The Pharma Innovation Journal 2023; SP-12(8): 1290-1297

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; SP-12(8): 1290-1297

www.thepharmajournal.com
Received: xx-06-2023
Accepted: xx-07-2023

Swati Mehta
Sher-e-Kashmir University of Agricultural Sciences and Technology, Chatha, Jammu, Jammu and Kashmir, India

Neetu Sharma
Sher-e-Kashmir University of Agricultural Sciences and Technology, Chatha, Jammu, Jammu and Kashmir, India

BC Sharma
Sher-e-Kashmir University of Agricultural Sciences and Technology, Chatha, Jammu, Jammu and Kashmir, India

Vishal Raina
Sher-e-Kashmir University of Agricultural Sciences and Technology, Chatha, Jammu, Jammu and Kashmir, India

Manish Kumar
Sher-e-Kashmir University of Agricultural Sciences and Technology, Chatha, Jammu, Jammu and Kashmir, India

Corresponding Author:
Swati Mehta
Sher-e-Kashmir University of Agricultural Sciences and Technology, Chatha, Jammu, Jammu and Kashmir, India

Strategies for round the year fodder availability

Swati Mehta, Neetu Sharma, BC Sharma, Vishal Raina and Manish Kumar

Abstract
An experiment entitled, "Strategies for round the year fodder availability" was conducted at the Research Farm, Division of Agronomy, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu during 2020-2021 and 2021-2022 to study the various forage based cropping systems for round the year green fodder availability in the irrigated conditions of Jammu. The forage based cropping system comprised of the combination of annual cereals, perennial grasses and legume crops. The experiment was laid out in a randomized block design and replicated thrice. The soil of the experimental field was non saline, sandy clay loam in texture, slightly alkaline in reaction, low in organic carbon & available nitrogen and medium in available potassium and phosphorous. The nutrients were applied according to the recommended package of practice. The efficiency of different forage based sequences was adjudged by taking system productivity and green forage yield. Statistical analysis was done with one-way ANOVA. Henceforth, based on two years study, it was concluded that Multicut Sorghum + Maize with root slips of Napier planted on the field boundaries in July recorded significantly highest green forage yield which was though statistically at par with the Multicut Sorghum + Maize with root slips of Setaria planted on the field boundaries in July followed by Multicut Sorghum + Maize with stem cuttings of Napier planted on the field boundaries in January and Multicut Sorghum + Maize with stem cuttings of Setaria planted on the field boundaries in January during *kharif* season whereas with regard to rabi season, Berseem + Oat with root slips of Napier planted on the field boundaries in July was found to be significantly superior than the other treatments.

Keywords: Annual fodder, cropping system, system productivity, legumes, perennial grasses

Introduction
Forage and livestock are the integral part of the Indian agricultural system (Ghosh *et al.*, 2016) [6]. The agriculture and livestock sector provides employment to 52 percent of the work force. Whereas, the livestock sector alone creates large self-employment opportunities and nearly 70 percent of Indian population is engaged in livestock production and management especially in rural areas (Raju, 2013) [17]. The country has a vast and diverse livestock population. India supports nearly 20 percent of world's livestock population on just 2.2 percent of the world's geographical area (Palsaniya *et al.*, 2012) [15]. India is world's largest livestock owner (535.78 million) with total bovine population of about 302.79 million and cattle population of about 192.49 million (Anonymous, 2023a) [3]. Despite being the fact that India has highest livestock population, the productivity of livestock is very low *viz.* 20 to 60 percent lower than the global average due to lack of quality fodder (Halli *et. al.*, 2018) [7]. If we trace out the possible reasons, deficiency of feed and fodder accounts for half of the total loss followed by the problems of health, breeding and reproduction and management. To compensate for the low productivity of the livestock, farmers maintain a large herd of animals, which adds to the pressure on land and fodder resources (Palsaniya *et al.*, 2008; Palsaniya *et al.*, 2009; Palsaniya *et al.*, 2010) [12, 13, 14]. On the other hand, traditional green grasses in pasture lands are reducing gradually due to urbanization and industrialization but the demand of cultivated fodders are increasing due to increasing growth of livestock sector (Singh *et al.*, 2018) [19]. Availability of green forage to animals is the key to success of dairy enterprises and it is difficult to maintain the health and milk production of the livestock without supply of green fodder. This puts a pressure to increase fodder production for a healthy livestock population. Only way to meet the fodder needs of livestock is to enhance productivity per unit land area and also through integration of fodder crops in the cropping system. But, cultivated fodder is limited to less than 4.5 percent (8.6 million hectare) out of the 159.7 million hectare area under cultivation in country with annual total forage production of 846 million tonnes (Anonymous, 2023c) [5].

