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Research Paper

Quality fodder production and economics of dual-purpose pearlmillet (*Pennisetum glaucum*) under different fertility levels and nitrogen scheduling

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ABSTRACT

A field trial was conducted during the rainy seasons of 2011 and 2012, to evaluate the pearlmillet [*Pennisetum glaucum* (L.) R. Br.] variety 'AVKB 19' for different purpose, viz. grain, fodder and both grain and fodder, under low, medium and high soil fertility levels for yields and fodder quality. Crop grown for dual purpose recorded 42.0 and 31.5% higher green fodder-equivalent yield over grain and fodder purpose respectively. Similarly, net returns (₹31,700/ha) and benefit: cost ratio (2.0) were also maximum under dual-purpose pearlmillet. The benefit: cost ratio under fodder purpose pearlmillet was almost equal to dual purpose. Application of 125% recommended dose of fertilizer (RDF) recorded significantly higher green fodder equivalent yield (53.75 t/ha) and crude protein yield (696 kg/ha), being 9.3 and 17.4% higher over 100% RDF. This treatment also improved crude protein content of fodder as well as stover. Splitting of N fertilizer improved yields and quality of fodder and resulted in higher net returns and benefit: cost ratio. Energy balance (200 × 10^3 MJ/ha) and energy-use efficiency (28.5) were the highest with dual-purpose followed by grain-purpose pearlmillet. Application of 125% RDF and splitting of N fertilizer improved energy balance, while energy-use efficiency was maximum in 75% RDF.

Key words : Dual purpose pearlmillet, Economics, Energetics, Fodder yield, N management, Quality

At present, India faces a net deficit of 35.6% green fodder, 10.9% dry crop residues and 44% feed (IGFRI, 2013). There is tremendous pressure of livestock on fodder, as the arable land for forage production is becoming scarce and fallow land and communal property resources available for grazing are declining. The ever-rising demand for fodder and feed for sustaining livestock production can be met through increasing productivity of fodder and utilizing untapped feed resources. The fodder resources can be improved without additional land requirement through introduction of dual-purpose crops/genotypes. Among major coarse cereals, pearlmillet have a potential to produce good amount of grain yield with substantially higher green fodder. It is a quick-growing and short-duration crop, grown for both fodder and grain purposes mainly under rainfed conditions because of its high tillering potential, high dry matter production and drought escaping mechanism (Rana and Bana, 2012).

Crop residues are important fodder resources for ruminant in India. However, the nutritive value of crop residue is generally poor (Erenstein *et al*., 2011). Among various agronomic factors that may affect the yield and quality of forage, the fertilizers application, particularly of nitrogen is considered to be the most important, which improves quality of forage especially protein contents (Ayub *et al*., 2007). To improve the yield and quality of forage, it is essential to determine the fertilizer requirement of crop and judicious use. The present study was therefore, designed to evaluate recently released pearlmillet variety 'AVKB 19' for different purposes like grain, fodder and dual under low, medium and high fertility conditions for yield and quality of fodder.

MATERIALS AND METHODS

The field experiment was carried out during the rainy (*kharif*) seasons of 2011 and 2012 at Central Research Farm of the Indian Grassland and Fodder Research Institute, Jhansi, Uttar Pradesh. The experimental site is characterized by semi-arid climate with extreme temperature during summer (43 to 46 °C) and winter (as low as 2°C). The rainfall received during June to September was 593 and 708 mm during 2011 and 2012, respectively. The soil was sandy loam, slightly alkaline (pH 7.8), low in organic carbon (0.40%), available nitrogen (187 kg/ha) and phosphorus (9.8 kg/ha) and high in available potassium

