A-6005
[1-6]

RESEARCH ARTICLE Indian Journal of Agricultural Research, Volume Issue : ()

Productivity and Quality of Fodder Crops under Late-sown Conditions in Semi-arid Tropics of India

A. Malliswara Reddy, C. Radha Kumari, B. Sahadeva Reddy, B. Ravindranatha Reddy 10.18805/IJARe.A-6005

ABSTRACT

Background: In India, agriculture and animal husbandry are inextricably linked and are essential for livelihood security. Despite the fact that India has the world's largest livestock population, feed and fodder supply is under huge strain, especially as area accessible for fodder cultivation has been shrinking. During the months of March-May and November-February are known as lean periods of fodder production, the supply of green fodder is limited throughout the year in a rainfed condition. Fodder crops develop swiftly and cover the ground surface quickly, even in low-rainfall conditions, producing a significant amount of green fodder while also providing vegetative cover over the land, resulting in resource conserving as well as increased productivity. In this context, the current study was conducted to evaluate various fodder crops, assess their productivity and quality and make appropriate recommendations for semi-arid tropics of India.

Methods: Field experiments were carried out for three years from 2015-16 to 2017-18 at the Agricultural Research Station, Ananthapuramu andhra Pradesh, India, which is located between 14°41′N Latitude and 77°40′E Longitude and an altitude of 350 m. above mean sea level, which falls under the Semi-Arid Tropics. The experiment was laid out in a randomized block design with nine treatments (fodder crops) and three replications. The treatments comprised of different fodder crops *viz*., fodder sorghum, fodder maize, fodder bajra, clusterbean, fodder cowpea, field bean, brown top millet, horse gram and sunhemp.

Result: The current study concludes that fodder bajra, fodder sorghum and fodder maize are potential forage cereals because they can produce more quantity and quality fodder while also ensuring net monetary returns and fodder cowpea and sunhemp are the next best suitable forage legumes under late-sown conditions in the semi-arid tropics of India.

Key words: Fodder crops, Green fodder, Late-sown conditions, Livestock.

INTRODUCTION

In India, agriculture and animal husbandry are inextricably linked, with mixed farming and livestock rearing essential to rural livelihoods. In addition to agricultural husbandry, livestock is an important secondary activity. Livestock production is the backbone of Indian agriculture, accounting for 4.4 per cent of the country's total value added in 2014-15 at current prices (Anonymous 2018a). Currently, India contributes roughly 15% and 17% of the world's livestock and human population, respectively, relying on 2.3 and 4.2 per cent of the world's geographical area and water resources (Kumar *et al.*, 2012). The contribution of India's livestock sector to the country's agriculture's gross value production has been steadily expanding at a higher rate than the crop sector.

Fodder crops are an essential part of a livestock-based farming system. Fodder crops are considered abandoned crops in India; hence they are primarily cultivated in infertile and stressed conditions, resulting in inferior quality herbages (Kumar, 2016). The total area under grown fodder in India is only 8.4 million hectares (5.23 per cent), which has remained unchanged for the past two decades and is insufficient to fulfil the needs of India's rising livestock population (Mohan *et al.,* 2017). In arid and semi-arid environments, poor soil fertility, low soil moisture content and protracted dry spells during the crop growing season are all key factors restricting fodder crop productivity. By 2050, the demand for green fodder and dry forage will be 1012 and 631 m.t., respectively. In the year 2050, at the current rate of expansion in forage supplies, there will be an 18.4% and 13.2% shortfall in green and dry fodder, respectively. Green fodder supply must expand at a rate of 1.69 per cent per year to make up for the deficiency (Anonymous 2018b). Land availability, as well as variations in the commencement and distribution of monsoon rain, exacerbate the problem. As a result, dryland farmers pay little attention to fodder production. The only realistic solutions for meeting the growing fodder needs of the livestock sector are increasing productivity per unit land area through efficient natural resource management and integrating fodder crops into existing cropping systems

Department of Agronomy, Agricultural Research Station, Acharya N.G. Ranga Agricultural University, Ananthapuramu-515 001, Andhra Pradesh, India.

