Range Management and Agroforestry 46 (1) : 129-136, 2025
ISSN 0971-2070 (Print); 2249-5231 (Online)
https://doi.org/10.59515/rma.2025.v46.i1.18

Research article

Productivity, profitability and quality of fodder-based cropping systems for year-round fodder production in shivalik foothills plains of India

Swati Mehta[1], Neetu Sharma[2*], B.C. Sharma[2], Vikas Sharma[2], Manish Kumar[2], Vishal Raina[2], Faraaz Farooq[2] and Joy Samuel MeCarty[2]

[1]Lovely Professional University, Phagwara-144411, India
[2]Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu-180009, India
[*]Corresponding author email: hanshunitu77@rediffmail.com

Received: 30th July, 2024 Accepted: 15th March, 2025

Abstract
An experiment was conducted over two consecutive years (2020-2021 and 2021-2022) at the Research Farm, Division of Agronomy, SKUAST-Jammu, India. The experiment was laid out in a randomized block design with three replications. Treatments involved forage-based cropping system comprising combinations of annual cereals, perennial grasses and legume crops. Experimental results revealed that multicut sorghum + maize, along with root slips of napier planted on the field boundaries in July recorded significantly highest green forage yield. During the *rabi* season, berseem + oat combination with root slips of napier planted on the field boundaries in July was significantly superior to other treatments. Multicut bajra + maize -berseem + barley with stem cuttings of napier planted on the field boundaries in January recorded higher system productivity and profitability.

Keywords: Annual fodder, Cropping system, Legumes, Perennial grasses, System productivity

Introduction
India, with over 58% of its population relying on agriculture, faces significant challenges in ensuring food security for its growing population while preserving natural resources (Meena *et al*., 2023). Modern agricultural trends emphasize the need for highly productive, cost-effective, sustainable and eco-friendly cropping practices. However, fodder crops often compete with food and cash crops, limiting the potential for expanding fodder crop areas. Despite India being the global leader in livestock population and milk production, its productivity remains below the world average (DAHD, 2022). One of the main reasons for this low productivity is the scarcity of quality feed and fodder (Mahanta *et al*., 2020). Shortage of feeding resources leads under nutrition and malnutrition in livestock, which becomes particularly severe during the lean periods of May to June and November to December (Ahmad *et al*., 2016). Currently, India faces a net deficiency of 35.6% in green fodder, 10.9% in dry fodder, and 44% in concentrate feed materials (IGFRI Vision, 2050). Green fodder is the most cost-effective and feasible option for reducing the input costs of dairy enterprises. Practicing a diversified fodder cropping system that combines perennial and annual cereals and legumes is a recognized solution for the sustainable use of farm resources to maintain higher livestock productivity (Ghosh *et al*., 2016; Hindoriya *et al*., 2019; Mehta *et al*., 2024).

Annual or seasonal fodder production requires additional maintenance and higher input costs. Hence, adopting perennial grasses and high-value dual-purpose crops, which require comparatively lower maintenance and costs, can ensure a year-round supply of fodder. Many studies have established that perennial or biennial grasses and legumes (such as napier, berseem, and lucerne) demand fewer input requirements and result in higher yield advantage as compared to annual forage crops (Palsaniya *et al*., 2010; Manoj *et al*., 2022). Moreover, it has been observed that the nutritional quality of cereal fodder crops is generally lower than that of legume fodder (Kumar *et al*., 2020). Therefore, the nutritional quality of cereal fodder or grasses can be enhanced by mixing them with legumes or growing legumes (Halli *et al*., 2018; Kumar *et al*., 2018). Sustainable soil health is another significant advantage of including legumes with grasses (Helmy *et al*., 2011; Bhakar *et al*., 2021). Therefore, combining seasonal fodder crops with perennial crops could be a better option to boost the productivity of dairy farming. Based on these facts, the present study was planned to evaluate fodder cropping systems to enhance productivity and ensure year-round fodder availability in a sustainable way

