout growing period, hence crops remained free from nutrient stress and also sufficient nutrient supply accelerated the protein synthesis from carbohydrates and reduced the rate of lignification, thereby maintaining the fodder quality. Saleem et al. (2015) also reported the significant improvement in DM, CP, fat and TA content of fodder oats due to seed inoculation with biofertilizer. In addition to this, the foliar application of panchagavya enhanced the quality characters of fodder oats because it contains considerable amounts of N and other essential plant nutrients which could have helped in succulent growth, thus lower fibre fractions. The higher CPY, EEY and TAY was ascribed to higher DFY and their content. Moreover, the higher

CPY, EEY and TAY under integrated nutrient management plots might be also due to the fact that it imparted the succulence to green fodder by reducing both the ADF and NDF content. Similar results were also reported by Kaur and Goyal (2017).

### Nitrate concentration

Results (Figure 2) indicated that different maize cultivars failed to exert their residual effect on nitrate and nitrate-N concentration of oats. While nutrient management options showed significant influences on these attributes. Control (N<sub>0</sub>) plot showed significantly lowest nitrate and nitrate-N concentration compared to plot receiving 100% RDF (N<sub>1</sub>). Among nutrient applied treatments (N<sub>1</sub>, N<sub>2</sub> and N<sub>3</sub>), the reduction/ replacement of 50% RDF through organic nutrient sources (N<sub>3</sub>) showed significantly lower nitrate content compared to N<sub>1</sub>, though it remained at par with N<sub>2</sub>. The replacement/ reduction of 25% RDF through organic nutrient sources also indicated numerically lower nitrate content over N<sub>1</sub>.

Nitrate (NO<sub>3</sub>) is the anti-quality factors of fodder crops if it exceeds the permissible limit. It is generally higher in oats as compared to other fodder crops. In our experiment (Figure 2), the nitrate and nitrate-N concentration in fodder oats was however, below the toxic level in all the treatments and safe for animal feeding. The higher nitrate content with 100% RDF through chemical fertilizer might be due to the fact that rate of nitrate conversion into protein

**Table 3** Economic analysis of fodder oats as influenced by residual effect of maize cultivars and nutrient management options (mean of two years)

Treatments	Cost of cultivation (INR ha <sup>-1</sup> )	Gross returns (INR ha <sup>-1</sup> )	Net returns (INR ha <sup>-1</sup> )	Returns per rupee invested	Economic efficiency (INR ha <sup>-1</sup> day <sup>-1</sup> )
Residual effect of maize cultivars on oats cv. Kent					
African Tall	35979	85933	49953	2.38	725
J-1006	35979	81798	45818	2.26	690
P-3396	35979	83166	47186	2.30	702
SEd(±)	–	3108	3108	0.06	19
LSD ( <i>P</i> =0.05)	–	NS	NS	NS	NS
Nutrient management options					
N <sub>0</sub>	30631	60924 <sup>C</sup>	30293 <sup>D</sup>	1.99 <sup>C</sup>	514 <sup>C</sup>
N <sub>1</sub>	35657	89036 <sup>B</sup>	53379 <sup>B</sup>	2.50 <sup>A</sup>	751 <sup>B</sup>
N <sub>2</sub>	37756	94667 <sup>A</sup>	56911 <sup>A</sup>	2.51 <sup>A</sup>	799 <sup>A</sup>
N <sub>3</sub>	39874	89902 <sup>B</sup>	50028 <sup>C</sup>	2.25 <sup>B</sup>	759 <sup>B</sup>
SEd(±)	–	1385	1385	0.03	8
LSD ( <i>P</i> =0.05)	–	2910	2910	0.08	25

**Note:** N<sub>0</sub>: Control; N<sub>1</sub>: 100% RDF; N<sub>2</sub>: 75% RDF + PGPR + Panchagavya spray; N<sub>3</sub>: 50% RDF + 25% FYM + PGPR + Panchagavya spray; INR: Indian rupee; Same letter within each column indicate non-significant difference among the treatments using LSD test (*P*<0.05).