Further, there are also seasonal and regional imbalances in fodder production in the country. Plenty of fodder is available during monsoon or rainy season (July-September), which reduces in winter and practically there is negligible amount of fodder during summer season. Also, the scarcity of green fodder is aggravated during lean periods of May-June and November-December. Thus, the need of the hour is not only to enhance the fodder production but also to make fodder accessible round the year for all types of dairy animals adequately. This situation can be handled through use of year round alternative sources of fodder which include perennial grasses, annual cereal fodders and legume fodders which could provide good quality fodder throughout the year so that the milk productivity as well as animal health may be maintained. The combination of graminaceous and leguminous fodder crops improves the herbage quality substantially in terms of protein and mineral balances as the legumes component contains higher amount of protein, calcium and phosphorus (Kumar *et al.*, 2014; Kumar *et al.*, 2014a; Palsaniya *et al.*, 2014) [10, 11, 16]. This system of cropping also helps to maintain soil fertility over a long period due to addition of root organic matter and better utilization of plant nutrients from different soil depth. Farmers can get round the year green fodder through proper planning of fodder production as per resources, soil type, agro climate and requirement in the cropping year. Keeping all the above stated facts in view, a study entitled "Strategies for round the year fodder availability" was taken with the objective to assess the feasibility and production potential of different forage systems to supply green fodder round the year.

Materials and Methods

Location of the study: The field experiment was conducted at the Research Farm, Agronomy, SKUAST-J, Main campus Chatha, Jammu. Geographically, 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 Shiwalik foothills of North-Western Himalayas in Jammu and Kashmir.

Climatic condition: The experimental site, in general, is endowed with hot and dry early summers followed by hot and humid summers and cold winters. During the crop growth period in first year, the maximum temperature of 41.8 °C was recorded during May whereas; minimum temperature i.e. 4.8 °C was recorded in February. On the other hand, during second year the maximum temperature was recorded in June (39.8 °C) and the minimum temperature was 2.8 °C in the month of December. As per the rainfall, the contribution of South-West monsoon rains which are usually received from June to September about 75%, whereas the remaining 25% of rains are received in few showers of cyclonic winter rains. During the first year cropping period, there was 5.66% decrease in actual rainfall than the normal rainfall whereas during the second year there was 10.23% increase in actual rainfall.

Period of study: Round the year green fodder production cropping systems were planned and executed at Research Farm, Division of Agronomy, Chatha, SKUAST - Jammu during 2020-2021 and 2021-2022. The plan was executed and laid down by in an area of approximately 1387.5 m^2 by making plots of an area of 13.125 m^2 each. Accordingly, each and every corner of land was kept under utilization of fodder as per the feasibility of an area. The data presented in the paper were taken during year 2020-21 and 2021-2022.

Crop study: Different sources of fodder, *viz.* seasonal fodders and perennial fodders were tried. In *kharif* season, fodders like Maize (*Zea mays*, Cowpea (*Vigna unguiculata* L. Walp.), Bajra (*Pennisetum glaucum*), Sorghum (*Sorghum bicolor* L. Morlch.) were sown and in *rabi* season, Berseem (*Trifolium alexandrinum*), Oats (*Avena sativa*), Lucerne (*Medicago sativa*), Barley (*Hordeum vulgare*) were sown. Hybrid Napier (*Pennisetum purpureum*) and Setaria (*Setaria sphaceualta*) were perennial grasses which were taken as boundary plantations sown 50 m apart from each other along with cereal fodders and legumes. The seasonal fodders were sown by the method of broadcasting in the plots where land was prepared twice by rotavator. In case of berseem fodder, the land was puddled and then sowing was done. The varieties of different crops used are given in Table 1. The rootslips @ 20,000/ha were used for the establishment of perennial grasses namely Hybrid Napier and Setaria with spacing of 50 cm, respectively. Crops were fertilized with the recommended dose of $N:P_2O_5:K_2O$. Full dose of P and K and half dose of N was given as basal before sowing/planting of the crops; the remaining half dose of recommended N was applied in split doses after each cut. The irrigation was given to crops as and when required.

Table 1: Information regarding crops and varieties used in the experimental research

Crop	Variety
Multicut Sorghum	Sprint Gold CSH- 24 MF
Multicut Bajra	Wonder Leaf-HB-21
Maize	African tall
Cowpea	EC4216
Berseem	BL-1
Oats	JHO-851
Barley	VL-118
Lucerne	Sirsa no. 9
Napier Grass	Hybrid Napier NB-21
Setaria	S-92

Parameter recorded: Green forage yield (t/ha) was calculated by taking fresh forage yield of *kharif* and *rabi* annual fodders with perennial grasses.

Statistical analysis: The data recorded for fodder crop characters were subjected to statistical analysis according to procedure outlined by Cochran and Cox (1963) [20].

