



Developing cropping sequence modules for round the year green fodder production under irrigated conditions in North-west Himalayan region

MANPREET KOUR¹, NAZAM KHAN¹, RAJIV SINGH¹, B C SHARMA¹, N P THAKUR¹, MANDEEP SINGH AZAD¹, PARSHOTAM KUMAR¹, PUNEET CHOUDHARY¹ and SUMIT MAHAJAN^{2✉}

Sher-e-Kashmir University of Agricultural Sciences and Technology, Chatha, Jammu, Jammu and Kashmir 180 009 India

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ABSTRACT

The objective of the experiment was to develop cropping sequence modules for round the year green fodder production for feeding 50 dairy cattle under irrigated conditions in North-West Himalayan region. Various modules were initiated at Research Farm of Instructional Livestock Farm Centre, R.S. Pura, FVSc. & A.H., SKUAST-Jammu during 2016 in an area of 2.5 ha. The experimental data was collected after fully establishing fodder unit during 2017-18 and 2018-19. Five fodder sequences modules viz. Module 1 – Maize+Cowpea-Berseem+Mustard; Module 2- Swankhi, Cowpea, Bajra-Berseem+Oats; Module 3 – Sorghum-oats; Module 4 – perennial module (two perennial grasses and two fodder trees) and Module 5 – azolla (supplemental module) were developed for ensuring supply of quality green fodder round the year to feed 50 dairy animals. The efficiency of modules was adjudged by taking system productivity and economic parameters of fodder and milk yield, and composition parameters for lactation study. Statistical analysis was done with one-way and two-way ANOVA. Among annual crop sequence modules, Module 1 showed highest system productivity, maximum net returns and B:C ratio while among perennial fodder grasses, hybrid napier produced significantly highest system productivity along with maximum net returns and B:C ratio. Among fodder trees, *Bauhinia variegata* had maximum productivity. Further, lactation studies revealed that highest total milk yield of 12 animals (10 cows and 2 buffaloes) and milk components (10 cows), viz. fat yield, protein yield, lactose yield, SNF yield, etc. were achieved when animals were fed with mixed fodder of maize+cowpea whereas, the highest milk energy was found from those sampled cows which were fed berseem+oats. Thus, under subtropical conditions of Jammu, Maize+Cowpea-Berseem+Mustard—module was considered more remunerative based on system productivity and milk parameters followed by perennial fodder and Sorghum-oat module.

Keywords: Annual fodder, Cropping sequence, Cropping modules, Energy productivity, Fodder production, Lactation study, Milk yield, Milk composition, Perennial fodder, Supplemental fodder

Under the scenarios of climate change and fragmented land holdings, the dairy farming is appearing as most resilient and profitable enterprise of Indian agriculture sector whose success depends on the feed and fodder of high nutritional value, which accounts for over two-third of total animal production costs (Ginwal *et al.* 2019). Good quality green fodders in balanced ratio plays an important role to make livestock as a profitable farm enterprise (Mohapatra *et al.* 2019).

In India, the area under cultivated fodder is only 8.4 million ha and it has been static during last two decades. Our country is facing a net deficiency of 35.6% green fodder, 10.95% dry fodder and 44% concentrate feed materials (Singh *et al.* 2022). This has forced majority of the farmers to feed their animals on poor quality crop

residue or wild grasses (Hegde 2019). Insufficient and poor-quality fodder is jeopardizing animal health and milk productivity. Despite India leading globally in milk production, the animal productivity is low (1538 kg/year) over global average (2238 kg/year), which can be linked to malnutrition due to huge deficit of animal feed (Vijay *et al.* 2018).

Further, due to Indian seasonal variations, plenty of green fodder is available during rainy season (July to September), followed by winter and practically negligible amount during summer season. Also, this scarcity is aggravated during lean periods of May-June and November-December. This seasonal scarcity can reduce the milk yield from 5.6 litres per cow per day in the wet season to 3.0 litres in the dry season along with declined energy (6.0 MJ/kg in wet season to 4.8 MJ/kg in dry season) and crude protein (10.1% in wet season to 7.8% in dry season) (Maleko *et al.* 2018). Thus, the need of the hour is not only to enhance the fodder production, but also to make the quality fodder accessible round the year mitigating seasonal variations for all types of dairy animals.

Present address: ¹Sher-e-Kashmir University of Agricultural Sciences and Technology, Chatha, Jammu, Jammu and Kashmir.

²Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar, Haryana. ✉Corresponding author email: sumit.mahajan@luvas.edu.in

This situation can be handled through developing round the year fodder production modules, through agronomical interventions, i.e. by staggering planting time of seasonal fodders, blending legumes with cereals and using alternative sources of perennial fodders i.e., grasses, location specific fodder trees, supplemental fodder along with annual sources of fodder, which could enhance herbage yield, quality and hence, animal productivity.

Hence, the present investigation was undertaken with an objective to make strategies for developing modules of round the year supply of quality green fodder production for feeding 50 crossbred cattle under irrigated conditions of North-Western Himalayas.

MATERIALS AND METHODS

Location of the study: Geographically, the experimental site is situated in the sub-tropical Shiwalik foothills of Jammu and Kashmir at 32°60' N latitude and 74°73' E longitude at an elevation of 270 meter above mean sea level.

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, May and June were the hottest month with an average maximum temperature of 38.3°C and 38.1°C, respectively. Maximum temperature range varied from 18 to 19°C in the month of December and January and 40°C in the month of June. 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 from December to March with mean annual rainfall of about 1174 mm. During the cropping period, the total annual rainfall ranged between 800 mm to 1150 mm. Mean maximum and mean minimum relative humidity varied from 25% (May-June) to 95% (December-January).

Period of study: Round the year quality green fodder production model was planned and executed at Fodder unit of Division of Instructional Livestock Farm Centre (ILFC) at R.S. Pura, FVSc. &A.H., SKUAST-Jammu during 2016 for feeding about 50 crossbred cattle. The plan was executed and laid down by in an area of approximately 2.5 ha by making blocks of an area of 0.4 ha. 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 2017-18 and 2018-19.

Crop study: Different sources of fodder, viz. seasonal fodders, perennial fodders grasses and trees, and supplemental fodder azolla (rich source of protein) were tried. In *kharif* season, fodders like Maize (*Zea mays*)+cowpea (*Vigna unguiculata* L. Walp.), Swankhi (*Echinochloa frumentaceae*), Bajra (*Pennisetum glaucum*), Cowpea (*Vigna unguiculata* L. Walp.), Sorghum (*Sorghum bicolor* L. Morlch.) were sown and in *rabi* season, Berseem (*Trifolium alexandrinum*)+Mustard (*Brassica campestris*, var. *Sarson*), Berseem (*Trifolium alexandrinum*)+oats (*Avena sativa*), and oats (*Avena sativa*), were sown

and in perennial fodders grasses like hybrid napier (*Pennisetum purpureum*), Para grass (*Brachiaria amutica*) and in fodder tree spp. *Bauhinia variegata* and *Albizia* spp. were taken as boundary plantations 5 m apart from each other. The supplemental fodder *Azolla pinnata* was grown from waste pits and drains. Following seasonal fodder sequences were tested in blocks: Maize + cowpea-Berseem + mustard, Swankhi + Cowpea + Bajra-Berseem + Oats, Sorghum-oats. The information regarding the date of sowing and harvesting of fodder crop is presented in Table 1.

The seasonal fodders except berseem were sown by the method of broadcasting in the blocks 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 were: Maize ('African tall'), cowpea ('GFC-2'), Swankhi ('local variety'), Bajra ('CO-8'), Sorghum ('M.P. Charri'), Berseem ('Mescavi'), oats ('Kent'), hybrid napier ('NB-21') and pargrass ('Local variety'), respectively. Seed rate maintained for various seasonal crops were: Maize+cowpea (70+10 kg/ha), Swankhi (25 kg/ha), Bajra (10kg/ha), Cowpea (60 kg/ha), Sorghum (60 kg/ha), Berseem+Mustard (25+5 kg/ha), Berseem+oats (25+40 kg/ha), Oats (100 kg/ha). The rootslips @ 18,000/ha was used for the establishment of perennial grasses namely hybrid napier and Para grass with spacing of 90 cm × 70 cm and 60 cm × 60 cm, respectively. Crops were fertilized with the recommended dose of N:P₂O₅:K₂O, viz. Maize+cowpea (90:30:30), Swankhi (60:20:15), Bajra (60:40:0), Cowpea (40:60:0), Sorghum (60:40:20), Berseem+Mustard (50:50:0), Berseem+Oats (50:50:0), Oats (40:40:20). 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. For azolla cultivation, artificial water bodies or waste pits and drains were used. About 10-15 kg of fertile soil was mixed with 5 kg of cow dung by using 10 litres of water and was uniformly added in the pit to make the water level at about 10-20 cm. About 1 kg of fresh healthy azolla seed culture was inoculated in the waste pits/drains. Within 7-10 days, azolla filled the pit and about 1 kg of azolla/pit was harvested daily thereafter. To keep the growth of azolla in rapid multiplication phase, about 1 kg of sieved soil and 1 kg of cow dung (1:1) was made into slurry in 2 litres of water and poured in to the pit at 10 days interval as per need. Azolla was harvested by using plastic sieves, washed and then stored.