**Table 4** Correlation matrix for different quality parameters and dry fodder yield of oats

	DFY	CPY	EEY	TAY	NDF	ADF	ADL	Nitrate
DFY	1	0.989**	0.979**	0.993**	-0.838**	-0.743**	-0.845**	-0.464**
CPY		1	0.987**	0.982**	-0.826**	-0.735**	-0.849**	-0.489**
EEY			1	0.991**	-0.852**	-0.745**	-0.856**	-0.472**
TAY				1	-0.853**	-0.731**	-0.853**	-0.484**
NDF					1	0.676**	0.754**	0.295*
ADF						1	0.683**	0.255*
ADL							1	0.690**
Nitrate								1

**Note:** DFY: Dry fodder yield; CPY: Crude protein yield; EEY: Ether extract yield; TAY: Total ash yield; NDF: Neutral detergent fibre; ADF: Acid detergent fibre; ADL: Acid detergent lignin; \**P*<0.05, \*\**P*<0.01 were significant levels for Pearson Correlation (two tailed).

was slower than its uptake rate which led to nitrate accumulation in foliage. Similar results were also reported by Kalra and Sharma (2015) in fodder maize. Integrated use of organic and inorganic nutrient sources releases N slowly and continuously resulted in its proper utilization and conversion into protein, thereby lower nitrate accumulation in foliage. Nitrate content in fodder crops is increased with increasing rate of N fertilizer (Holman et al. 2019).

### Economics

The various economic indices i.e. gross returns, net returns, return per rupee invested (RPRI) and economic efficiency were not differed significantly due to residual effect of maize cultivars (Table 3). Lowest cost of cultivation was incurred under control plot and it increases with increasing proportion of organic nutrient sources. Significantly highest gross returns, net returns and economic efficiency were obtained with N<sub>2</sub> amongst all treatments.

While, the maximum RPRI was noted with N<sub>2</sub> and N<sub>1</sub> options compared with remaining treatments.

With regard to milk production of Indian livestock, the feed/ fodders accounted for around 70% of the total cost (Ghule et al. 2012). Chand et al. (2017) also reported that feed cost accounted for major portion of variable cost and it was ranged from 57% for local cattle to 64% for buffalo. Henceforth, economic analysis for fodder production has paramount importance. The maximum gross and net returns under N<sub>2</sub> plot were due to its higher green fodder yield (Table 3). Further, the higher RPRI under N<sub>2</sub> and N<sub>1</sub> options was owing to their low CoC and higher gross returns resulting from higher green fodder yield. Chahal et al. (2021) also reported the better economics of oats under plots receiving FYM @10 t ha<sup>-1</sup> along with Azotobacter and PSB than control. Hossain et al. (2017) also reported the significance of green fodder for

lactating buffaloes as it was found more economical than feeding only concentrate.

### Correlation studies

Correlation studies (Table 4) indicated that the relationship between DFY vs. CP yield ( $r=0.989$ ), EE yield ( $r=0.979$ ) and TA yield ( $r=0.993$ ) was strongly positive; vs. NDF ( $r=-0.838$ ), ADF ( $r=-0.743$ ) and ADL ( $r=-0.845$ ) was strongly negative; vs. nitrate ( $r=-0.464$ ) was moderately negative at  $P<0.01$ . Correlation between nitrates vs. NDF ( $r=0.295$ ) and NDF ( $r=0.255$ ) was weak and positive at  $P<0.05$  and vs. ADL ( $r=0.690$ ) was strong and positive at  $P<0.01$ .

### Conclusions

Results indicated that application of 75% RDF + PGPR + Panchagavya spray enhances the fodder quality, productivity, profitability and reduces the nitrate concentration in oats grown after maize besides replacing 25% chemical fertilizers.

### Acknowledgements

Authors are thankful to Director, ICAR-National Dairy Research Institute, Karnal (India) for providing necessary assistance and financial support throughout course of this study. Authors also thank to ICAR-Indian Agricultural Statistical Research Institute, New Delhi (India) to provide access for analyzing data at SAS software.