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(291 kg/ha). The experiment was laid out in randomized block design with 3 replications. Pearlmillet variety 'AVKB 19' was grown. This variety was bred by IGFRI-RRS, Avikanagar by selection from material collected from Nagaur, Rajasthan in 2006. The variety is recommended for cultivation in western Uttar Pradesh, Rajasthan, Haryana, Punjab and foothills (*Tarai*) region of Uttarakhand. It is a dual purpose with green fodder yield potential of 36.7 t/ha, dry fodder 8.8 t/ha and 1.02 t/ha seed yield. Treatments consisted of 3 purposes of pearlmillet (grain, fodder and dual), 3 fertility levels [75, 100 and 125% recommended dose of fertilizer (RDF)] and 2 nitrogen-scheduling practices, viz. (100% N as basal and 75% as basal + 25% N at 25 days after sowing (DAS). For grain purpose, the crop was harvested at maturity and for fodder purpose first cut was taken at 50% flowering and second cut at 25 days after first cut. For dual purpose, crop was cut at 50 DAS for green fodder and left for grain production from regeneration. Crop was grown as rainfed. The recommended dose of fertilizer for pearlmillet was 80 kg N and 40 kg P_2O_5. Entire phosphorus was applied as basal at sowing, whereas N was applied as per treatment. The pearlmillet was sown on 6 and 20 July during 2011 and 2012, respectively. The crop was sown in rows at 45 cm (grain) and at 30 cm (fodder and dual) apart. Thinning and gap filling were done at 15 DAS to maintain the uniform plant stand. Random chopped samples of green fodder were sun-dried and placed in the oven at 65°C for 72 hr to estimate dry-matter percentage and then it was multiplied with respective green fodder yield to calculate dry fodder yield. Green-fodder equivalent yield was calculated by multiplying grain or stover yield with its respective price and divided by the market price of green fodder of pearlmillet. Oven-dried samples were used for crude protein analysis. This was estimated by extracting N with H_2SO_4 and determining the concentration in the digested solution by Kjeldahl analysis and expressed as N × 6.25. Crude protein yield was calculated by multiplying crude protein content with dry-matter yield. Apparent nitrogen balance was estimated as the difference between nitrogen added through fertilizers and nitrogen removed by crop under different treatments. Economics was computed using prevailing prices of inputs and outputs. Benefit: cost ratio was calculated by dividing net returns by cost of cultivation. Energy values of various inputs and outputs used in the experimentation were calculated as per suggested by Devasenapathy *et al.* (2009). The following formulas were used to calculate energy balance and energy-use efficiency:

Energy balance = Energy output (MJ/ha) − Energy input (MJ/ha)

$$\text{Energy–use efficiency} = \frac{\text{Energy output (MJ/ha)}}{\text{Energy input (MJ/ha)}}$$

The results were analysed using standard statistical procedure given by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Grain and fodder yield

Purpose of growing, fertility levels and nitrogen splitting significantly affected the fodder and grain yield of pearlmillet (Table 1). Significantly higher green and dry fodder yields were recorded when pearlmillet grown for fodder purpose. This increased the green and dry fodder yield by 70.6 and 66.3%, respectively over dual purpose. The highest grain and stover yields were recorded in grain-purpose pearlmillet. The highest green-fodder equivalent yield was recorded when crop was sown for dual purpose followed by fodder purpose. This may be due to production of green fodder, grain and stover in dual purpose, whereas grain and stover produced in grain purpose and only green fodder in fodder purpose pearlmillet.

Graded dose of fertilizer application had significant effect on grain, stover and fodder yields. The grain, stover, green fodder and green fodder equivalent yield increased with on increase in dose of fertilizer. Application of 125% RDF recorded the highest green-fodder equivalent yield, being 13.3 and 23.9% higher over 100 and 75% RDF respectively. This may be owing to build up of soil fertility that led to increased nutrient availability that induces more tillering, converting into higher grain as well as fodder yield. Patel *et al.* (1994) and Rao *et al.* (2007) also reported higher fodder yield of sorghum under higher dose of fertilizers.

The crop receiving 75% N as basal and 25% N at 25 DAS as top dressing significantly increased grain, stover and fodder yield. This treatment also significantly improved green-fodder equivalent yield by 7.3% over full dose of N when applied basal. This may be due to reduced loss of nitrogen and extent supply and availability of applied N for longer time throughout the crop growth period under split of nitrogenous fertilizer.

Quality of fodder

Leaf: stem ratio and crude protein content were not significantly influenced by pearlmillet grown for different purpose, while crude protein yield and N uptake by crop were significantly affected (Table 1). The highest crude protein yield and N uptake were recorded in dual purpose pearlmillet, which were 72.7 and 53.0% higher over grain purpose, respectively. The increase in crude protein yield and N uptake was mainly owing to production of higher biomass in dual-purpose pearlmillet.