Materials and Methods

Study area: A field experiment was carried out for two consecutive years (2020-21 and 2021-2022) at Research Farm, Agronomy, SKUAST-J, Main Campus Chatha, Jammu. The experimental site was located at 32^0 40' N latitude and 74^0 58' E longitude with an altitude of 332 meters above mean sea level in the sub-tropical Shivalik foothills of the North-Western Himalayas. The experimental site experiences hot and dry early summers followed by hot and humid monsoons and cold winters. The soil of the experimental site was sandy clay loam in texture with neutral in reaction (pH 7.35), medium in organic carbon (5.4 g/kg), available phosphorus (11.26 kg/ha) and potassium (146.2 kg/ha) but low in available nitrogen (245.7 kg/ha). The experiment was laid out in a randomized block design and replicated thrice. The experiment comprised 24 treatments *viz*. The treatments consist of different *Kharif* (summer) and *Rabi* (winter) forage crop combinations, along with a perennial grass planted either by stem cuttings (January) or root slips (July). The *Kharif-Rabi* combinations included: (1) Multicut bajra + cowpea – berseem + oat, (2) Multicut sorghum + cowpea – lucerne + oat, (3) Multicut bajra + maize – berseem + barley, (4) Multicut sorghum + maize – lucerne + barley, (5) Multicut bajra + cowpea + maize – berseem + oat + barley, and (6) Multicut sorghum + cowpea + maize – lucerne + oat + barley. These combinations were further categorized based on the perennial grass planted: Napier or Setaria, using stem cuttings in January (CS1-CS4, CS9-CS12, CS17-CS20) or root slips in July (CS5-CS8, CS13-CS16, CS21-CS24). The precise treatment codes (CS1-CS24) were determined by the specific crop combination, perennial grass type, and method of establishment (Table 1).

Cultural operations and crop varieties: Recommended doses of nitrogen, phosphorus and potassium were applied to all the crops. In seasonal fodder crops, a half a dose of nitrogen and a full dose of phosphorus and potassium were applied in the form of urea, single super phosphate (SSP) and muriate of potash (MOP), respectively, as a basal dose. The remaining half dose of nitrogen was supplied in a split application. In multicut cereal crops (Napier, Setaria and sorghum), 25 kg/ha N was top dressed after each cut for smooth regeneration of the fodder crops. All other standard agronomic practices and need-based plant protection measures were followed as recommended. Napier grass (var. NB-21) and *Setaria sphacelata* (S-92) were sown as perennial crops and multicut sorghum (CSH-24 MF), multicut bajra (Wonderleaf-HB-21), cowpea (EC 4216) and maize (J-1006) were sown during *Kharif* season. Berseem (BL-1), lucerne (Sirsa No. 9), oats (JHO-851) and barley (VL-118) were sown as *rabi* annual fodder crops.

Yield, berseem + oat equivalent yield and system productivity: The total fresh forage from the plot was recorded at every cut and weighed to record the fodder yield and then converted into t/ha. Berseem + oats forage equivalent yield was calculated by converting the yield of component fodder crops of particular treatment into berseem + oats forage equivalent yield.

Berseem + oats equivalent yield (t/ha) = Σ Yi × ei

Where,

Yi = Economic yield of crops whose yield has to be converted

$$\text{ei = Equivalent factor} = \frac{\text{Price of crops whose yield has to be converted}}{\text{Price of berseem + oats}}$$

System productivity was obtained by adding the Berseem + Oats equivalent yield of different annual *kharif* and *rabi* fodder crops with perennial grasses taken in different forage-based cropping systems and was expressed in t/ha.

***Fodder samples and their chemical analysis*:** Perennial napier and Setaria were harvested when plants attained more than 1.5 m in height. *Kharif* and *rabi* annual fodder crops were taken at 45 DAS and subsequent cuts were taken at intervals of 35-40 days. Seasonal fodder crops were cut at 5 to 7 cm above the ground level for better regrowth. Fresh fodder yield was recorded, and a known quantity of samples was dried in a hot air oven at 65 ± 5°C till they attained constant weight. The oven-dried fodder samples were ground to pass through a 40-mesh sieve in a Macro-Wiley Mill for chemical analysis. The determination of different quality parameters, *viz*., neutral detergent fiber (NDF) and acid detergent fiber (ADF) were analyzed as per the method suggested by Van Soest *et al.* (1991). Hemi-cellulose content was determined by subtracting ADF from NDF.