Results

1. *Kharif* Green forage yield (t/ha)

A perusal of data presented in Table 1 and 2 regarding the green forage yield of *kharif* fodder crops sown on April 15 revealed that among the treatments T_1 to T_8, Multicut Sorghum + Cowpea with root slips of Napier planted in July (22.36 t/ha) recorded significantly higher yield at first cut which was found to be at par with Multicut Sorghum + Cowpea with root slips of *Setaria* planted in July, Multicut Sorghum + Cowpea with stem cuttings of Napier planted in January and Multicut Sorghum + Cowpea with stem cuttings of *Setaria* planted in January.

However, green forage yield of *kharif* fodder crops sown on April 30 with respect to treatment T_9 to T_{16} revealed that, Multicut Sorghum + Maize with root slips of Napier planted in July (26.00 t/ha) recorded significantly higher green forage

yield at first cut which was found to be at par with Multicut Sorghum + Maize with root slips of *Setaria* planted in July, Multicut Sorghum + Maize with stem cuttings of Napier planted in January and Multicut Sorghum + Maize with stem cuttings of *Setaria* planted in January.

It was evident from the data that from treatment T_{17} to T_{24}, *kharif* fodder crops sown on May 15 recorded significantly higher green forage yield at first cut in the treatment Multicut Sorghum + Cowpea + Maize with root slips of Napier planted in July (21.15 t/ha) which was found to be at par with Multicut Sorghum + Cowpea + Maize with root slips of *Setaria* planted in July, Multicut Sorghum + Cowpea with stem cuttings of Napier planted in January and Multicut Sorghum + Cowpea with stem cuttings of *Setaria* planted in January. Green forage yield of *kharif* annual fodder crops decreased markedly with successive cuts. By and large, similar trend was observed in second cut and third cut.

Amongst the three different staggers, Multicut Sorghum + Maize with Root slips of Napier planted in July sown on April 30 recorded significantly higher total green forage yield (69.43 t/ha) which was found to be statistically at par with Multicut Sorghum + Maize with root slips of *Setaria* planted in July, Multicut Sorghum + Maize with stem cuttings of Napier planted in January and Multicut Sorghum + Maize with stem cuttings of *Setaria* planted in January. However, significantly lowest total green forage yield was recorded with Multicut Bajra + Cowpea + Maize with stem cuttings of *Setaria* planted in January sown on May 15 with the corresponding value of 40.52 t/ha. Almost a similar trend with respect to total green forage yield was observed during second year of experimentation except for that a slight increase in green forage yield.

2. *Rabi* Green forage yield (t/ha)

The data with regard to *Rabi* green forage yield (t/ha) of *rabi* fodder crops sown on September 20 with respect to treatment T_1 to T_8 given in Table 3 and 4 revealed that Berseem + Oat with root slips of Napier planted in July recorded significantly higher green forage yield at first cut to the tune of 12.22 t/ha which was found to be at par with Berseem + Oat with root slips of *Setaria* planted in July, Berseem + Oat with stem cuttings of Napier planted in January and Berseem + Oat with stem cuttings of *Setaria* planted in January.

A critical appraisal of data with regard to green forage yield of *rabi* fodder crops sown on October 05 with respect to treatment T_9 to T_{16} revealed that significantly higher green forage yield at first cut was observed with Berseem + Barley with root slips of Napier planted in July (16.63 t/ha) which was found to be statistically at par with Berseem + Barley with root slips of *Setaria* planted in July, Berseem + Barley with stem cuttings of Napier planted in January and Berseem + Barley with stem cuttings of *Setaria* planted in January.

Further, an insight of data indicated that from treatment T_{17} to T_{24}, *rabi* fodder crops sown on October 20 recorded significantly higher green forage yield at first cut with the treatment Berseem + Oat + Barley with root slips of Napier planted in July (14.59 t/ha) which was found to be statistically at par with Berseem + Oat + Barley with root slips of *Setaria* planted in July, Berseem + Oat + Barley with stem cuttings of Napier planted in January and Berseem + Oat + Barley with stem cuttings of *Setaria* planted in January. Green forage yield of *rabi* annual fodder crops increased markedly till third cut then it showed decreasing trend in fourth and fifth cut. By and large, similar trend was observed in each subsequent cut.

Among the different forage cropping systems of three different staggers, maximum total green forage yield was recorded with Berseem + Oat with root slips of Napier planted in July sown on September 20 with the corresponding value of 91.10 t/ha which was found to be statistically at par with Berseem + Oat with root slips of *Setaria* planted in July, Berseem + Oat with stem cuttings of Napier planted in January, and Berseem + Oat with stem cuttings of *Setaria* planted in January. Significantly lowest green forage yield was recorded with Lucerne + Barley with stem cuttings of *Setaria* planted in January sown on October 05 to the tune of 52.22 t/ha. Almost a similar trend with respect to total green forage yield was observed during second year of experimentation except for that a slight increase in green forage yield.