Experimental animals: The lactation study was conducted at Dairy farm, ILFC. Although, all fifty dairy cattle were fed with green fodder, the lactation study was conducted on twelve animals, viz. ten cows of Holstein Friesian breed and two buffaloes of Murrah breed. The animals were selected on the basis of parity (10 to 50 days in milk). Ten cows were milked by machine milking whereas two buffaloes were hand milked. Buffalo milk was taken in to consideration for estimation of milk yield

Table 1. Module wise information of sowing and harvesting dates under round the year fodder production

Module	Kharif	Rabi	Area (ha)	Date of sowing		Date of harvesting					
				Kharif	Rabi	Kharif		Rabi			
						1 st	2 nd	1 st	2 nd	3 rd	4 th
1	Maize+ Cowpea	Berseem+ Mustard	0.4	1 st May	1 st Oct.	1 st July- 14 th July	1 st Sept.- 6 th Sep.	1 st Dec.- 7 th Dec.	1 st Jan.- 17 th Jan.	20 th Feb.- 28 th Feb.	1 st Apr.- 8 th Apr.
1	Maize +Cowpea	Berseem +Mustard	0.4	15 th May	15 th Oct.	15 th July- 31 st July	3 rd Oct.- 10 th Oct.	8 th Dec.- 18 th Dec.	18 th Jan.- 31 st Jan.	1 st Mar.- 8 th Mar.	19 th Apr.- 23 rd Apr.
2	Swankhi	Berseem +Oats	0.2	1 st June	15 th Oct.	1 st Aug.- 4 th Aug.	7 th Sept.- 9 th Sept.	19 th Dec.-	1 st Feb.- 10 th Feb.	9 th Mar.- 20 th Mar.	24 th Apr.- 30 th Apr.
	Bajra	Berseem+ Oats	0.2	1 st June	15 th Oct.	8 th Aug.- 13 th Aug.	1 st Oct.- 2 nd Oct.	28 th Dec.			
	Cowpea	Berseem+ Oats	0.1	1 st June	15 th Oct.	5 th Aug.- 7 th Aug.	-				
3	Sorghum	Oats	0.4	15 th June	30 th Oct.	14 th Aug.-31 st Aug.	11 th Oct.- 27 th Oct.	25 th Dec.-	21 st Mar.-	-	-
3	Sorghum	Oats	0.4	1 st July	15 th Nov.	10 th Sep.- 30 th Sept.	1 st Nov.- 20 th Nov.	11 th Feb.- 26 th Feb.	9 th Apr.- 18 th Apr.	-	-
4 & 5	Perennial fodder		0.35	July	-	1 st May- 31 st May/ 1 st June- 28 th June	-	28 th Oct- 31 st Oct./ 21 st Nov.- 27 th Nov	-	-	-
	Hybrid Napier										
	Para grass		0.05	August	-	29 th June-30 th June	-	28 th Nov.-30 th Nov.			
	Fodder trees Supplemental fodder (Azolla)	Boundary Pits/ waste bodies		July	-	-	-	31 st Oct.			

parameters while for milk composition, the pooled milk of ten cows was taken in to consideration.

Parameter recorded: System productivity (kg/ha/year) was calculated by adding produce of different seasons in a year and benefit cost ratio was calculated on the basis of net returns.

Daily milk yield was recorded by using weighing balance. For milk composition, the milk samples were collected on 1st, 15th and last day of every month from pooled milk of ten cows excluding buffaloes and analyzed for composition viz. milk fat, protein, lactose and solid not fat as per standard method of AOAC (2005) by automatic milk analyzer (Lactostar). Fat and energy corrected milk (4%) (ECM), milk energy was calculated by the equation given by Tyrrell and Reid (1965), where SCM is solid corrected milk, which was calculated as follows:

$$\text{SCM (Kg)} = 12.3(\text{F}) + 6.56(\text{SNF}) + 0.0752(\text{M})$$

where F, SNF and M were expressed as kg of fat, kg of solid not fat and kg of milk yield, respectively.

Statistical analysis: The data recorded for fodder crop characters were subjected to statistical analysis according

to procedure outlined by Cochran and Cox (1963). Milk parameters were statistically analysed by using the method outlined by Snedecor and Cochran (1989) by using SPSS software.