Soil samples and their physico-chemical analysis: Soil samples of the experimental field were collected from a depth of 0 to 15 cm (for annual fodder) and 0 to 30 cm (for perennial fodder). Soil pH was analyzed (1:2 soil: water suspension) using a pH meter fitted with a calomel glass electrode (Page *et al*., 1982). The electrical conductivity (EC) of 1:2 soil: water supernatant was estimated by a portable ECTestr11 meter (Jackson, 1967). The soil organic carbon, available N, P and K were determined using the wet oxidation method (Walkley and Black, 1934), Kjeldahl method (Subbiah and Asija, 1956), 0.5 M sodium bicarbonate method (Olsen *et al*., 1954) and flame photometer method (Jackson, 1967), respectively.

Table 1. Treatment details

Experimental code	Treatment details
C1	Multicut Bajra + Cowpea - Berseem + Oat + Stem cuttings of Napier planted in January
C2	Multicut Bajra + Cowpea - Berseem + Oat + Stem cuttings of Setaria planted in January
C3	Multicut Sorghum + Cowpea - Lucerne + Oat + Stem cuttings of Napier planted in January
C4	Multicut Sorghum + Cowpea - Lucerne + Oat + Stem cuttings of Setaria planted in January
C5	Multicut Bajra + Cowpea - Berseem + Oat + Root slips of Napier planted in July
C6	Multicut Bajra + Cowpea - Berseem + Oat + Root slips of Setaria planted in July
C7	Multicut Sorghum + Cowpea - Lucerne + Oat + Root slips of Napier planted in July
C8	Multicut Sorghum + Cowpea - Lucerne + Oat + Root slips of Setaria planted in July
C9	Multicut Bajra + Maize - Berseem + barley + Stem cuttings of Napier planted in January
C10	Multicut Bajra + Maize - Berseem + barley + Stem cuttings of Setaria planted in January
C11	Multicut Sorghum + Maize - Lucerne + barley + Stem cuttings of Napier planted in January
C12	Multicut Sorghum + Maize - Lucerne + barley + Stem cuttings of Setaria planted in January
C13	Multicut Bajra + Maize - Berseem + barley + Root slips of Napier planted in July
C14	Multicut Bajra + Maize - Berseem + barley + Root slips of Setaria planted in July
C15	Multicut Sorghum + Maize - Lucerne + barley + Root slips of Napier planted in July
C16	Multicut Sorghum + Maize - Lucerne + barley + Root slips of Setaria planted in July
C17	Multicut Bajra + cowpea + Maize - Berseem + Oat + barley + Stem cuttings of Napier planted in January
C18	Multicut Bajra + cowpea + Maize - Berseem + Oat + barley + Stem cuttings of Setaria planted in January
C19	Multicut Sorghum +Cowpea + Maize - Lucerne + Oat + Barley + Stem cuttings of Napier planted in January
C20	Multicut Sorghum +Cowpea + Maize - Lucerne + Oat + Barley + Stem cuttings of Setaria planted in January
C21	Multicut Bajra + cowpea + Maize - Berseem + Oat + barley + Root slips of Napier planted in July
C22	Multicut Bajra + cowpea + Maize - Berseem + Oat + barley + Root slips of Setaria planted in July
C23	Multicut Sorghum + Cowpea+ Maize – Lucerne + Oat + Barley + Root slips of Napier planted in July
C24	Multicut Sorghum + Cowpea+ Maize – Lucerne + Oat + Barley + Root slips of Setaria planted in July

Economic analysis: The cost of different operations was calculated for different treatments on the basis of existing market prices of inputs and operations and the total cost was calculated by adding the expenditure involved in all kinds of operations as per treatment on a per hectare basis in ₹/hectare. Gross returns were worked out by multiplying the total forage yield with the prevalent market prices of the items and then presented on a per-hectare basis as per treatments. Net returns were computed by deducting the total cost of cultivation from the gross returns as per treatments. Benefit:Cost ratio was calculated by dividing net returns with the cost of cultivation for each treatment.

Statistical analysis: Experimental data were processed in MS Excel-2019 and statistical analyses were done using the analysis of variance (ANOVA) technique for RBD. Statistical significance differences among treatment means for various parameters were analyzed by critical differences (CD) at a 0.05 probability level (Gomez and Gomez, 1984).