Table 1: Effect of *kharif* annual fodder with perennial grasses on green forage yield (t/ha)

Treatments		I cut		II cut		III cut		Total Yield	
		2020	2020	2020	2020	2020	2020	2020	2020
		Kharif	Perennial	*Kharif*	Perennial	*Kharif*	Perennial	*Kharif*	Perennial
T_1	Multicut Bajra + Cowpea with Stem cuttings of Napier planted in January	20.69	23.21	15.10	23.96	12.43	24.64	48.22	71.81
T_2	Multicut Bajra + Cowpea with Stem cuttings of Setaria planted in January	20.51	07.41	14.92	08.16	12.25	08.84	47.68	24.41
T_3	Multicut Sorghum + Cowpea with Stem cuttings of Napier planted in January	22.14	23.24	16.55	23.99	13.88	24.67	52.57	71.90
T_4	Multicut Sorghum + Cowpea with Stem cuttings of Setaria planted in January	21.87	07.3	16.29	08.05	13.62	08.73	51.78	24.08
T_5	Multicut Bajra + Cowpea with Root slips of Napier planted in July	20.92	23.66	15.31	24.41	12.64	25.09	48.87	73.16
T_6	Multicut Bajra + Cowpea with Root slips of Setaria planted in July	20.89	07.36	15.25	08.11	12.60	08.79	48.74	24.26
T_7	Multicut Sorghum + Cowpea with Root slips of Napier planted in July	22.36	23.69	16.77	24.44	14.10	25.12	53.23	73.25
T_8	Multicut Sorghum + Cowpea with Root slips of Setaria planted in July	22.34	07.25	16.75	08.00	14.08	08.68	53.17	23.93
T_9	Multicut Bajra + Maize with Stem cuttings of Napier planted in January	23.68	23.89	19.84	24.64	17.17	25.32	60.69	73.85
T_{10}	Multicut Bajra + Maize with Stem cuttings of Setaria planted in January	23.65	07.61	19.79	08.36	17.12	09.04	60.56	25.01
T_{11}	Multicut Sorghum + Maize with Stem cuttings of Napier planted in January	25.84	23.26	23.01	24.01	20.34	24.69	69.19	71.96
T_{12}	Multicut Sorghum + Maize with Stem cuttings of Setaria planted in January	25.76	07.75	22.93	08.50	20.26	09.18	68.95	25.43
T_{13}	Multicut Bajra + Maize with Root slips of Napier planted in July	23.91	24.34	19.81	25.09	17.14	25.77	60.86	75.20
T_{14}	Multicut Bajra + Maize with Root slips of Setaria planted in July	23.84	07.84	19.78	08.59	17.10	09.27	60.72	25.70

T_{15}	Multicut Sorghum + Maize with Root slips of Napier planted in July	26.00	23.71	23.05	24.46	20.38	25.14	69.43	73.31
T_{16}	Multicut Sorghum + Maize with Root slips of Setaria planted in July	25.99	07.69	22.98	08.44	20.29	09.12	69.26	25.25
T_{17}	Multicut Bajra + Cowpea + Maize with Stem cuttings of Napier planted in January	19.62	23.53	12.04	24.28	9.36	24.96	41.02	72.77
T_{18}	Multicut Bajra + Cowpea + Maize with Stem cuttings of Setaria planted in January	19.45	07.34	11.87	08.09	9.20	08.77	40.52	24.20
T_{19}	Multicut Sorghum + Cowpea + Maize with Stem cuttings of Napier planted in January	21.08	23.96	13.23	24.71	10.56	25.39	44.87	74.06
T_{20}	Multicut Sorghum + Cowpea + Maize with Stem cuttings of Setaria planted in January	20.65	07.88	13.15	08.63	10.51	09.31	44.31	25.82
T_{21}	Multicut Bajra + Cowpea + Maize with Root slips of Napier planted in July	19.81	23.98	12.19	24.73	9.48	25.41	41.48	74.12
T_{22}	Multicut Bajra + Cowpea + Maize with Root slips of Setaria planted in July	19.70	07.25	12.12	08.00	9.46	08.68	41.28	23.93
T_{23}	Multicut Sorghum + Cowpea + Maize with Root slips of Napier planted in July	21.15	23.41	13.56	24.16	10.75	24.84	45.46	72.41
T_{24}	Multicut Sorghum + Cowpea + Maize with Root slips of Setaria planted in July	21.14	07.84	13.49	08.59	10.70	09.27	45.33	25.70
S.Em (±)		0.38	0.92	0.38	1.01	0.39	0.82	1.11	1.19
CD (5%)		1.14	2.77	1.15	3.03	1.17	2.47	3.20	3.44

