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RESEARCH ARTICLE

Nutritional value and energy balance of pearl millet fodder as influenced by different nutrient management practices

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Abstract: Fodder deficiency and its poor-quality leads to lower productivity of Indian cattle. To improve productivity and nutritional value of fodder pearl millet, the present study was undertaken during *kharif* season of 2019-20 at Agronomy research farm, ICAR-NDRI, Karnal, and laid out in Randomized Block Design with eight treatments, *viz*. $T_{1:}$ Absolute control; T_{2}: 100% RDF; T_{3}: 100% RDF + Cow urine foliar spray (CU); T_{4}: 100% RDF + PGPR; T_{5}: 100% RDF + PGPR + Cow urine foliar spray (CU); T_{6}: 75% RDF + Cow urine foliar spray (CU); T_{7}: 75% RDF + PGPR and T_{8}: 75% RDF + PGPR + Cow urine foliar spray (CU) with three replications. The results showed that the fodder nutritional value and digestibility *viz*., total digestible nutrients, digestible dry matter, digestible crude protein and dry matter intake increase by 28.46, 13.10, 40.26 and 8.45% respectively, with T_5 treatment than absolute control. The higher energy fraction such as digestible energy (11.54 MJ/Kg), metabolisable energy (9.47 MJ/Kg), digestible feed energy (9.27 MJ/Kg), net energy (3.07 MJ/Kg) and net energy for lactation (5.29 MJ/Kg) was observed with the application of 100% RDF+PGPR+CU (T_5), which was found statistically at par with applications of 100% RDF+PGPR and both were found significantly higher over rest of the treatments. Quality fodder strengthen and sustain the performance of livestock in terms of health and milk production.

Keywords: Energy, Fodder, Milk, Nutritional Value, Pearl millet

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Introduction

Gross Value Added (GVA) of livestock sector is about Rs. 11,14,249 crores at current prices during FY 2020-21 and it is about 30.87% of agricultural and allied sector, and 6.17% of total GVA (Anonymous 2022). India has 535.78 million livestock population, and it has increased by 4.63% (20^{th} livestock census) as compared to previous livestock census (Anonymous 2022). Green fodder is an essential component for livestock production, and ever-increasing livestock population has tremendous pressure on total available feed and fodder resources. Quality fodder can curtail the cost of feeding livestock because feeding contributes to about 65 to 70% of total cost of livestock farming (Kumar et al. 2023). Currently, India is facing a net deficit of green fodder by 35.6%, dry fodder (straw) by 10.95% and concentrates by 44% (Kushwaha et al. 2018). Deficiency of quality fodder and feed for livestock leads to decrease in their production level, and has an impact on their health, which ultimately influences return from livestock sector (Surve et al. 2011). Among the different fodder crops pearl millet (*Pennisetum glaucum*) is a gifted crop of the tropical and sub-tropical regions that provide food, fodder and stover (dry straw) to millions of families of poor farmer and their livestock. Nutrient management is an important aspect to achieve sustainable crop production. Scenario from green revolution era, shows that productivity of cereals increased largely with the use of high yielding variety, intensive agronomic practices and indiscriminate use of chemical fertilizers at higher rate with little or no use of organic source of nutrients to plant, that creates adverse effects on soil *viz.,* inadequacy in one or more nutrients and deterioration of soil fertility which leads to stagnating or even declining of crop productivity and quality (Shormy et al. 2013). Deficiency of nutrients in soils leads to the production of mineral deficient foods and fodder. However, animal and humans depending on such fodder and foods have also shown symptoms of nutrients deficiency (Shukla et al. 2015). Judicious use of inorganic and organic sources of nutrients may sustain and enhance the fodder quality.