Results and Discussion

Green forage yield: Green forage yield is influenced by genetic and environmental factors, both of which are crucial for plant growth and development, ultimately affecting fodder yield. Data on *kharif* annual fodder yields revealed that the combination of C15 (multicut sorghum + maize - lucerne + barley + napier root slips planted in July) yielded significantly higher green fodder at 70.00 t/ha (Table 2) and was statistically similar to the green forage yield of C16 (69.76 t/ha), C11 (69.74 t/ha), and C12 (69.52 t/ha). This significant increase in green forage yield might be due to the exceptional yield potential of multicut sorghum and maize in comparison to other *kharif* annual fodders. Additionally, the incorporation of perennial grasses with kharif cereals provided year-round green fodder throughout the year, further optimizing the overall green forage yield (Gupta *et al*., 2022). Furthermore, the data on *rabi* annual fodder crop yields (Table 2) indicated that the combination of C5 (multicut bajra + cowpea - berseem + oat + napier root slips planted in July) produced a significantly higher green fodder yield of 92.69 t/ha and it was statistically comparable to green forage yield of C6 (92.37 t/ha), C1 (92.25 t/ha), and C2 (91.59 t/ha). A significant increase in green forage yield was likely due to the efficient nutrient absorption, enhanced light interception at various canopy layers, and improved photosynthetic rates achieved by mixing berseem with cereal crops (Kumar and Sarlach, 2020). Additionally, including berseem with oats offered several advantages, such as higher yields through more efficient resource utilization and improved soil fertility via nitrogen fixation, which ultimately enhanced yield (Patil *et al*., 2018). These results aligned closely with the findings of Lodhi *et al*. (2009) and Ayub *et al*. (2013).

Berseem + oat equivalent yield (t/ha): The economic yield of each crop component in the eight forage cropping sequences was converted into Berseem + Oat forage equivalent yield (Table 2). This conversion was based on the local market sale prices of the produce. The equivalent yield of all crops in each sequence was then summed to obtain the total Berseem + Oat forage equivalent yield for that sequence. In the *kharif* season, the significantly higher Berseem equivalent yield was observed in the sequence of C15 (multicut sorghum + maize followed by lucerne + barley + napier root slips planted in July) (52.06 t/ha). This yield was statistically similar to C16 (51.87 t/ha), C11 (51.88 t/ha), and C12 (51.70 t/ha). The significant increase in equivalent yield might

Table 2. Green forage yield (t/ha), berseem + oat equivalent yield (t/ha) and system productivity (t/ha) of sustainable forage cropping system for *Kharif*, *Rabi* and perennial seasons (pooled data of two years)

Cropping system	Green forage yield (t/ha)		Berseem + oat equivalent yield (t/ha)			System productivity
	Kharif	*Rabi*	*Kharif*	*Rabi*	Perennial fodders	
C1	48.79	92.25	36.28	75.28	207.82	319.38
C2	48.25	91.59	35.88	74.55	88.38	198.81
C3	53.14	65.07	39.52	48.04	208.00	295.56
C4	52.36	63.85	38.93	46.81	87.73	173.47
C5	49.43	92.69	36.76	75.66	158.11	270.53
C6	49.10	92.37	36.51	75.25	75.52	187.28
C7	53.81	65.33	40.01	48.29	158.24	246.54
C8	53.74	65.27	39.96	48.24	75.03	163.23
C9	61.24	86.77	45.54	69.75	211.73	327.02
C10	61.14	86.47	45.46	69.44	89.51	204.41
C11	69.74	54.99	51.88	37.97	208.11	297.96
C12	69.52	53.81	51.70	36.78	90.25	178.73
C13	61.44	88.46	45.69	71.43	161.18	278.30
C14	61.17	88.02	45.49	71.00	76.43	192.92
C15	70.00	56.64	52.06	39.60	158.33	249.99
C16	69.76	55.68	51.87	38.63	77.01	167.51
C17	41.59	88.03	30.93	70.98	210.34	312.25
C18	41.10	87.76	30.57	70.55	88.13	189.25
C19	45.55	61.47	33.89	45.08	212.13	291.10
C20	45.03	61.36	33.49	45.29	91.06	169.84
C21	42.03	88.85	31.26	71.80	159.55	262.61
C22	41.85	88.43	31.12	71.39	75.34	177.85
C23	45.96	63.39	34.18	46.35	161.49	242.02
C24	45.79	61.94	34.03	44.89	77.65	156.57
SEM (±)	1.02	1.26	0.80	1.21	1.81	3.60
CD ($p < 0.05$))	2.92	3.79	2.30	3.45	5.15	10.25