Table 2: Effect of *kharif* annual fodder with perennial grasses on green forage yield (t/ha)

Treatments		I cut		II cut		III cut		Total Yield	
		2021	2021	2021	2021	2021	2021	2021	2021
		Kharif	Perennial	*Kharif*	Perennial	*Kharif*	Perennial	*Kharif*	Perennial
T_1	Multicut Bajra + Cowpea with Stem cuttings of Napier planted in January	21.07	23.84	15.46	24.39	12.84	24.68	49.37	72.91
T_2	Multicut Bajra + Cowpea with Stem cuttings of Setaria planted in January	20.89	08.04	15.28	08.59	12.66	08.88	48.83	25.51
T_3	Multicut Sorghum + Cowpea with Stem cuttings of Napier planted in January	22.52	23.87	16.91	24.42	14.29	24.71	53.72	73.00
T_4	Multicut Sorghum + Cowpea with Stem cuttings of Setaria planted in January	22.25	07.93	16.66	08.48	14.03	08.77	52.94	25.18
T_5	Multicut Bajra + Cowpea with Root slips of Napier planted in July	21.28	24.29	15.67	24.84	13.05	25.13	50.00	74.26
T_6	Multicut Bajra + Cowpea with Root slips of Setaria planted in July	21.06	07.99	15.60	08.54	12.80	08.83	49.46	25.36
T_7	Multicut Sorghum + Cowpea with Root slips of Napier planted in July	22.74	24.32	17.13	24.87	14.52	25.16	54.39	74.35
T_8	Multicut Sorghum + Cowpea with Root slips of Setaria planted in July	22.72	07.88	17.11	08.43	14.49	08.72	54.32	25.03
T_9	Multicut Bajra + Maize with Stem cuttings of Napier planted in January	24.06	24.52	20.15	25.07	17.58	25.36	61.79	74.95
T_{10}	Multicut Bajra + Maize with Stem cuttings of Setaria planted in January	24.04	08.24	20.15	08.79	17.53	09.08	61.72	26.11
T_{11}	Multicut Sorghum + Maize with Stem cuttings of Napier planted in January	26.22	23.89	23.37	24.44	20.75	24.73	70.34	73.06
T_{12}	Multicut Sorghum + Maize with Stem cuttings of Setaria planted in January	26.14	08.38	23.29	08.93	20.67	09.22	70.10	26.53
T_{13}	Multicut Bajra + Maize with Root slips of Napier planted in July	24.31	24.97	20.17	25.52	17.55	25.81	62.03	76.30
T_{14}	Multicut Bajra + Maize with Root slips of Setaria planted in July	24.22	08.47	20.01	09.02	17.39	09.31	61.62	26.80
T_{15}	Multicut Sorghum + Maize with Root slips of Napier planted in July	26.38	24.34	23.41	24.89	20.79	25.18	70.58	74.41
T_{16}	Multicut Sorghum + Maize with Root slips of Setaria planted in July	26.34	08.32	23.32	08.87	20.60	09.16	70.26	26.35
T_{17}	Multicut Bajra + Cowpea + Maize with Stem cuttings of Napier planted in January	19.99	24.16	12.40	24.71	9.77	25.00	42.16	73.87
T_{18}	Multicut Bajra + Cowpea + Maize with Stem cuttings of Setaria planted in January	19.83	07.97	12.23	08.52	9.63	08.81	41.69	25.30
T_{19}	Multicut Sorghum + Cowpea + Maize with Stem cuttings of Napier planted in January	21.68	24.59	13.59	25.14	10.96	25.43	46.23	75.16
T_{20}	Multicut Sorghum + Cowpea + Maize with Stem cuttings of Setaria planted in January	21.52	08.51	13.43	09.06	10.81	09.35	45.76	26.92
T_{21}	Multicut Bajra + Cowpea + Maize with Root slips of Napier planted in July	20.12	24.61	12.52	25.16	9.95	25.45	42.59	75.22
T_{22}	Multicut Bajra + Cowpea + Maize with Root slips of Setaria planted in July	20.08	07.88	12.48	08.43	9.87	08.72	42.43	25.03
T_{23}	Multicut Sorghum + Cowpea + Maize with Root slips of Napier planted in July	21.35	24.04	13.82	24.59	11.29	24.88	46.46	73.51
T_{24}	Multicut Sorghum + Cowpea + Maize with Root slips of Setaria planted in July	21.25	11.72	13.79	12.27	11.21	12.56	46.25	36.55
S.Em (±)		0.42	0.33	0.91	0.41	0.94	0.37	0.94	1.19
CD (5%)		1.14	1.05	2.66	1.23	2.83	1.12	2.73	3.45

Table 3: Effect of *rabi* annual fodder with perennial grasses on green forage yield (t/ha)