RESULTS AND DISCUSSION

Round the year supply of green fodder plan to meet the fodder needs of 50 crossbred cattle was executed in fodder unit of Division of ILFC by integration of annual and perennial fodder sources in such a way that perennial sources provide fodder especially during lean period for the month of May to June, and October to November while annual fodders provide green fodder during seasons. Moreover, the system provides a balanced blending of cereals with leguminous fodder so that more desirable nutritional quality fodder is ensured for animals. The following cropping sequences modules were developed for ensuring round the year greenfodder production and their effect on lactation process.

Module 1: Maize+Cowpea-Berseem+Mustard: The fodder sequence maize along with cowpea was sown

Table 2. Green fodder yield (q/block) from different fodder modules under round the year fodder production

Blocks	<i>Kharif</i>	<i>Rabi</i>	Area (ha)	<i>Kharif</i> yield		Total <i>kharif</i> yield	<i>Rabi</i> yield				Total <i>rabi</i> yield	Total system yield
				1 st cut	2 nd cut		1 st	2 nd	3 rd	4 th		
A	Maize+Cowpea	Berseem + Mustard	0.4	210	40	250	77	125	74	58	334	584
B	Maize +Cowpea	Berseem + Mustard	0.4	240	50	290	78	125	74	47	324	614
	Total of block A&B		0.8	450	90	540	155	250	148	105	658	1198
C	Swankhi	Berseem +Oats	0.2	30	16	46	73	128	89	54	344	353.2
	Bajra	Berseem+oats	0.2	35	12	47						
	Cowpea	Berseem+Oats	0.1	11.5		11.5						
	Total of block C		0.5	76.5	28	104.5	73	128	89	54	344	448.5
D	Sorghum	Oats	0.4	179.28	130	309.28	93.12	80.67			173.79	483.07
E	Sorghum	Oats	0.4	181.00	141	322	115.00	73.00			188.0	510
	Total of block D&E		0.8	360.28	271	631.28	208.12	153.67			361.79	993.07
F	Perennial fodder	Perennial	0.35				442	98			540	540
	Hybrid Napier											
	Para grass	Perennial	0.05				15	22			37	37
	Fodder trees	Perennial	Boundary				0.06/ plant				1.2	1.2
	Supplemental fodder (Azolla)	Perennial	Pits/ waste bodies				1kg/ day				3.65	3.65

Two cuts were taken from maize and cowpea whereas berseem+mustard was harvested thrice in a whole season with total green fodder production of 540 and 658 q/0.8 ha, respectively (Table 2).

during *kharif* season under staggered planting technique @ interval of 15 days to a total allotted 0.8 ha area and followed by berseem with mustard during *rabi* season in a system (Table 2).

Under this module, maize+cowpea supplied green fodder to meet requirement of 50 cows in the month of July and September whereas berseem+mustard provided fodder in the months of December, January, February and April (Table 3). Among all annual green fodder sequences, significantly highest system productivity of 149750 kg/ha/year, net returns ₹114860.72, B:C ratio of 3.29 was found in this system followed by sorghum+oats and Swankhi, bajara, cowpea-berseem+oats, respectively (Table 4). It might be due to continuously diversified cropping of legumes along with cereals in this system for 361 days with highest LUE of 98.90%. Javanmard *et al.* (2017) also reported that intercropping as a low-input cropping system in maize fodder has been associated with higher forage yield in comparison with sole crops. Also, Luce *et al.* (2020) showed that diversified cropping system that cover the land for more days and include pulses

produced higher system productivity and returns.

Module 2: Swankhi, Cowpea, Bajra-Berseem+Oats: About 0.5 ha area was allotted to this module, during *kharif* season Swankhi (0.2 ha), cowpea (0.2 ha) and bajra (0.1 ha) was grown and it was followed by berseem+oats during the *rabi* season. Two cuts were taken from Swankhi (August and September) and bajra (August and October) besides, single cut was taken in cowpea during the month of August. This system produced green fodder (104.5 q/0.5 ha) from Swankhi, bajra and cowpea during *kharif* season and from berseem+oat (344 q/0.5 h) during *rabi* season, respectively (Table 2). Among all annual fodder sequences, Swankhi, Cowpea, Bajra-Berseem+Oats module cropping sequence recorded significantly lowest system productivity of 89700 kg/ha/year and B:C ratio of 1.83 (Table 4). This lowest productivity is due to use of sole crops of Swankhi, bajra and cowpea in their respective blocks during *kharif* season which drastically reduced the *kharif* yield and thus effect total system productivity. Similarly, Nigussie *et al.* (2021) also reported lesser grain yields and nutrient acquisition in maize mono cropping systems

Module 3: Sorghum-oats: This module produced 993.07 q/0.80 ha/year of green fodder annually with contribution of sorghum and oat in a system was 631.28 q/0.8 ha and 361.79 q/0.8 ha, respectively (Table 2). This module provided green fodder during the months of August to April continuously (Table 3) with system productivity of 124134 kg/ha/year and B:C ratio of 3.11 (Table 4). Raja *et al.* (2019) also observed that sorghum followed by oat produced 710.66 q/ha of green fodder yield under Manasbal, Kashmir.