For details of cropping systems, go to Table 1

Table 3. Effect of *kharif* and *rabi* annual fodder with perennial grasses on system relative economics (mean data of 2 years)

Cropping systems	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C ratio
C1	191378	1098317	906938	4.74
C2	331378	560921	229542	0.69
C3	200378	1057265	856886	4.27
C4	340378	513692	173314	0.50
C5	191378	1122612	931233	4.86
C6	331378	562039	230661	0.69
C7	200378	1074102	873724	4.36
C8	340378	516897	176519	0.51
C9	187778	1132199	944421	5.03
C10	327778	579913	252134	0.77
C11	196778	1067411	870633	4.42
C12	336778	539390	202612	0.60
C13	187778	1143682	955903	5.09
C14	327778	590575	262796	0.80
C15	196778	1086053	889275	4.52
C16	336778	541142	204364	0.60
C17	185218	1089475	904256	4.88
C18	325218	539660	214442	0.66
C19	190618	1062433	871814	4.57
C20	330618	516588	185970	0.56
C21	185218	1106943	921724	4.97
C22	325218	539067	213849	0.65
C23	190618	1047984	857365	4.50
C24	330618	519543	188925	0.57

For details of cropping systems, go to Table 1

be attributed to the maximum forage equivalent yield of the multicut sorghum + maize combination. Whereas, for the *rabi* forage crops, among the different sequences C5 (multicut bajra + cowpea - berseem + oat + napier root slips planted in July) (75.66 t/ha) was recorded with significantly higher berseem + oat equivalent yield and it was statistically similar to the equivalent yield of C6 (75.25 t/ha), C1 (75.28 t/ha), and C2 (75.28 t/ha). The higher equivalent yield could be attributed to the combination of substantial forage yield and favorable market price. Further, with respect to perennial grasses, significantly higher berseem equivalent yield was recorded with C19 (multicut sorghum + cowpea + maize - lucerne + oat + barley + stem cuttings of napier planted in January) (212.13 t/ha) and it was at par to C9 (211.73 t/ha), C17 (210.34 t/ha), C11 (208.11), C3 (208.00 t/ha) and C1 (207.82 t/ha). The obtained results were in agreement with Ross *et al*. (2004) and Loannis and Dhima (2008).

***System productivity (t/ha)*:** The data revealed that system productivity of different fodder sequences was significantly higher in C9 (multicut bajra + maize - berseem + barley + stem cuttings of napier planted in January) (327.02 t/ha) and it was at par to C1 (319.38 t/ha) and C17 (312.25 t/ha) (Table 2). The highest system productivity might be attributed to the higher green forage yield of napier, berseem and bajra.

Economics of fodder-based cropping system: Economic evaluation plays a vital role in knowing the practical feasibility of any package of practice. Experimental results (Table 3) indicated that the highest system gross returns, net returns and B:C ratio over two years was recorded with the treatment C13 (Rs 11436 82, Rs 955903 and 5.09, respectively) closely followed by C9 (Rs 1132199, Rs 944421 and 5.03). This might be attributed to the higher green forage yield of this forage cropping

Table 4. Quality parameters of different fodder crops during *Kharif* season and *Rabi* season (pooled data of two years)