Corresponding Author: A. Malliswara Reddy, Department of Agronomy, Agricultural Research Station, Acharya N.G. Ranga Agricultural University, Ananthapuramu-515 001, Andhra Pradesh, India. Email: malliagronomy@gmail.com

How to cite this article: Reddy, A.M., Kumari, C.R., Reddy, B.S. and Reddy, B.R. (2022). Productivity and Quality of Fodder Crops under Late-sown Conditions in Semi-arid Tropics of India. Indian Journal of Agricultural Research. DOI: 10.18805/IJARe.A-6005.

Submitted: 30-04-2022 **Accepted:** 22-06-2022 **Online:** 13-07-2022

(Kumar *et al.*, 2012). Green fodder is a very nutritious, palatable, mineral and vitamin-rich and cost-effective source of macro and micro nutrients. Due to extreme seasonal severity during the months of March-May and November-February, known as lean periods of fodder production, the supply of green fodder is limited throughout the year in a rainfed condition. Fodder crops develop swiftly and cover the ground surface quickly, even in low-rainfall conditions, producing a significant amount of green fodder while also providing vegetative cover over the land, resulting in resource conserving as well as increased productivity (Kumari *et al.*, 2017).

Andhra Pradesh is India's sixth-largest livestock producer (34 million). Sheep rearing is a key income-earning subsidiary activity and vital source of livelihood for small and marginal farmers in Ananthapuramu district of Andhra Pradesh, alongside groundnut cultivation. Ananthapuramu district has the highest sheep population (4.9 million), accounting for 27.9% of Andhra Pradesh's total sheep population. Due to cyclonic/untimely rainfall in the months of October and November, precious groundnut fodder has been ruined on the field after harvesting. In such situations, rainfed farmers face the biggest challenge in maintaining a consistent source of fodder for their animals. Farmers choose to cultivate groundnut even when the rain is delayed because they need fodder for their livestock. In the Ananthapuramu district, monsoon delays are common and farming groundnut for fodder purposes alone is not cost-effective. Not only does the experimental site receive insufficient precipitation (595 mm), but its temporal distribution is also highly unpredictable. As a result, producing fodders for small and large ruminants is inevitable and there was little scientific information on suitable fodder crops, their performance and fodder quality in dryland regions. In this context, the current study was conducted to evaluate various fodder crops, assess their productivity and quality and make appropriate recommendations for semi-arid tropics of India.

METERIALS AND METHODS

Field experiments were carried out for three years from 2015-16 to 2017-18 at dryland farm Agricultural Research Station, Ananthapuramu, which is situated between 14°41′N Latitude and 77°40′E Longitude and an altitude of 350 m. above mean sea level, which falls under the Semi-Arid Tropics. The soil of the experimental site was red sandy loam in texture, slightly acidic in reaction (5.82), low in organic carbon (0.32%) and available nitrogen (165 kg ha^{-1}), high in available phosphorus (47 kg ha^{-1}) and medium in available potassium (252 kg ha^{-1}). The major climatic constraints were low and uneven rainfall distribution, early monsoon cessation, late monsoon onset and prolonged dry spells during crop growing season. The fodder crops studied were planted in late-sowing conditions, *i.e.*, in August.

The experiment was laid out in a randomized block design with nine treatments and three replications. The treatments comprised of different fodder crops *viz*., T_1: Fodder sorghum; T_2: Fodder maize; T_3: Fodder bajra; T_4: Clusterbean; T_5: Fodder cowpea; T_6: Field bean; T_7: Brown top millet; T_8: Horse gram and T_9: Sunhemp. The rainfall received during the crop growth period was 275.2 mm, 86.2 mm and 444.6 mm on 21, 6 and 25 rainy days during the years 2015, 2016 and 2017, respectively. During the period of experimentation, the fodder crops were raised purely under rainfed conditions. The details of variety, seed rate, spacing and fertilizer for various fodder crops were presented in Table 1.