Module 4: Perennial fodders: About 0.4 ha area is allotted under this module in which perennial grasses, viz. hybrid napier (0.35ha) and Para grass (0.05ha) were planted as per specified distance, along with boundary plantations, viz. *Bauhinia variegata*, *Albizia* spp to meet the green fodder requirement of dairy animals during lean periods of May-June and October-November (Table 3). Bhakhar and Ram (2019) also found that hybrid napier with vigorous vegetative growth and high biomass production provide fodder during scarcity period. Among perennial grasses, hybrid napier recorded significantly highest system productivity (154285 kg/ha), net returns (₹120425.71), B:C ratio (3.55) (Table 4). Rahman and Talukder (2015) also reported from Bangladesh that highest biomass yield (204 t/ha/year) was found for napier hybrid whereas para grass recorded biomass yield of 81.07 t/ha/year. Similarly, Kadam *et al.* (2017) reported profuse tillering, high yield, more biomass and palatability in hybrid napier. Among fodder trees, *Bauhinia variegata* out-yielded *Albizia* spp. in system productivity and also provided fodder during the time of scarcity. Franzel *et al.* (2014) also reported that fodder trees are equally important to feed dairy cows during lean period.

Module 5: Supplemental fodders: Azolla was grown as supplemental fodder in the waste pits and contributed 365 kg in system productivity (Table 3). Pant *et al.* (2020)

Table 3. Month-wise green fodder (q/block) availability under round the year green fodder modules

Month	Fodder	Quantity	Total production month-wise	Availability for number of days
January	Berseem	250	250	33
February	Berseem	202	317	42
	Oats	115		
March	Berseem	163	244	32
	Oats	80.67		
April	Berseem	159	232	31
	Oats	73		
May	Napier	222	222	30
June	Napier	220	235	31
	Para grass	15		
July	Maize +Cowpea	450	450	60
August	Sorghum	179.28	256	34
	Swankhi	30		
	Cowpea	11.5		
	Bajra	35		
September	Sorghum	181	237	32
	Swankhi	16		
	Maize+ cowpea	40		
October	Sorghum	130	231	31
	Napier	38		
	Bajra	12		
	Maize+ cowpea	50		
	Trees	1.2		
November	Sorghum	141	223	30
	Para grass	22		
	Napier	60		
December	Berseem	228	321	43
	Oats	93.12		

Table 4. Mean value of system productivity, system cost of cultivation and economics from different fodder models under round the year fodder production

Module	Cropping sequence models	Kharif yield (kg/ha)	Rabi yield (kg/ha)	System productivity (kg/ha/year)	System cost of cultivation (₹)	Gross returns (₹)	Total net returns (₹)	B:C ratio
1.	Maize+ Cowpea- Berseem + Mustard	67,500	82,250	149,750	34,889.28	149,750	114,860.72	3.29
2.	Swankhi, Cowpea, Bajra- Berseem+Oats	20,900	68,800	89,700	31,716.40	89,700	57,983.60	1.83
3.	Sorghum-Oats	78,910	45,224	124,134	30,176.00	124,134	93,958	3.11
4.	Perennial fodder	-	-	-	-	-	-	-
	Hybrid Napier	126,285	28,000	154,285	33,860	154,285.71	120,425.71	3.55
	Para grass	30,000	44,000	74,000	23,709	74,000	50,291	2.12
	C.D	8,448	4,820	13,519				
	S.E(m)±	2,813	1,611	4,486				
	Fodder trees (20 no)	-	-	-	-	120	120	-
	<i>Bauhinia variegata</i> (10 no.)		80	80				
	<i>Albizia</i> (10 no.)		40	40				
5.	Supplemental fodder (Waste pits/drains)	-	-	365	-	365	365	-

Table 5. Month-wise milk production (litres) and 4% FCM under round the year green fodder modules