Cropping system	Kharif season				Rabi season			
	ADF (%)	NDF (%)	Hemi cellulose (%)	Cellulose (%)	ADF (%)	NDF (%)	Hemi cellulose (%)	Cellulose (%)
C1	28.08	44.55	16.47	22.40	42.51	69.96	27.45	23.18
C2	27.50	44.29	16.79	22.14	42.35	69.77	27.42	23.11
C3	38.96	59.72	20.76	31.44	33.42	60.79	27.37	28.69
C4	38.82	59.65	20.83	31.31	33.58	60.75	27.17	28.33
C5	29.79	45.66	15.87	23.56	42.52	71.17	28.65	24.18
C6	29.44	45.45	16.01	23.3	42.47	71.12	28.65	24.07
C7	39.72	59.82	20.1	32.11	34.48	62.21	27.73	29.26
C8	39.65	59.74	20.09	31.94	33.47	62.15	28.68	28.78
C9	32.76	51.24	18.48	27.6	35.25	65.00	29.75	17.80
C10	32.52	51.14	18.62	27.02	33.96	64.65	30.69	17.29
C11	42.08	64.83	22.75	34.38	28.62	55.75	27.13	25.08
C12	41.94	64.71	22.77	34.26	27.72	54.87	27.15	25.05
C13	33.38	52.58	19.2	28.68	34.09	66.72	32.63	18.95
C14	33.12	52.53	19.41	28.26	35.64	66.70	31.06	18.58
C15	43.09	66.12	23.03	35.42	28.31	56.73	28.42	25.84
C16	42.96	65.32	22.36	34.98	28.16	56.55	28.39	25.53
C17	26.23	42.27	16.04	22.82	41.41	67.42	26.01	20.78
C18	25.86	42.04	16.18	22.46	40.55	67.15	26.60	20.67
C19	37.75	58.33	20.58	28.19	32.05	58.54	26.49	27.12
C20	37.65	57.94	20.29	28.02	31.41	58.34	26.93	26.77
C21	29	42.98	13.98	23.37	40.61	68.44	27.83	21.81
C22	28.71	42.36	13.65	23.17	40.28	67.78	27.50	21.35
C23	37.91	58.74	20.83	29.02	32.97	58.12	25.15	27.90
C24	37.83	58.77	20.94	28.96	32.57	57.88	25.31	27.64
SEM (±)	1.22	1.92	0.52	1.38	1.69	1.85	0.16	1.74
CD ($p < 0.05$))	3.67	5.76	1.56	4.15	5.08	5.55	NS	5.21

For details of cropping systems, go to Table 1; ADF: Acid detergent fiber; NDF: Neutral detergent fiber.

system The other factor might be enhanced production potential of the forage cropping systems. Similar findings were observed by Patil *et al*. (2018) and Gupta *et al*. (2022).

Quality of fodder crops in kharif and rabi: Fodder quality plays a crucial role in animal nutrition by ensuring a balanced diet. The quality parameters of fodder crops varied significantly depending on their nature (Table 4). The analysis of different cropping systems for ADF, NDF, hemicellulose, and cellulose content revealed significant variations, with lower values indicating better quality. The lowest ADF was observed in the cropping system of C18 (25.86%), followed closely by the same system with stem cuttings of Napier (26.23%), while the highest ADF was noted in C15 (43.09%). For NDF, the lowest value was recorded in C18 (42.04%), indicating superior forage quality, whereas the highest NDF was found in C15 (66.12%), reflecting lower digestibility. The lowest hemicellulose content was observed in C6 (13.65%), while the highest was in C15 (23.03%). In terms of cellulose, C2 (22.14%) exhibited the lowest content, indicating enhanced digestibility, whereas the highest cellulose content was recorded in C15 (35.42%). These differences are likely due to variations in the stage of fodder maturity and crop growth conditions. Hemicellulose content is calculated by subtracting ADF from NDF, and NDF showed a positive correlation with both ADF and hemicellulose (Tiwari *et al*., 2019).

As for the quality of *rabi* crops under different sequences is concerned, the data presented in Table 4 revealed that significantly higher ADF (42.52%) and NDF (71.17%) content was recorded under C5 and it was at par with C6 (42.52%), C2 (42.35%), C1 (42.51%), C17 (41.41%) and C21 (40.28). In contrast, the treatment C12 was recorded with significantly lower ADF (27.72 %) and NDF (54.87%) contents, followed by C11 (28.62 and 55.75%). However, significantly higher Cellulose content (29.26) was recorded under C7, which was at par with the cellulose content of C8 (28.78%). As regards hemicellulose content no significant differences were observed. However, higher hemicellulose content (32.63 %) was recorded under C13 followed by C14 (31.06 %). Further, berseem + oat with root slips of napier planted in July recorded significantly higher content of acid detergent fiber, neutral detergent fiber, hemicellulose and cellulose in rabi fodder crops during both the years of study. This might be due to the inclusion of legumes with cereals that increased the cell wall content (Konapura *et al*., 2021). These results aligned closely with the findings of Ayub *et al*. (2013) and Singh *et al*. (2021).