Treatments		I cut		II cut		III cut		IV Cut		V Cut		Total Yield	
		2020-2021	2020-2021	2020-2021	2020-2021	2020-2021	2020-2021	2020-2021	2020-2021	2020-2021	2020-2021	2020-2021	2020-2021
		Rabi	Perennial	*Rabi*	Perennial	*Rabi*	Perennial	*Rabi*	Perennial	*Rabi*	Perennial	*Rabi*	Perennial
T_1	Berseem + Oat with Stem cuttings of Napier planted in January	12.09	24.83	16.99	24.99	21.73	25.33	20.88	25.61	19.03	26.02	90.57	126.78
T_2	Berseem + Oat with Stem cuttings of Setaria planted in January	12.01	9.03	16.91	9.19	21.54	9.53	20.69	9.81	18.84	10.22	89.99	47.78
T_3	Lucerne + Oat with Stem cuttings of Napier planted in January	8.64	24.86	13.54	25.02	14.95	25.36	14.1	25.64	12.25	26.05	63.48	126.93
T_4	Lucerne + Oat with Stem cuttings of Setaria planted in January	8.29	8.92	13.32	9.08	14.73	9.42	13.88	9.7	12.03	10.11	62.25	47.23
T_5	Berseem + Oat with Root slips of Napier planted in July	12.22	25.28	17.12	25.44	21.77	25.78	20.92	26.06	19.07	26.47	91.10	129.03
T_6	Berseem + Oat with Root slips of Setaria planted in July	12.15	8.98	17.05	9.14	21.68	9.48	20.83	9.76	18.98	10.17	90.84	47.53
T_7	Lucerne + Oat with Root slips of Napier planted in July	8.69	25.31	13.59	25.47	15	25.81	14.15	26.09	12.3	26.5	63.73	129.18
T_8	Lucerne + Oat with Root slips of Setaria planted in July	8.68	8.87	13.58	9.03	14.99	9.37	14.14	9.65	12.29	10.06	63.68	46.98
T_9	Berseem + Barley with Stem cuttings of Napier planted in January	16.22	25.51	18.22	25.67	18.1	26.01	17.25	26.29	15.4	26.7	85.19	130.18
T_{10}	Berseem + Barley with Stem cuttings of Setaria planted in January	16.11	9.23	18.11	9.39	18.07	9.73	17.22	10.01	15.37	10.42	84.88	48.78
T_{11}	Lucerne + Barley with Stem cuttings of Napier planted in January	10.58	24.88	12.58	25.04	11.26	25.38	10.42	25.66	8.57	26.07	53.41	127.03
T_{12}	Lucerne + Barley with Stem cuttings of Setaria planted in January	10.33	9.37	12.35	9.53	11.03	9.87	10.18	10.15	8.33	10.56	52.22	49.48
T_{13}	Berseem + Barley with Root slips of Napier planted in July	16.63	25.96	18.65	26.12	18.38	26.46	17.53	26.74	15.68	27.15	86.87	132.43
T_{14}	Berseem + Barley with Root slips of Setaria planted in July	16.56	9.46	18.56	9.62	18.29	9.96	17.44	10.24	15.59	10.65	86.44	49.93
T_{15}	Lucerne + Barley with Root slips of Napier planted in July	10.91	25.33	12.91	25.49	11.59	25.83	10.74	26.11	8.89	26.52	55.04	129.28
T_{16}	Lucerne + Barley with Root slips of Setaria planted in July	10.98	9.31	12.65	9.47	11.33	9.81	10.48	10.09	8.63	10.5	54.07	49.18
T_{17}	Berseem + Oat + Barley with Stem cuttings of Napier planted in January	14.25	25.15	18.35	25.31	19.11	25.65	18.28	25.93	16.43	26.34	86.42	128.38
T_{18}	Berseem + Oat + Barley with Stem cuttings of Setaria planted in January	14.18	8.96	18.24	9.12	19.04	9.46	18.19	9.74	16.34	10.15	85.99	47.43
T_{19}	Lucerne + Oat + Barley with Stem cuttings of Napier planted in January	9.24	25.58	12.87	25.74	14.55	26.08	12.91	26.36	10.95	26.77	60.52	130.53
T_{20}	Lucerne + Oat + Barley with Stem cuttings of Setaria planted in January	9.2	9.5	12.98	9.66	13.52	10	13.11	10.28	11.92	10.69	60.73	50.13
T_{21}	Berseem + Oat + Barley with Root slips of Napier planted in July	14.59	25.6	18.57	25.76	19.21	26.1	18.36	26.38	16.51	26.79	87.24	130.63
T_{22}	Berseem + Oat + Barley with Root slips of Setaria planted in July	14.5	8.87	18.53	9.03	19.12	9.37	18.27	9.65	16.41	10.06	86.83	46.98
T_{23}	Lucerne + Oat + Barley with Root slips of Napier planted in July	9.4	25.03	13.04	25.19	14.3	25.53	13.45	25.81	11.6	26.22	61.79	127.78
T_{24}	Lucerne + Oat + Barley with Root slips of Setaria planted in July	9.35	9.36	12.92	9.85	13.87	10.12	13.02	10.95	11.17	11.12	60.33	51.40
S.Em (±)		0.41	0.86	0.90	0.87	0.93	0.97	0.92	0.89	0.91	0.87	1.27	1.34
CD (5%)		1.21	2.57	2.69	2.62	2.81	2.92	2.77	2.67	2.72	2.63	3.83	4.03