Among different organic source of nutrients for plant, cow urine and Plant Growth Promoting *Rhizobacteria* (PGPR) are excellent and important for agriculture uses. Cow urine contains; nitrogen, phosphorus, potassium, sulphur, sodium, manganese, iron, carbolic acid, silicon, chlorine, enzymes and hormones (Saunders 1982). PGPR, is a consortium of bacteria that actively colonize around plant roots and enhances plant growth and yield (Wu et al. 2005). PGPR strains belongs to a wide range of genera *viz.*, *Pseudomonas, Azospirillum, Bacillus, Serratia* and *Azotobacter* (Bashan et al. 2004). The beneficial effects of PGPR are due to their ability to produce various organic compounds *viz.*, auxins, gibberellins, cytokinin, ethylene, organic acids, siderophores, nitrogen fixation, solubilization of insoluble inorganic soil phosphate to available form, sulphur oxidation, extra cellular production of antibiotics, increase in root permeability and enhancement of essential plant nutrients uptake (Enebak and Carey 2000 and Pal et al. 1999). Considering the above facts, the present study was executed to find out a suitable combination of nutrient source to enhance the fodder quality of pearl millet.

Materials and Methods

Description of experimental site

This study was conducted during *kharif* season of 2019-20 at Agronomy research farm, ICAR-NDRI, Karnal, Haryana, India, located at 29º45' North latitude and 76º58' East longitude and at an altitude of 245m above mean sea level. The area has a semi-arid climate, with a mean annual rainfall of 707 mm, and 70-80% of the rainfall is received during the months of July-September and rest during winter and spring seasons. The mean minimum and maximum temperature during study period was 20.49°C and 34.54°C, respectively. The soil of experimental site was clay loam in texture (Piper 1942) with pH of 7.35, Electrical conductivity of 0.37 dS/m (Jackson 1967), organic carbon of 0.49% (Walkley and Black's 1934), available nitrogen of 215 kg/ha (Subbiah and Asija 1956), available phosphorus of 24.70 kg/ha (Olsen et al. 1954), and available potassium of 285 kg/ha (Jackson 1967).

Treatment details and input application

The experiment was laid out in simple Randomized Block Design with eight treatments *viz.*, T_1: Absolute control; T_2: 100% Recommended dose of fertiliser (RDF); T_3: 100% RDF + Cow urine foliar spray (CU); T_4: 100% RDF + PGPR; T_5: 100% RDF + PGPR+ Cow urine foliar spray (CU); T_6: 75% RDF + Cow urine foliar spray (CU); T_7: 75% RDF + PGPR; T_8: 75% RDF + PGPR + Cow urine foliar spray (CU). Each treatment had three replications. The land preparation involved one deep ploughing each with disc plough, disc harrow and thereafter planking. As per treatments, recommended dose of fertilizers (80:30:30 kg/ha, N: P_2O_5: K_2O, respectively) were applied. The half of N and full doses of P_2O_5 and K_2O were applied before last ploughing operation during land preparation. The remaining half of the nitrogen was top-dressed as two doses 1st at 25 days after sowing (DAS) and 2nd at 40 DAS as per the treatment. Other package of practices was followed as per standard procedure for fodder pearl millet cultivation. The PGPR (100 ml/10kg seeds) liquid culture was diluted in water, and applied on seeds. Thereafter, inoculated seeds were dried in shade for 60-90 minutes, after drying seeds were manually sown. Nutrified variety of fodder pearl millet (*Pennisetum glaucum*) was sown using 10 kg seed per hectare with maintaining row to row spacing of 30 cm and plant to plant spacing of 10 cm. As per treatments, cow urine (10%) foliar spray was applied at 30 and 45 days after sowing.

Fodder sample collection and their quality analyses

The crop was harvested manually at 50 % flowering stage. Net plot area was harvested separately from each plot. Fresh chopped plant samples were collected and subjected to analysis of different quality parameters. The oven-dried fodder samples were ground to pass through 40 mesh sieves using a Macro-Wiley Mill, stored in air tight containers, and were used for chemical analysis. Fibre