Month	Fodder	Milk yield of cow (M ± SE)	Milk yield of buffalo (M± SE)	Total milk yield	Average milk yield/day	Wet average (Milk yield/ animal)	Average% FCM
January	Berseem	2682.00±165.50	46.25±46.25	2728.25±211.75	86.52±5.34	7.21±0.44	7.11±0.44
February	Berseem	2428.50±40.00	28.75±28.75	2457.25±11.25	86.73±1.43	7.23±0.12	7.11±0.12
March	Oats						
	Berseem	2950.25±255.75	0.00±0.00	2950.25±255.75	95.17±8.25	7.93±0.69	7.41±0.64
April	Oats						
	Berseem	3075.50±34.50	90.25±90.25	3165.75±124.75	102.52±1.15	8.54±0.10	7.84±0.09
May	Napier	3096.88±409.88	221.50±221.50	3318.38±188.375	99.90±13.22	8.32±1.10	7.34±0.97
June	Napier	3058.00±508.50	241.75±241.75	3299.75±266.75	101.93±16.95	8.49±1.41	7.65±1.27
July	Para grass						
	Maize +Cowpea	3293.88±308.88	272.50±272.50	3566.38±36.375	106.25±9.96	8.85±0.83	7.67±0.72
August	Sorghum	3198.50±312.00	256.50±256.50	3455.00±55.50	103.18±10.06	8.60±0.84	7.50±0.73
September	Swankhi						
	Cowpea						
	Bajra						
	Sorghum	3010.88±342.88	238.50±238.50	3249.38±104.375	100.36±11.43	8.36±0.95	7.22±0.82
October	Swankhi						
	Maize+cowpea						
	Sorghum	2733.50±283.50	219.00±219.00	2952.50±64.50	88.18±9.15	7.35±0.76	7.01±0.72
	Napier						
November	Bajra						
	Maize+cowpea						
	Trees						
	Sorghum	2505.25±121.75	130.75±130.75	2636.00±252.50	83.51±4.06	6.96±0.34	6.97±0.34
December	Para grass						
	Napier						
	Berseem	2796.50±237.50	46.00±46.00	2842.50±283.50	90.21±7.66	7.52±0.64	6.85±0.58
	Oats						

observed azolla as a sustainable feed for livestock due to its high protein and low lignin content besides providing macronutrients like calcium, magnesium, potassium and vitamins. Kour *et al.* (2020) found azolla supplementation in feeding regimen of crossbred cows is beneficial which is evident by improved benefit cost ratio from 0.73 in control group to 1.01 in treatment group.

Effect of round the year fodder production on lactation:

The round the year fodder production improved quantity and quality of milk production. Research results indicated that highest total milk yield of 3566.38±36.375 litres was produced when animals were fed with mixed fodder of maize+cowpea during the month of July followed by milk yield of 3455.00±55.50 when mixed fodder Swankhi, cowpea and bajra was fed during the month of August and 3318.38±188.375 when animals were fed with perennial hybrid napier during the month of May (Table 5).

Milk composition in terms of fat yield (0.30 ± 0.03 kg/d), protein yield (0.27±0.02 kg/d), lactose yield (0.35±0.03 kg/d) and SNF yield (0.63±0.06 kg/d) was highest when animals were fed with maize+cowpea fodder followed by fat yield, protein yield, lactose yield and SNF

yield of 0.29±0.03 kg/d, 0.27±0.03 kg/d, 0.34±0.03 kg/d and 0.63±0.06 kg/d, respectively when animals were fed with Swankhi, cowpea and bajra (Table 6).

The milk yield and content of fat in the milk are mostly influenced by the diet taken by animals, the highest production and enriched composition of milk of those animals that were fed on mixed fodder was due to higher palatability and stimulating effect of these green fodder, which might have increased the intake of fodder by the animals without health issues. The findings were in agreement with Naik *et al.* (2012). Whereas, in terms of energy values, the highest milk energy was found in the milk of those animals which were fed by berseem+oats (6.20±0.07 M cal) followed by maize+cowpea (6.16±0.58 M cal) (Table 6). The nutritive value of leguminous based fodder, viz. berseem or cowpea was rich in protein and energy and can meet the requirement of relatively high milk producing dairy animals and produced higher energy in milk (Ahmed 2016 and Corea *et al.* 2017).