The plant height (cm) of fodder crops was recorded for five randomly selected plants. The leaf area of five destructively sampled plants from border rows was measured by using the LI-COR model, the LT-300 leaf area meter with transparent conveyor belt and electronic digital display and expressed in cm^2. The green fodder from the gross plot's five observation hills was collected and sun dried first, then kept at 60°C for 48 hours in a hot air oven and the weight was recorded as dry weight. The fodder yields (t ha^{-1}) were estimated from the green and dry fodder yields per plot. The nitrogen (N) concentration of fodder on a dry weight basis was estimated by the Micro-Kjeldhal method (Jackson, 1973) and crude protein concentration was calculated by the following formula:

$$\text{Crude protein (\%)} = \text{Nitrogen content (\%)} \times 6.25$$

Crude fibre content in whole plant was estimated by acid-alkali digestion method and was expressed in per centage.

Crude fibre (%) =

$$\frac{\text{Weight before ashing - Weight after ashing}}{\text{Weight of the sample taken}} \times 100$$

Ash is the inorganic component of the sample left after complete ignition of the sample at 600°C in muffle furnace. Total ash was calculated by the following formula and expressed in per centage.

$$\text{Total ash (\%)} = \frac{\text{Weight of ash}}{\text{Weight of the sample}} \times 100$$

Production efficiency was calculated by the following formula and expressed in kg ha^{-1} day^{-1}

Production Efficiency (kg ha^{-1} day^{-1}) =

$$\frac{\text{Green fodder yield (kg ha}^{-1}\text{)}}{\text{Crop duration (days)}}$$

The economics of various treatments were calculated individually for three years of study considering the prevailing price of inputs and produce. The data obtained during the course of investigation were subjected to 'Analysis of Variance' technique as standard procedure.

RESULTS AND DISCUSSION

Plant height

In three years of study and pooled data, plant height of several fodder crops was dramatically altered under late-sown conditions (Table 2). However, among the several fodder crops assessed in 2015, fodder maize generated the maximum plant height (201.1 cm), which was statistically comparable to fodder bajra (190.3 cm), which was in turn comparable to fodder sorghum (185.0 cm). Fodder cowpea (51.4 cm) had the shortest plant height, which was comparable to clusterbean (61.9 cm) and field bean (63.3 cm). During 2016, higher plant height was registered with fodder sorghum (167.2 cm), which was comparable with fodder bajra (160.3 cm), which was in turn on par with fodder maize (155.3 cm). However, fodder cowpea had a lower plant height (50.7 cm), which was comparable to cluster bean (56.9 cm) and field bean (57.2 cm). In the year 2017, fodder bajra (197.7 cm) recorded higher plant height, which was statistically similar to fodder maize (189.6 cm) and fodder sorghum (186.8 cm). According to Gangaiah and Kundu (2020), perennial sorghum has a higher plant height than annual cereal forages. The lowest plant height was registered with cluster bean (93.8 cm), which was comparable with field bean (95.8 cm), fodder cowpea (96.6 cm) and horse gram (97.6 cm). Pooled data revealed that higher plant height was recorded with fodder bajra (182.8 cm), however, which was statistically similar with fodder maize (182.0 cm) and fodder sorghum (179.7 cm). Fodder cowpea (66.2 cm) had the shortest plant height, which was comparable to cluster bean (70.9 cm) and field bean (72.1 cm).

Leaf area

Photosynthetic efficiency is measured by the leaf area. During three years of study and pooled data, fodder maize produced the considerably greatest leaf area among the different fodder crops studied (Table 2). Cell elongation and expansion, as well as the production of large leaves, may be responsible for the higher leaf area in fodder maize. However, fodder bajra was next best treatment, which was on par with fodder sorghum in 2015, 2016, 2017 and pooled data when it came to recording higher leaf area. Clusterbean, on the other hand, recorded the smallest leaf area in three years of study and pooled data, which could be attributed to the leaf's shorter length and breadth.

Green fodder yield

The green fodder yields of the various fodder crops examined were presented in Table 2. Because of the good amount and distribution of rainfall (444.6 mm) obtained throughout the crop growing period in 2017, a greater green fodder production was documented in all tested fodder crops. The lowest green fodder production in all fodder crops was observed in 2016, owing to insufficient and ill-distributed

Table 1: Variety, seed rate, spacing and fertilizer dose for different fodder crops.