Conclusion

On the basis of a two-year study, it was concluded that C9 (multicut bajra + maize -berseem + barley with stem cuttings of napier planted on the field boundaries in January) could be a better option for quality green fodder throughout the year in terms of productivity. On the other hand, C13 (multicut bajra + maize - berseem + barley + root slips of napier planted in July) seems to be a viable option for higher profitability of dairy farmers in a sustainable way.

Acknowledgment

The authors are thankful to the Sher-e Kashmir University of Agricultural Sciences and Technology- Jammu, Jammu & Kashmir, India for providing necessary assistance for this study.

References

Ahmad, S., J.P. Singh, P.A. Khan and A. Ali. 2016. Pastoralism for strengthening rangeland resources of Jammu & Kashmir. *Annals of Agriculture-Biological Research* 21: 49-54.

Ayub, M., H. Abbas, M. Tariq, M. Tahir, M.A. Nadeem and M.H. Siddiqui. 2013. Periodic assessment of dry matter production and nutritional value of millet legumes mix fodder. *Agricultural Research* 2: 265-269.

Bhakar, A., M. Singh, S. Kumar, D. Kumar, B.L. Meena, V.K. Meena and Y.V. Singh. 2021. Enhancing root traits and quality of sorghum and guar through mixed cropping and nutrient management. *Indian Journal of Agricultural Sciences* 91: 99-104.

DAHD. 2022. Annual Report 2022-23. Department of Animal Husbandry and Dairying, Ministry of Fisheries, Animal Husbandry and Dairying, Government of India. pp 1-182

Ghosh, P.K., S. Kumar and D.R. Palsaniya. 2016. Forage research in India: Issues and Strategies. *Agriculture Research Journal* 53: 1-12.

Gomez, K.A. and A.A. Gomez. 1984. *Statistical and Procedures for Agricultural Research*. 2nd edn. John Wiley & Sons, New York. pp. 1-680.

Gupta, S.K., G.S. Panwar, R.S. Choudhary, Hariom, R. Kumar, A. Kumar, R.K. Naresh, A.B. Patel, R. Kumar, and S.M. Chandra. 2022. Evaluation of production potential and feasibility of different forage-based cropping systems for round-the-year fodder production. *Agricultural Mechanization in Asia* 53: 9545-9556.

Halli, M.H., S.S. Rathore, N. Manjunatha and K.V. Wasnik. 2018. Advances in agronomic management for ensuring fodder security in semi-arid zones of India: A review. *International Journal of Current Microbiology and Applied Sciences* 7: 1912-1921.

Helmy, A, A., M.S. Wafaa and I.M.I. Hoda. 2011. Evaluation of fodder yield and its quality of barley and ryegrass sown alone or intercropped with Berseem clover. *Journal of Plant Production* 2: 851-863.

Hindoriya, P.S., R.K. Meena, R. Kumar, M. Singh, H. Ram, V.K. Meena, D. Ginwal, and S. Dutta. 2019. Productivity and profitability of cereal-legume forages vis-a-vis their effect on soil nutrient status in Indo-Gangetic Plains. *Legume Research* 42: 812-817.

IGFRI Vision 2050. 2018. Indian Grassland and Fodder Research Institute, Jhansi, India. pp. 1-132.

Jackson, M.L. 1967. *Soil Chemical Analysis*. Wisconsin Prentice Hall of India Private Limited, New Delhi. pp. 46.

Konapura, R., S. Prasad and B. Shivakumar. 2021. Biomass quantity and quality from different year-round cereal-legume cropping systems as forage or fodder for livestock. *Sustainability* 13: 9414-9422.