Table 1 Estimation of data according to different standard equations

Particulars	Equation	References
TDN (%)	(-1.291 × ADF%) + 101.35	Horrocks and Vallentine (1999)
DDM (%)	88.9 – (0.779 × ADF%, dry matter basis)	Horrocks and Vallentine (1999)
DMI (% of body weight)	(120/NDF%, dry matter basis)	Horrocks and Vallentine (1999)
NE_1 (MJ kg^{-1})	(1.044 – (0.0119 × ADF%) × 2.205 × 4.184	Horrocks and Vallentine (1999)
RFV (%)	DDM% × DMI% × 0.775	Horrocks and Vallentine (1999)
RFQ	DMI% × TDN%/1.23	Undersander et al. (2002)
DE (MJ Kg^{-1})	0.27+ [0.0428 × DDM%] × 4.184	Fonnesbeck et al. (1984)
ME (MJ Kg^{-1})	DE (MJ Kg^{-1}) × 0.821	Gonzalez and Everitt (1982)
DCP (%)	(0.929 × CP%) – 3.52	Demarquilly and Weiss (1970)
DFE (MJ Kg^{-1})	[{TDN (%) × 4.4}/100] × 4.184	Bull (1981)
NE (MJ Kg^{-1})	[{(TDN % × 3.65)-100}/188.3] × 6.9	Riviere (1977)

Note: TDN: Total digestible nutrients; DDM: Digestible dry matter; DMI: Dry matter intake; NE_1: Net energy for lactation; NDF: Neutral detergent fibre; ADF: Acid detergent fibre; RFV: Relative feed value; RFQ: Relative feed quality; DE: Digestible energy; ME: Metabolizable energy; DCP: Digestible crude protein; DFE: Digestible feed energy and NE: Net energy.

$$\text{TDN yield (q/ha)} = \frac{\text{TDN content (\%)} \times \text{Dry matter yield (q/ha)}}{100}$$

fractions *viz.*, NDF and ADF were determined as per Van Soest et al. (1991). Another data was estimated according to following equations (Table 1):

Statistical data analysis

All data recorded were analysed with the help of analysis of variance (Gomez and Gomez 1984). Significance among treatments mean differences for various parameters were analysed by least significant differences (LSD) at 0.05 probability level.

Results and Discussion

Dry matter yield

Study indicated (fig. 1) that dry matter yield of fodder pearl millet was significantly influenced with different nutrient management practices and recorded significantly higher dry matter yield (113.35 q ha^{-1}) at harvest with T_5 treatment, which was found statistically at par with T_4 treatment 100% RDF+PGPR and both were significantly higher over rest of the treatments. Balanced and regular supply of essential plant nutrients, PGPR produce phytohormones (Enebak and Carey 2000) and cow urine supply enzyme and hormones (Saunders 1982) that attributed to stimulate plant physiological processes leads to increase leaf area index that responsible for higher interception of solar radiation and produce more photosynthates and nutrients acquired, resulted in to increase dry matter assimilation in different part of plant leads to increase dry matter yield. Further, higher biomass production and dry matter content attributed to increase dry matter yield. The similar results also reported by Chattha et al. (2017).

fibre fraction

The chemical analysis of fodder pearl millet showed that fibre fractions was significantly influenced with different nutrient management practices (fig. 1) and found decreasing trend of these parameters with increased fertility levels. Significantly lowest neutral detergent fibre (63.99%) and acid detergent fibre (39.50%) was observed with the application of 100% RDF+PGPR+CU. However, it remained at par with the treatment that received 100% RDF+PGPR and both were found significantly lower over rest of the treatments. Fibre fraction *viz.*, neutral detergent fibre (NDF) and acid detergent fibre (ADF) content recorded lowest with

Table 2 Effect of nutrient management practices on mean* nutritional value, digestibility, intake and relative feed value (RFV) of pearl millet fodder

Treatment	TDN%	TDN yield (q/ha)	DDM%	DMI%	RFV	DCP%
Absolute control	39.20	21.83	51.40	1.73	68.89	3.97
100% RDF	46.77	46.27	55.96	1.83	79.19	4.83
100% RDF + CU	46.99	47.16	56.10	1.83	79.56	5.00
100% RDF+PGPR	50.09	55.99	57.97	1.87	84.07	5.28
100% RDF+PGPR+CU	50.35	57.09	58.13	1.88	84.50	5.57
75% RDF+ CU	42.54	35.02	53.42	1.76	73.07	4.35
75% RDF+ PGPR	45.52	42.84	55.21	1.80	77.10	4.58
75% RDF+PGPR+CU	45.96	44.21	55.48	1.81	77.80	4.71
SEm (±)	0.53	1.24	0.32	0.01	0.90	0.11
CD (P=0.05)	1.59	3.77	0.96	0.04	2.74	0.33