Treatments (Fodder crops)	Variety	Seed rate (kg ha^{-1})	Spacing (cm)	Fertilizer dose (kg ha^{-1}) $N-P_2O_5-K_2O$
T_1: Fodder sorghum	M.P. Chari	25	30 × 15	60-40-30
T_2: Fodder maize	African tall	50	30 × 15	60-40-30
T_3: Fodder bajra	APFB-09-01	15	30 × 15	60-40-30
T_4: Clusterbean	BG-1	25	30 × 10	20-40-40
T_5: Fodder cowpea	EC-4216	25	30 × 15	20-50-0
T_6: Field bean	TFB-5	50	30 × 15	20-50-0
T_7: Brown top millet	Local	15	30 × 10	40-20-0
T_8: Horse gram	Local	30	30 × 10	10-20-20
T_9: Sunhemp	Local	35	30 × 10	20-50-0

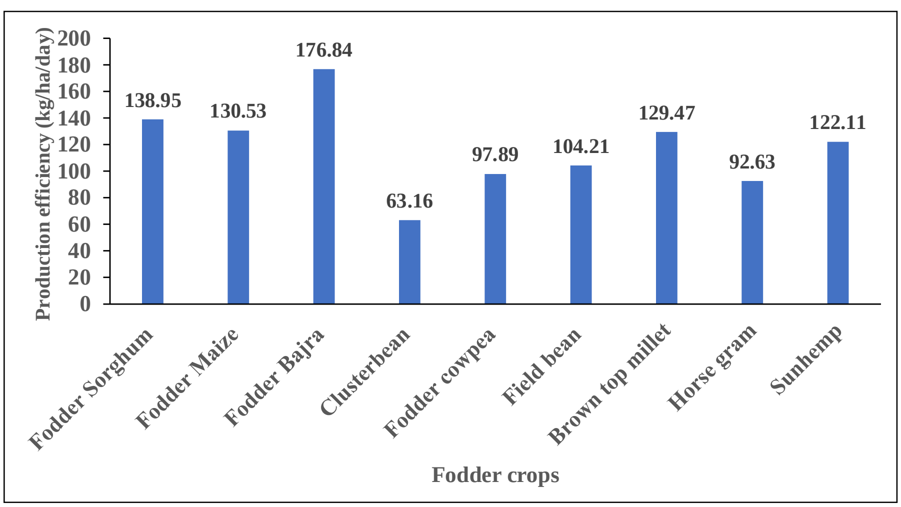

Fig 1: Production efficiency (kg ha^{-1} day^{-1}) of different fodder crops under late sown conditions in rainfed *alfisols* (Mean of three years).

rainfall (86.8 mm) received throughout the crop growth period. Among the various fodder crops studied in 2015, fodder bajra produced significantly more green fodder (18.6 t ha^{-1}). Brown top millet (11.4 t ha^{-1}) was the next best treatment in terms of higher green fodder yield, but it was statistically similar to fodder maize (10.7 t ha^{-1}) and fodder sorghum (9.7 t ha^{-1}). Fodder maize is one of the best appropriate cereal fodder crops planted during the rainy season, since it grows quickly, generates high palatable biomass and has a greater nutritional value (Chaudhary *et al.*, 2016). In the year 2016, among all tested fodder crops, brown top millet produced significantly higher green fodder (7.2 t ha^{-1}) and fodder bajra was the next best treatment for recording green fodder yield (6.2 t ha^{-1}). However, in 2017 fodder bajra produced a higher green fodder yield (25.6 t ha^{-1}), which was on par with fodder sorghum (25.6 t ha^{-1}) and sunhemp (24.7 t ha^{-1}). The combined data (3 years) clearly showed that fodder bajra produced significantly higher green fodder (16.8t ha^{-1}). However, fodder sorghum (13.2 t ha^{-1}), which was on par with fodder maize (12.4 t ha^{-1}), were the next best treatments in terms of higher green fodder yield. Higher plant height and leaf area per plant may have contributed to enhanced photosynthate accumulation, which resulted in higher green fodder yield (Saimaheswari *et al.*, 2020). Due to their biomass yield potential, shorter duration and resilience to adverse weather events, fodder bajra, fodder sorghum and fodder maize are ideal cereal forages under subtropical circumstances (Ramachandrappa *et al.*, 2019). Clusterbean produced the lowest green fodder production throughout the course of three years of experimentation and pooled data.