Kumar, S., D.R. Palsaniya, K.T. Kiran and S.K. Rai. 2020. Nutrient management strategies for sustainable forage production: a review. *Current Advances in Agricultural Sciences*, 6: 103-114.

Kumar and Sarlach, 2020. Effect of foliar sprays of sulphuric acid and thiourea on herbage and seed yield in Berseem. *Indian Journal of Agricultural Research* 54: 35-42.

Kumar, R., S. Kumar, M. Singh, B.S. Meena, S.K. Tomar, D. Chander, H. Ram, and D.K. Rathore. 2018. Performance of quality protein maize under different planting windows. *Indian Journal of Animal Nutrition* 33: 154-159.

Loannis, V. and K. Dhima. 2008. Forage yield and competition indices of berseem clover intercropped with barley. *Agronomy Journal* 100: 1749-1756.

Lodhi, M.Y., I.B. Marghazani, K. Hamayun and M.J. Marri. 2009. Comparative performance study of different oat varieties under agro-climatic conditions of Sibi. *Journal of Animal and Plant Sciences* 19: 34-36.

Mahanta, S.K., S.C. Garcia and M.R. Islam. 2020. Forage based feeding systems of dairy animals: issues, limitations and strategies. *Range Management and Agroforestry* 41: 188-199.

Manoj, K.N., B.G. Shekara, R.K. Agrawal and N.M. Chikkarugi. 2022. Productivity and quality of fodder as influenced by different bajra napier hybrid and legume fodder cropping systems. *Range Management and Agroforestry* 43: 88-93.

Meena, R. K., P.S. Hindoriya, R. Kumar, H. Ram, M. Singh and D. Kumar. 2023. Quality, productivity and profitability of diversified fodder-based cropping systems for year-round fodder production in Indo-gangetic plains of India. *Range Management and Agroforestry* 44: 152-159.

Mehta, S., N. Sharma, N. Rana, R. Kumar, M. Attri, F. Farooq and J.S. Mecarty. 2024. Sustainable forage cropping systems for round the year green fodder supply in irrigated subtropics of Jammu. *Range Management and Agroforestry* 45: 342-350.

Olsen, S.R., C.V. Cole, F.S. Watanabe and L.A. Dean. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. United States Department of Agriculture. *Circular* 939: 19-23.

Page, A.L., R.H. Miller and D.R. Keeney. 1982. *Methods of Soil Analysis*. Part-2 (2nd edn). *Soil Science Society of America Journal*, Madison, Wisconsin, USA. pp. 225-260.

Palsaniya, D. R., R. Singh, A. Venkatesh, R. K. Tewari and S. K. Dhyani. 2010. Grass productivity and livestock dynamics as influenced by integrated watershed management interventions in drought prone semi arid Bundelkhand, India. *Range Management and Agroforestry, Symposium Issue* (A): 4-6.

Patil, L.M., V.K. Kauthale, T.G. Bhalani and D.J. Modi. 2018. Productivity and economics of different forage production systems in south Gujarat conditions of India. *Forage Research* 44: 14-18.

Ross, S.M.J.R., J.T. King, J.K. Lopetinsky, O. Donovant and D. Spannet. 2004. Forage potential of intercropping berseem with barley, oat, or triticale. *Agronomy Journal* 96: 1013-1020.

Singh, K., H. Ram, R. Kumar, R.K. Meena and R. Kumar. 2021. Fodder quality and yields of mung bean as influenced by different weed management practices. *Indian Journal of Animal Nutrition* 38: 233-239.

Subbiah, B.V. and G.L. Asija. 1956. A rapid procedure for the determination of available nitrogen in soils. *Current Science* 25: 259-260.

Tiwari, R.R., J.S. Verma, and I.S. Agarwal. 2019. Studies on forage production potential and quality of different varieties of oats (*Avena sativa* L.). *Forage Research* 28: 134-141.

Van Soest, P.J., J.B. Robertson and B.A. Lewis. 1991. Methods for dietary fibre, neutral detergent fibre and non-starch polysaccharides in relation to animal nutrition. *Journal of Dairy Science* 74: 3583-3597.

Walkley, A.J. and I.A. Black. 1934. An examination of the Degtjareff method for determination of soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science* 37: 29-38.