Note: *Mean of three replications; PGPR: Plant growth promoting rhizobacteria; CU: Cow urine; RDF: Recommended dose of fertiliser; SEM: Standard error of mean and CD: Critical difference

Fig. 1 Effect of nutrient management practices on NDF, ADF content and dry matter yield of pearl millet

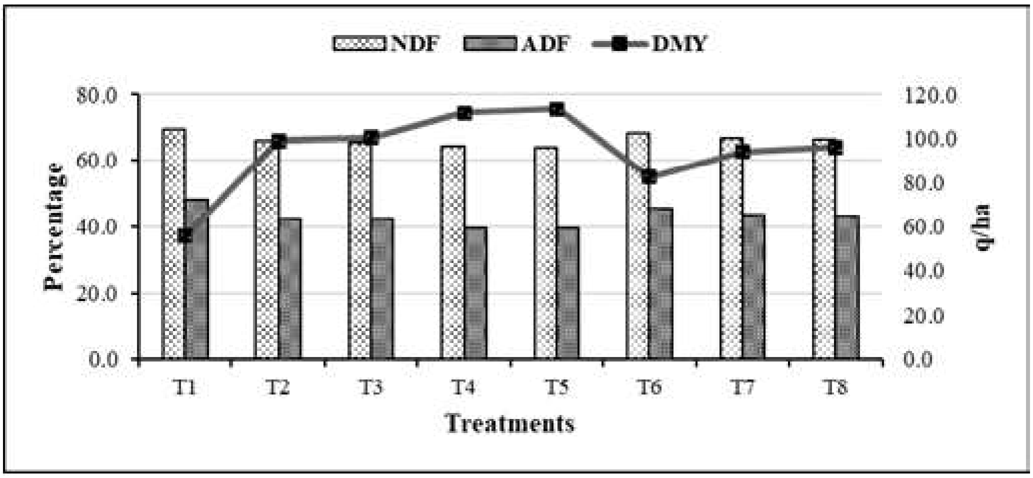

Table 3 Effect of nutrient management practices on mean* energy fraction and relative fodder quality (RFQ) of pearl millet fodder

Treatment	DE (MJ/Kg)	ME (MJ/Kg)	DFE (MJ/Kg)	NE (MJ/Kg)	NEL (MJ/Kg)	RFQ
Absolute control	10.33	8.48	7.22	1.58	4.35	55.11
100% RDF	11.15	9.16	8.61	2.59	4.99	69.42
100% RDF + CU	11.18	9.18	8.65	2.62	5.01	69.92
100% RDF+PGPR	11.51	9.45	9.22	3.04	5.27	76.21
100% RDF+PGPR+CU	11.54	9.47	9.27	3.07	5.29	76.80
75% RDF+ CU	10.70	8.78	7.83	2.03	4.63	61.06
75% RDF+ PGPR	11.02	9.04	8.38	2.42	4.88	66.68
75% RDF+PGPR+CU	11.06	9.08	8.46	2.48	4.92	67.62
SEm (±)	0.06	0.05	0.10	0.07	0.04	1.17
CD (P=0.05)	0.17	0.14	0.29	0.21	0.14	3.55

Note: *Mean of three replications

100% RDF+PGPR+CU followed by 100% RDF+PGPR treatments, due to higher nitrogen level in plant tissue that increase metabolism of carbohydrates leads to decrease cell wall constituents/carbohydrates (Iqbal et al. 2017). Less fibre fraction attributed to increase cell soluble contents in plant. These results are in line reported by Kushwaha et al. (2018).