The successive increase in fertility levels up to 125% RDF significantly increased crude protein content, crude protein yield and N uptake, while leaf: stem ratio was not significantly affected by different fertilizer doses (Table 1). Application of 125% RDF significantly enhanced crude protein content in fodder and stover by 17.8 and 17.6% respectively, over 75% RDF. The increase in crude protein contents with increasing fertility levels may be the result of enhancement in amino acid formation. Our results confirm the findings of Ayub *et al.* (1999). Crude protein yield and N uptake increased significantly up to 125% RDF with an increase of 46.5 and 44.7% over 75% RDF and 17.3 and 17.1% over 100% RDF, respectively. The significant improvement in crude protein yield and N uptake were mainly owing to increase in yields (fodder and stover) and N content under improved nutrition. These results are in agreement with findings of Patel *et al*. (1994) and Rao *et al.* (2007).

Splitting of nitrogenous fertilizer significantly influenced leaf: stem ratio, crude protein content crude protein yield and N uptake (Table 1). Crude protein content in fodder and stover under 100% N as basal was 7.7 and 3.5% respectively, which increased to 8.2 and 3.8% when the dose of nitrogenous fertilizer was split. Likewise, crude protein yield and N uptake were also increased by 16.8 and 15.5% over full dose N applied as basal. This may be because of increased availability of N resulted higher biomass and N content. These results are confirms the findings of Almodares *et al.* (2009).

Apparent N balance

Apparent N balance in soil was found negative under all the treatments (Fig. 1). More negative apparent N balance was observed under dual purpose than grain and fodder pearlmillet. Slightly higher apparent N balance was observed under higher dose of fertilizer (100% RDF) than 75% RDF. More negative apparent N balance in soil was

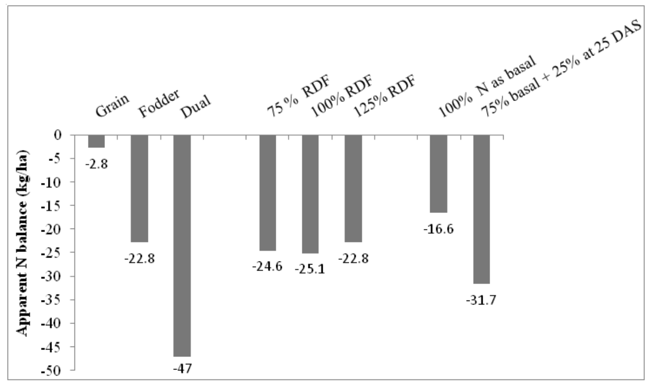

Fig. 1. Effect of fertilizer level and schedule on apparent nitrogen balance in soil when pearlmillet grown for grain, fodder and dual purpose

Table 1. Effect of fertility levels and nitrogen splitting on yields and quality of pearlmillet grown for different purposes (mean data of 2 years)

Treatment	Green fodder yield (t/ha)	Dry fodder yield (t/ha)	Grain yield (t/ha)	Stover yield (t/ha)	Green fodder equivalent yield (t/ha)	Leaf : stem ratio	Crude protein (%)		Crude protein yield (kg/ha)	N uptake (kg/ha)
							fodder	stover		
Purpose										
Grain	-	-	1.07	10.91	41.81	-	-	3.7	411	83
Fodder	45.13	8.10	-	-	45.13	0.42	7.9	-	642	103
Dual	26.45	4.87	0.84	8.57	59.36	0.43	8.0	3.6	710	127
SEm±	0.66	0.13	0.02	0.22	0.69	0.01	0.13	0.08	11.3	2.3
CD (P=0.05)	1.93	0.39	0.04	0.64	1.99	NS	NS	NS	33.8	6.6
Fertility level										
75 % RDF	32.14	5.79	0.85	8.57	43.39	0.41	7.3	3.4	475	85
100% RDF	35.94	6.52	0.97	9.83	49.16	0.43	8.0	3.7	593	105
125% RDF	39.30	7.14	1.04	10.83	53.75	0.44	8.6	4.0	696	123
SEm±	0.81	0.16	0.02	0.27	0.69	0.01	0.16	0.10	11.3	2.3
CD (P=0.05)	2.37	0.47	0.05	0.79	1.99	NS	0.46	0.30	33.8	6.6
N scheduling										
100% N as basal	34.38	6.19	0.94	9.34	47.05	0.41	7.7	3.5	542	97
75% as basal + 25% N at 25 DAS	37.20	6.78	0.97	10.14	50.48	0.44	8.2	3.8	633	112
SEm±	0.66	0.13	0.02	0.22	0.56	0.01	0.13	0.08	12.9	1.9
CD (P=0.05)	1.93	0.39	NS	0.64	1.62	0.02	0.38	0.25	38.4	5.4