Dry fodder yield

Among various fodder crops were examined, fodder maize produced significantly higher dry fodder in 2015 (7.5 t ha^{-1}). During 2016, higher dry fodder yield was recorded with fodder maize (2.6 t ha^{-1}), which was on par with fodder sorghum (2.6 t ha^{-1}), fodder bajra (2.4 t ha^{-1}) and brown top millet (2.3 t ha^{-1}). During 2017, fodder bajra produced a higher dry fodder yield (10.9 t ha^{-1}), however, which was on par with fodder sorghum (10.4 t ha^{-1}). Pooled data (3 years) revealed that, fodder maize produced higher dry fodder yield (6.5 t ha^{-1}), which was comparable with fodder bajra (6.3 t ha^{-1}). Cluster bean recorded the lowest dry fodder yields of 1.5 t ha^{-1}, 1.2 t ha^{-1}, 6.2 t ha^{-1} and 3.0 t ha^{-1} in 2015, 2016, 2017 and pooled data, respectively (Table 2).

Production efficiency

The maximum production efficiency was found in fodder bajra (176.8 kg ha^{-1} day^{-1}), followed by fodder sorghum (138.9 kg ha^{-1} day^{-1}) and fodder maize (130.5 kg ha^{-1} day^{-1}). This could be owing to the larger plant height and leaf area, which resulted in more photosynthates being accumulated. These findings were similar to those of Brar *et al.* (2016) in fodder maize. In a rainfed situation, sweet sorghum productivity per day was high (Gangaiah and Kundu, 2020). Clusterbean recorded the lowest production efficiency (63.2 kg ha^{-1} day^{-1}) of all the fodder crops (Fig 1).

Quality parameters

Crude protein

In this study, three-year mean data revealed that horsegram (25.4 per cent) had the highest crude protein content, followed by sunhemp (21.7 per cent), while brown top millet (3.8 per cent) had the lowest crude protein content (Fig 2). This could be attributed to increased protein content as a result of increased growth and metabolism, as evidenced by growth-related traits and biomass output (Saimaheswari *et al.,* 2020).

Crude fibre

In our three-year study, we discovered that fodder bajra (42.1 per cent) recorded the highest crude fibre content, followed by fodder sorghum (35.4 per cent). Horsegram recorded a lower crude fibre content (11.2 per cent) (Fig 2). According to Patel *et al.* (2017), the lowest crude fibre content of fodder

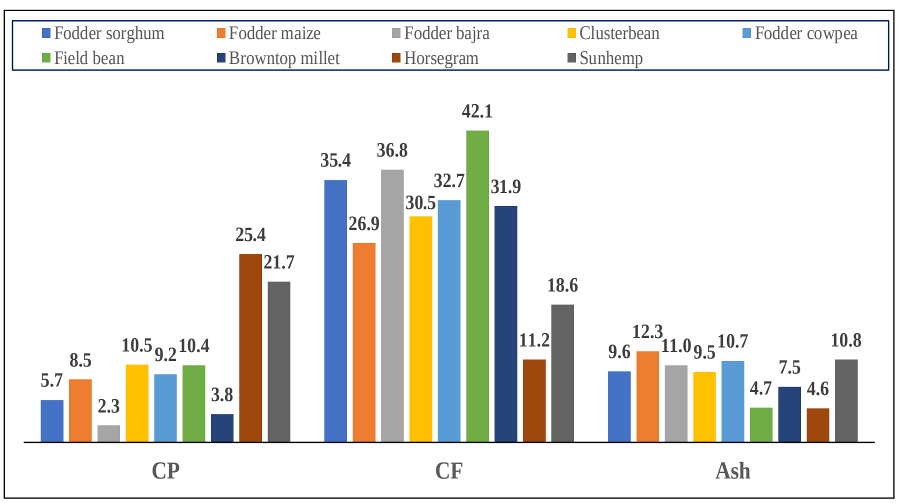

Fig 2: Quality parameters of different fodder crops under late sown conditions in rainfed *alfisols* (Mean of three years). CP: Crude Protein (%); CF: Crude Fibre (%); Ash: Ash content (%).