Table 4: Effect of *rabi* annual fodder with perennial grasses on green forage yield (t/ha)

Treatments		I cut		II cut		III cut		IV Cut		V Cut		Total Yield	
		2020-2021	2020-2021	2020-2021	2020-2021	2020-2021	2020-2021	2020-2021	2020-2021	2020-2021	2020-2021	2020-2021	2020-2021
		Rabi	Perennial	*Rabi*	Perennial	*Rabi*	Perennial	*Rabi*	Perennial	*Rabi*	Perennial	*Rabi*	Perennial
T_1	Berseem + Oat with Stem cuttings of Napier planted in January	12.24	25.09	17.34	25.47	22.32	25.90	21.90	26.41	20.11	26.73	93.93	129.6
T_2	Berseem + Oat with Stem cuttings of Setaria planted in January	12.16	9.29	17.26	9.67	22.13	10.10	21.71	10.61	19.92	10.93	93.2	50.6
T_3	Lucerne + Oat with Stem cuttings of Napier planted in January	8.79	25.12	13.89	25.5	15.54	25.93	15.12	26.44	13.33	26.76	66.66	129.75
T_4	Lucerne + Oat with Stem cuttings of Setaria planted in January	8.44	9.18	13.67	9.56	15.32	9.99	14.9	10.5	13.11	10.82	65.45	50.05
T_5	Berseem + Oat with Root slips of Napier planted in July	12.37	25.54	17.47	25.92	22.36	26.35	21.94	26.86	20.15	27.18	94.29	131.85
T_6	Berseem + Oat with Root slips of Setaria planted in July	12.3	9.24	17.4	9.62	22.27	10.05	21.85	10.56	20.06	10.88	93.9	50.35
T_7	Lucerne + Oat with Root slips of Napier planted in July	8.84	25.57	13.94	25.95	15.59	26.38	15.17	26.89	13.38	27.21	66.94	132
T_8	Lucerne + Oat with Root slips of Setaria planted in July	8.83	9.13	13.93	9.51	15.58	9.94	15.16	10.45	13.37	10.77	66.87	49.8
T_9	Berseem + Barley with Stem cuttings of Napier planted in January	16.37	25.77	18.57	26.15	18.69	26.58	18.27	27.09	16.48	27.41	88.36	133
T_{10}	Berseem + Barley with Stem cuttings of Setaria planted in January	16.26	9.49	18.46	9.87	18.66	10.3	18.24	10.81	16.45	11.13	88.06	51.6
T_{11}	Lucerne + Barley with Stem cuttings of Napier planted in January	10.73	25.14	12.93	25.52	11.85	25.95	11.44	26.46	9.63	26.78	56.58	129.85
T_{12}	Lucerne + Barley with Stem cuttings of Setaria planted in January	10.48	9.63	12.7	10.01	11.62	10.44	11.2	10.95	9.41	11.27	55.41	52.3
T_{13}	Berseem + Barley with Root slips of Napier planted in July	16.78	26.22	19	26.6	18.97	27.03	18.55	27.54	16.76	27.86	90.06	135.25
T_{14}	Berseem + Barley with Root slips of Setaria planted in July	16.71	9.72	18.91	10.1	18.88	10.53	18.46	11.04	16.67	11.36	89.61	52.75
T_{15}	Lucerne + Barley with Root slips of Napier planted in July	11.06	25.59	13.26	25.97	12.18	26.4	11.76	26.91	9.97	27.23	58.25	132.1
T_{16}	Lucerne + Barley with Root slips of Setaria planted in July	11.14	9.57	13.02	9.95	11.92	10.38	11.5	10.89	9.71	11.21	57.3	52
T_{17}	Berseem + Oat + Barley with Stem cuttings of Napier planted in January	14.4	25.41	18.72	25.79	19.7	26.22	19.3	26.73	17.51	27.05	89.65	131.2
T_{18}	Berseem + Oat + Barley with Stem cuttings of Setaria planted in January	14.33	9.22	18.61	9.6	19.97	10.03	19.21	10.54	17.42	10.86	89.54	50.25
T_{19}	Lucerne + Oat + Barley with Stem cuttings of Napier planted in January	9.39	25.84	13.24	26.22	14.14	26.65	13.72	27.16	11.93	27.48	62.42	133.35
T_{20}	Lucerne + Oat + Barley with Stem cuttings of Setaria planted in January	9.3	9.76	13.29	10.14	14.01	10.57	13.59	11.08	11.8	11.4	62	52.95
T_{21}	Berseem + Oat + Barley with Root slips of Napier planted in July	14.74	25.86	18.94	26.24	19.8	26.67	19.38	27.18	17.59	27.5	90.46	133.45
T_{22}	Berseem + Oat + Barley with Root slips of Setaria planted in July	14.65	9.13	18.9	9.51	19.7	9.94	19.29	10.45	17.49	10.77	90.03	49.8
T_{23}	Lucerne + Oat + Barley with Root slips of Napier planted in July	9.55	25.29	13.41	25.67	14.89	26.1	14.48	26.61	12.68	26.93	65	130.6
T_{24}	Lucerne + Oat + Barley with Root slips of Setaria planted in July	9.5	9.72	13.29	10.1	14.46	10.53	14.04	11.04	12.25	11.36	63.55	52.75
S.Em (±)		0.54	0.87	0.89	0.90	0.89	0.94	0.94	0.84	0.91	0.92	1.26	1.34
CD (5%)		1.63	2.62	2.59	2.69	2.66	2.82	2.83	2.52	2.73	2.77	3.79	4.03