RDF, recommended dose of fertilizer; DAS, days after sowing

Table 2. Effect of fertility levels and nitrogen splitting on economics and energetics of pearlmillet grown for different purposes (mean data of 2 years)

Treatment	Cost of cultivation (×10³ ₹/ha)	Net returns (×10³ ₹/ha)	Benefit: cost ratio	Input energy (×10³MJ/ha)	Output energy (×10³ MJ/ha)	Energy balance (×10³ MJ/ha)	Energy use efficiency (output/input)
Purpose							
Grain	14.0	19.5	1.39	7.13	152.1	145.0	21.3
Fodder	11.9	24.2	2.03	7.03	145.8	138.7	20.7
Dual	15.8	31.7	2.00	7.27	207.3	200.0	28.5
Fertility level							
75% RDF	13.3	21.4	1.61	5.82	149.2	143.3	25.6
100% RDF	13.9	25.4	1.83	7.14	169.7	162.6	23.8
125% RDF	14.5	28.5	1.96	8.46	186.2	177.7	22.0
N scheduling							
100% N as basal	13.8	23.8	1.72	7.13	161.4	154.3	22.6
75% as basal + 25% N at 25 DAS	14.0	26.4	1.89	7.14	175.3	168.2	24.5

Price of grain: 9,800 ₹/t (2011), 11,750 ₹/t (2012); Price of green fodder: 800 ₹/t; Price of stover: 2,000 ₹/t
RDF, recommended dose of fertilizer; DAS, days after sowing

recorded under splitting of nitrogenous fertilizer as compared to 100% N as basal. The negative N apparent balance may be due to continuous crop mining of N coupled with inadequate N replenishment (Rafique *et al*., 2012). More negative N apparent balance with dual-purpose pearlmillet and splitting of nitrogenous ferilizer induces a major increase in crop biomass. Consequently, greater amount of N was exported from soil.

Economics and energetics

The cost of cultivation and economic returns were higher under dual-purpose pearlmillet (Table 2). Higher cost of cultivation was under dual purpose due to additional cost involved in bird watching and scaring and threshing in comparison to fodder purpose. The highest net returns and benefit: cost ratio were realized with the dual purpose. In the present study, highest net returns and benefit: cost ratio were achieved with the application of 125% RDF and nitrogen splitting. It is obvious that realization of higher net returns and benefit: cost ratio was the result of higher productivity. Jat *et al.* (2013) also reported higher net returns and benefit: cost ratio with higher dose of fertilizer in sorghum.

The input energy consumption was influenced slightly under various purposes of pearlmillet and increased with increased levels of fertility (Table 2). The input energy required in different purpose of pearlmillet were in order of dual followed by grain and fodder. The highest value of input energy was recorded with 125% RDF. However, the maximum output energy was obtained when the pearlmillet was grown for dual purpose, followed by grain purpose. Moreover, more output energy was generated under 125% RDF and splitting of N. Energy balance was found higher under when pearlmillet grown dual purpose and 125% RDF, while the highest energy use efficiency was recorded when grown for dual and 75% RDF. More output energy and energy balance were recorded at higher levels of fertilizer (125% RDF) owing to higher yields performance of the crops. However, reverse trend was observed in energy-use efficiency with fertility levels, and this was due to input energy of fertility levels increased linearly whereas yields of the crop increased with decreased pace with increased levels of fertility.

It can be concluded that growing of pearlmillet variety 'AVKB 19' for dual purpose (grain and green fodder) with application of 125% RDF (100 kg N and 50 kg P_2O_5) and nitrogen splitting holds great promise for increased productivity, quality and profitability.

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