It is clear from the findings that best green fodder production modules, viz. Maize+Cowpea-Berseem+ Mustard-module, perennial fodder module and Sorghum-

Table 6. Average values of various milk parameters in Holstein-Friesian cows under round the year green fodder production modules*

Month	Fodder	Milk Fat %	Milk Protein %	Milk Lactose %	Milk SNF %	Fat yield (kg/d)	Protein yield (kg/d)	Lactose yield (kg/d)	SNF yield (kg/d)	ECM (kg)	SCM (kg)	Milk energy (M cal)
January	Berseem	3.91 ±0.13	3.61 ±0.19	3.99 ±0.14	7.61 ±0.41	0.28 ±0.02	0.26 ±0.02	0.29 ±0.02	0.55 ±0.03	6.19 ±0.36	7.6 ±0.47	5.70 ±0.35
February	Berseem	3.89 ±0.19	3.57 ±0.45	3.93 ±0.11	7.52 ±0.53	0.28 ±0.01	0.26 ±0.01	0.28 ±0.01	0.54 ±0.01	6.15 ±0.10	7.57 ±0.13	5.68 ±0.09
March	Berseem	3.56 ±0.23	3.31 ±0.34	3.87 ±0.10	7.38 ±0.62	0.28 ±0.02	0.26 ±0.02	0.31 ±0.03	0.59 ±0.05	6.25 ±0.52	7.91 ±0.69	5.93 ±0.52
April	Berseem	3.45 ±0.38	3.15 ±0.23	3.81 ±0.17	7.14 ±0.56	0.27 ±0.01	0.27 ±0.01	0.33 ±0.01	0.61 ±0.01	6.40 ±0.07	8.27 ±0.09	6.20 ±0.07
May	Napier	3.21 ±0.34	3.06 ±0.41	3.84 ±0.15	7.28 ±0.44	0.27 ±0.04	0.25 ±0.03	0.32 ±0.04	0.61 ±0.08	6.07 ±0.77	7.89 ±1.05	5.92 ±0.79
June	Napier	3.34 ±0.41	3.12 ±0.31	3.86 ±0.21	7.23 ±0.39	0.28 ±0.05	0.27 ±0.04	0.33 ±0.05	0.61 ±0.10	6.31 ±1.00	8.16 ±1.36	6.12 ±1.02
July	Maize +Cowpea	3.21 ±0.43	3.01 ±0.13	3.90 ±0.16	7.16 ±0.31	0.30 ±0.03	0.27 ±0.02	0.35 ±0.03	0.63 ±0.06	6.34 ±0.57	8.21 ±0.77	6.16 ±0.58
August	Sorghum	3.15 ±0.27	3.09 ±0.21	3.92 ±0.13	7.31 ±0.43	0.29 ±0.03	0.27 ±0.03	0.34 ±0.03	0.63 ±0.06	6.32 ±0.59	8.10 ±0.79	6.08 ±0.59
	Swankhi											
	Cowpea											
	Bajra											
September	Sorghum	3.09 ±0.15	3.01 ±0.15	3.83 ±0.14	7.12 ±0.29	0.26 ±0.03	0.25 ±0.03	0.32 ±0.04	0.60 ±0.07	6.01 ±0.65	7.72 ±0.88	5.79 ±0.66
	Swankhi											
	Maize +cowpea											
October	Sorghum	3.69 ±0.34	3.46 ±0.24	3.88 ±0.13	7.45 ±0.53	0.27 ±0.03	0.25 ±0.03	0.29 ±0.03	0.55 ±0.06	6.06 ±0.60	7.48 ±0.77	5.61 ±0.58
	Napier											
	Bajra											
	Maize +cowpea											
	Trees											
November	Sorghum	4.01 ±0.31	3.81 ±0.42	3.99 ±0.19	7.87 ±0.47	0.28 ±0.01	0.27 ±0.01	0.28 ±0.01	0.55 ±0.03	6.31 ±0.29	7.55 ±0.37	5.66 ±0.28
	Para grass											
	Napier											
December	Berseem	3.41 ±0.54	3.23 ±0.27	3.82 ±0.15	7.46 ±0.56	0.26 ±0.02	0.24 ±0.02	0.29 ±0.02	0.56 ±0.05	5.80 ±0.47	7.40 ±0.63	5.55 ±0.47
	Oats											

oat module, developed under North-west Himalayan region along with management techniques of staggered planting ensured the round year availability of quality fodder along with sustained lactation. The techniques and size of these modules may vary with the number of animals to be fed, and availability of land holding size.

REFERENCES

- Ahmed S M E. 2016. Comparison between the effects of feeding corn silage or berseem as a basal diet on: 1- milk production and economic efficiency of lactating Friesian cows. *Journal of Animal and Poultry Production* 7(12): 515–19.
- AOAC. 2005. *Official Methods of Analysis*, 18th edition. Association of Official Analytical Chemists, Arlington, Virginia, USA.
- Bhakar A and Ram H. 2019. Hybrid napier grass a boon to forage production. *Indian Farming* 69(2): 23–25.
- Cochran G and Cox G M. 1963. *Experimental Design*. Asia Publishing House, Bombay, India.
- Corea E E, Aguilar J M, Alas N P, Alas E A, Flores J M and Broderick G A. 2017. Effects of dietary cowpea (*Vigna sinensis*) hay and protein level on milk yield, milk composition, N efficiency and profitability of dairy cows. *Animal Feed Science and Technology* 226: 48–55.
- Franzel S C, Sammy L B, Sinja J and Wambugu C. 2014. Fodder trees for improving livestock productivity and smallholder livelihoods in Africa. *Current Opinion in Environmental Sustainability* 6: 98–03.
- Ginwal D S, Kumar R, Ram H, Dutta S, Arjun M and