Discussion

Green forage yield is a function of genetic as well as the environmental factors, which play a vital role in plant growth and development and ultimately contributed to fodder yield Ahmad *et al*. (2011) [1].

Green forage yield witnessed significant results at each cut in the *kharif* fodder crops, *rabi* fodder crops and perennial grasses depicted in the Tables 1, 2 and 3. The data regarding

kharif fodder crops yield observed a noticeable decrease in green fodder at first cut, second cut and third cut. This might be due to the fact that Multicut varieties of Sorghum and Bajra were sown in mixed cropping with single cut varieties of crops *viz.* cowpea and maize. The significantly highest yield was obtained with Sorghum + Maize combination over the others. The main cause of the difference in green fodder was due to difference in genetic makeup of genotypes of different crops or possibly attributed to their difference in leaf area, responsible for more photosynthetic activities having high capacity to store assimilative products of photosynthesis. These results are in close conformity with the finding of Lodhi *et al*., 2009 [21].

The data pertaining to *rabi* fodder crops yield observed a noticeable increase in green fodder at first cut, second cut, third cut whereas in fourth and fifth cut there was a slight decrease in green fodder yield. This might be due to differential day-to-day variation in daily temperature across the crop growing season, greater intensity with different patterns of rainfall and variation in relative humidity (Ahmad *et al.*, 2007) [1]. The overall results indicated that Berseem + Oats gave significantly highest yield over the others. This might be attributed to the fact that Berseem when sown with cereal crop as a mixed crop leads to more efficient absorption of nutrients from the soil, more interception of light energy at different layers and finally more photosynthetic rate, better translocation of photosynthates from source to sink lead to higher green forage yield (Kumar and Sarlach., 2020) [9].

On the other hand, a cursory look of data with regard to green forage yield of perennial grasses revealed that there was noticeable increase in green fodder at each cut. Significantly highest green forage yield was obtained with Napier grass. This might be due to the fact that Napier being a perennial crop performs better in good type of soil with assured irrigations. Moreover, the higher yield might be attributed to the genetic production potential of Napier grass over *Setaria* grass.

Further, the data regarding yield revealed that the green forage yield of *kharif, rabi* and perennial fodders were slightly higher during the second cropping cycle in comparison to the first cropping cycle. This might be due to better soil health in all the cropping systems because each cropping system having leguminous crops and legume effect of previous year. The increase in yield of crops in the second year might be due to the incorporation of legume crops (cowpea, berseem, lucerne) into cropping systems. This could be due to better soil health in all the cropping systems with leguminous crops, which improved the physico-chemical properties of soil and improved the organic matter and nutrient status of the soil, so supply of nutrients in continuous manner enhanced the availability and uptake of nutrients by crop roots, carbon assimilation rate, formation of starch, synthesis of sugar and protein also increase the process of differentiation of tissue led to higher forage yield. These results were in conformity with the findings of Ahmad *et al*. (2007) [1], Kumar and Sarlach (2020) [9].

Conclusion

Henceforth, based on two years study, it was concluded that treatment T1b (Multicut Bajra + Maize -Berseem + Barley with stem cuttings of Napier planted on the field boundaries in January) was found to be the best feasible sustainable forage cropping system for round the year availability of quality fodder with the maximum yield.

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