Nutritional value and digestibility

A critical examination of data presented in Table 2 indicated that among the different nutrient management practices, the significantly higher total digestible nutrients (50.35%), total digestible nutrients yield (57.09 q/ha), Digestible dry matter (58.13%) and relative feed value (84.50) was observed with the application of 100% RDF+PGPR+CU, which was found statistically at par with applications of 100% RDF+PGPR and both were found significantly higher over rest of the treatments. While, significantly highest dry matter intake (1.88%) and digestible crude protein (5.57%) was observed with the application of 100% RDF+PGPR+CU over rest of the treatments. The treatment supplied with 100% RDF+PGPR+CU increases total digestible nutrients by 0.52, 7.14, 7.67 and 28.46%; digestible dry matter by 0.27, 3.61, 3.87 and 13.10%; dry matter intake by 0.24, 2.51, 2.73 and 8.45%, and digestible crude protein by 5.45, 11.33, 15.18 and 40.24% over 100% RDF+PGPR, 100% RDF+CU, 100% RDF and absolute control, respectively.

The total digestible nutrients (TDN) refer to the nutrients, which, are available for animals and their availabilities are related to the ADF content of the fodder. The TDN contents decrease as ADF content increases in fodder, which means animals are not able to uses the nutrients present in the offered fodder (Lithourgidis et al. 2006). As ADF content increases resultant increase cellulose and lignin content of fodder leads to decrease DDM. Lower value of ADF content with application of 100% RDF+PGPR+CU attributed to higher value of TDN and DDM. Higher TDN value and dry fodder yield attributed to higher yield of TDN. The NDF content inversely correlated with dry matter intake (DMI), which means that when NDF content of fodder increase the DMI will be decrease because NDF contains; cellulose, hemicellulose and lignin that have lower digestibility and take more time to digest and passes through the gastrointestinal tract of ruminants (Horrocks and Vallentine 1999). The relative feed value (RFV) is an index that predict the energy value of the fodder and their intake. Higher value of DMI and DDM attributed to increase relative feed value. The digestible crude protein (DCP) content increase with increasing crude protein content of fodder. The TDN, DMI, DDM, RFV and DCP values increase with increasing N fertilization which, increase N concentration in plant part (Albayrak and Turk 2011). The similar results were also reported by Albayrak and Turk (2011) and Bhakar et al. (2020).

Energy balance

A critical examination of data presented in Table 3 indicated that among different nutrient management practices, the significantly higher digestible energy (11.54 MJ/Kg), metabolisable energy (9.47 MJ/Kg), digestible feed energy (9.27 MJ/Kg), net energy (3.07 MJ/Kg), net energy for lactation (5.29 MJ/Kg) and relative forage quality (76.80) was observed with the application of 100% RDF+PGPR+CU, which was found statistically at par with applications of 100% RDF+PGPR and both were found significantly higher over rest of the treatments. The treatment supplied with 100% RDF+PGPR+CU increases digestible and metabolizable energy by 0.24, 3.25, 3.47 and 11.66%; digestible feed energy by 0.52, 7.14, 7.67 and 28.46%; net energy for lactation by 0.42, 5.70, 6.11 and 21.82%; and relative forage quality by 0.77, 9.85, 10.63 and 39.35% over 100% RDF+PGPR, 100% RDF+CU, 100% RDF and absolute control, respectively.

Digestible energy (DE) is the fraction of total fodder energy that remain after excretion in the faeces. DE is positively correlated with DDM content of fodder. Metabolisable energy (ME) is the fraction of DE energy that remain after some losses in urine and as methane (CH_4) gas released by microbes of rumen and hind gut, which, are positively correlated with DE of fodder. Net energy (NE) is the fraction of ME energy that remain after heat losses in metabolism and digestion process, which is the actually energy that available for animal uses. NE and DFE are positively correlated with TDN content of fodder. Net energy of lactation (NE_l) is energy requirements for maintenance and milk production that are negatively correlated with ADF content of fodder. NE_l values increase with increasing N fertilization (Albayrak and Turk 2011). Higher DMI and TDN contents of pearl millet fodder attributed to increase relative feed quality. These results are in agreement to result reported by Albayrak and Turk (2011).

Conclusion

Study concludes that application of organic sources of nutrients *viz.*, PGPR and cow urine foliar spray with inorganic fertiliser shows positive effect on nutritional and energy value of pearl millet fodder. 100% RDF+PGPR+CU (T_5) remained productive as well as profitable in term of nutritional and energy value. For future line of work, as like pearl millet, different cereal fodder crops can be explored location wise along with proper dose and sources (inorganic and organic) of nutrients for better quality.

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