- Hindoriya P S. 2019. Fodder productivity and profitability of different maize and legume intercropping systems. *Indian Journal of Agricultural Sciences* **89**(9): 1451–55.
- Hegde N. 2019. Livestock development for sustainable livelihood of small farmers. *Asian Journal of Research in Animal and Veterinary Sciences* **3**(2): 1–17.
- Jackson M L. 1973. *Soil Chemical Analysis*. pp. 165-167. Asia Publication House, Bombay.
- Javanmard A, Majdi M, Nikoo H and Yousef N. 2017. Evaluation of forage production using maize-legumen intercropping and biofertilizer under low-input conditions. *Philippine Agricultural Scientist* **100**(1): 79–87.
- Kadam S S, Kumar A and Arif M. 2017. Hybrid napier for round the year quality fodder supply to the dairy industry-A review. *International Journal of Current Microbiology Applied Sciences* **6**(10): 4778–83.
- Kour M, Khan N, Singh R, Mahajan V, Amrutkar S and Kumar D. 2020. Effect of azolla (*Azolla pinnata*) supplementation on milk yield, composition and economics in crossbred HF cows. *International Journal of Current Microbiology Applied Sciences* **9**(10): 2661–66.
- Luce M S, Lemke R, Gan Y, Mcconkey B G, May W, Campbell C, Zentner R, Wang H, Kröbel R, Fernandez M and Brandt K. 2020. Diversifying cropping systems enhances productivity, stability, and nitrogen use efficiency. *Agronomy Journal* **112**(3): 1517–36.
- Maleko D, Ng W T, Msalya G, Mwilawa A, Pasape L and Mtei K. 2018. Seasonal variations in the availability of fodder resources and practices of dairy cattle feeding among the smallholder farmers in Western Usambara Highlands, Tanzania. *Tropical Animal Health Production* **50**: 1653–64.
- Mohapatra K K, Mohapatra S and Ekka R. 2019. Variations in round-the-year fodder production in a low-cost hydroponic shed. *National Academy Science Letters* **42**: 383–85.
- Naik K A H, Parashurama C, Naik B M, Pradeep S, Sannathimmappa and Sunil C. 2020. Study on hydroponic maize fodder effect on milk production. *Journal of Pharmacognosy and Phytochemistry* **9**(6): 664–69.
- Nigussie A, Haile W, Agegnehu G and Kifler A. 2021. Grain yield and nitrogen uptake of maize (*Zea mays* L.) as affected by soil management and their interactions on Cambisols and Chernozem. *International Journal of Agronomy* 341–456.
- Pant H, Jain G, Jain R and Singh A. 2020. Azolla: A alternate fodder supplement in livestock feed. *Proc. Conference: Innovations in Agriculture, Environment and Health Research for Ecological Restoration*. <https://www.researchgate.net/publication/342589320>
- Rahman M Z and Talukder M A. 2015. Production and nutritional quality of high yielding fodders in the coastal areas for ruminants. *Agriculturists* **13**(1): 01–08.
- Raja W, Hussain, A, Sheikh T, Haq A and Allam I. 2019. Direct and residual effect of organic and chemical sources of nutrients on fodder sorghum-fodder oat cropping sequence. *Indian Journal of Agricultural Research* **53**(1): 108–11.
- Singh V, Sinha V and Srivastava P. 2017. Azolla feeding status and it's benefit for livestock in Odisha. *International Journal of Recent Advances in Multidisciplinary Research* **4**(12): 3281–82.
- Singh D N, Bohra J S, Tyagi V, Singh T R and Gupta G. 2022. A review of India's fodder production status and opportunities. *Grass and Forage Science* 1–10.
- Snedecor G W and Cochran W G. 1989. *Statistical Methods*, 5th ed. Iowa State University Press, Ames, Iowa, USA.
- Tyrrell H F and Reid J T. 1965. Prediction of the energy value of the cow's milk. *Journal of Dairy Science* **48**: 1215–23.
- Vijay D, Gupta C K and Malviya D R. 2018. Innovative technologies for quality seed production and vegetative multiplication in forage grasses. *Current Science* **114**(1): 148–54.