### References

Anonymous (2020a) Vision 2050. ICAR – Indian Grassland and Fodder Research Institute, Jhansi, India. pp. 4-8

Anonymous (2020b) Basic Animal Husbandry Statistics – 2019. Department of Animal Husbandry and Dairying, Ministry of Fisheries, Animal Husbandry and Dairying, Government of India. p. 5

AOAC (2005) Official Methods of Analysis. (18<sup>th</sup> Edn.), Association of Official Analytical Chemists. Arlington, Virginia, USA, pp 684

Bandyopadhyay KK, Misra AK, Ghosh PK, Hati KM (2010) Effect of integrated use of farmyard manure and chemical fertilizers on soil physical properties and productivity of soybean. *Soil Till Res* 110: 115-125

Beneduzi A, Ambrosini A, Passaglia LMP (2012) Plant growth-promoting rhizobacteria (PGPR): Their potential as antagonists and biocontrol agents. *Genet Mol Biol* 35: 1044-1051

Bilal M, Ayub M, Tariq M, Tahir M, Nadeem MA (2017) Dry matter yield and forage quality traits of oat (*Avena sativa* L.) under integrative use of microbial and synthetic source of nitrogen. *J Saudi Soc Agric Sci* 16: 236-241

Chahal A, Sharma GD, Kumar N, Sankhya, NK, Katoch R, Rana MC, Chandel RS (2021) Impact of different nutrient sources on forage yield, nutritive value and economics of sorghum sudan grass hybrid-oat cropping system. *J Plant Nutr* 44: 1223-1240

Chand P, Sirohi S, Mishra A, Chahal VP (2017) Estimation of costs and returns from dairying in Malwa region of Madhya Pradesh. *Indian J Anim Sci* 87: 381-386.

Ghule AK, Verma NK, Cahuhan AK, Sawale P (2012) An economic analysis of investment pattern, cost of milk production and production and profitability of commercial dairy farms in Maharashtra. *Indian J Dairy Sci* 65: 329-336

Hameed S, Ayub M, Tahir M, Khan S, Bilal M, (2014) Forage yield and quality response of oat (*Avena sativa* L.) cultivars to different sowing techniques. *Int J Mod Agric* 3: 25-33

Hernández-Castellano LE, Nally JE, Lindahl J, Wanapat M, Alhidary IA, Fanguero D, Grace D, Ratto M, Bambou JC, de Almeida AM (2019) Dairy science and health in the tropics: challenges and opportunities for the next decades. *Trop Anim Health Prod* 51: 1009-1017

Holman JD, Obour AK, Mengel DB (2019) Nitrogen application effects on forage sorghum production and nitrate concentration. *J Plant Nutr* 42: 2794-2804

Hossain SA, Sherasia PL, Phondba BT, Pathan FK, Garg MR (2017) Effect of feeding green fodder based diet in lactating buffaloes: Milk production, economics and methane emission. *Indian J Dairy Sci* 70: 767-773

Kalra VP, Sharma PK (2015) Quality of fodder maize in relation to farmyard manure and nitrogen levels. *Forage Res* 41: 63-67

Kaur G, Goyal M (2017) Effect of growth stages and fertility levels on growth, yield and quality of fodder oats (*Avena sativa* L.). *J Appl Nat Sci* 9: 1287-96

Saleem M, Zamir MSI, Haq I, Irshad MZ, Khan MK, Asim M, Zaman Q, Ali I, Khan A, Rehman S (2015) Yield and quality of forage oat (*Avena sativa* L.) cultivars as affected by seed inoculation with nitrogenous strains. *Am J Plant Sci* 6: 3251-3259

Sarabia-Salgado L, Solorio-Sánchez F, Ramírez-Avilés L, Alves BJR, Ku-Vera J, Aguilar-Pérez C, Urquiaga S, Boddey RM (2020) Increase in milk yield from cows through improvement of forage production using the N<sub>2</sub>-fixing legume *Leucaena leucocephala* in a silvopastoral system. *Animal* 10: 734

Singh KM, Meena MS, Kumar A (2012) An economic view to forage and fodder production in Eastern India. <http://dx.doi.org/10.2139/ssrn.2030697>

Van Soest PJ, Robertson JB, Lewis BA (1991) Methods for dietary fiber, neutral detergent fiber, and non starch polysaccharides in relation to animal nutrition. *J Dairy Sci* 74: 3583-3597

Vejan P, Abdullah R, Khadiran T, Ismail S, Boyce AN (2016) Role of plant growth promoting rhizobacteria in agricultural sustainability – A review. *Molecule* 21: 573-589

Woolley JT, Hicks GP, Hageman RH (1960) Plant analyses, rapid determination of nitrate and nitrite in plant material. *J Agric Food Chem* 8: 481-482