could be due to the crop's more vegetative growth, which is associated with higher nitrogen uptake, a major constituent of amino acids and protein, which tones down fibre constituents like pectin, cellulose.

Ash content

The current study's three-year mean data revealed that fodder maize had the highest ash level (12.3 per cent), followed by fodder bajra (11.4 per cent). This could be attributed to increased dry matter production, which has resulted in an increase in mineral matter (Meena *et al.,* 2017). Horse gram, on the other hand, had a lower ash content (4.6 per cent) in the three years of data (Fig 2).

Economics

Gross returns (INR. ha^{-1})

Higher gross and net returns, as well as a higher benefit-cost ratio, were achieved in 2017 due to the production of more green fodder from various forage crops over the three years of investigation (Table 2). In 2015, the highest gross returns were realized by fodder bajra (INR.18,600 ha^{-1}) followed by brown top millet (INR.11,400 ha^{-1}) and fodder maize (INR.10, 700 ha^{-1}). Brown top millet had the highest gross returns (INR 7,220 ha^{-1}) in 2016, followed by fodder bajra (INR 5,600 ha^{-1}) and fodder maize (INR. 5090 ha^{-1}). In 2017, fodder bajra and fodder sorghum had higher gross returns (INR. 25,600 ha^{-1}), followed by sunhemp (INR. 24,700 ha^{-1}). The pooled mean revealed that fodder bajra produced higher gross returns (INR.16,803 ha^{-1}) than other tested fodder crops.

Net returns (INR. ha^{-1})

The perusal of data from Table 2 shows the net monetary returns of various fodder crops. Among the several fodder crops examined in 2015, fodder bajra (INR. 6867 ha^{-1}), followed by fodder cowpea (INR. 278 ha^{-1}), yielded higher net returns, while all other fodder crops produced negative net returns. All of the fodder crops that were tested in 2016 realized negative net returns. It was mostly due to lower green fodder yield in all fodder crops as a result of exceptionally low rainfall during the crop growing season. In 2017, fodder bajra gave the highest net returns (INR. 13,867 ha^{-1}), followed by fodder sorghum (INR. 13367 ha^{-1}) and sunhemp (INR. 12472 ha^{-1}). As per pooled data, fodder bajra produced higher net returns (INR. 5071 ha^{-1}), whereas clusterbean gave the lowest and negative net returns (INR. - 5388 ha^{-1}). Higher net returns have been realized with fodder bajra throughout time, which could be owing to its higher biomass potential, drought tolerance and resilient crop, making it a good cereal fodder crop to produce under dryland circumstances (Kaushik *et al.,* 2015).

B:C ratio

The benefit cost ratio of different fodder crops is presented in Table 2. In 2015, fodder bajra produced a higher B:C ratio (1.59), which was closely followed by fodder cowpea (1.03). In 2016, all fodder crops had a negative B:C ratio. In 2017,

Table 2: Growth parameters, fodder yield and economics of fodder crops under late sown conditions in rainfed *alfisols*.

Treat-ments	Plant height (cm)				Leaf area (cm^2)				Green fodder yield (t ha^{-1})				Dry fodder yield (t ha^{-1})				Gross returns (INR. ha^{-1})				Net returns (INR. ha^{-1})				B:C ratio			
	2015	2016	2017	Pooled	2015	2016	2017	Pooled	2015	2016	2017	Pooled	2015	2016	2017	Pooled	2015	2016	2017	Pooled	2015	2016	2017	Pooled	2015	2016	2017	Pooled
T_1	185	167.2	186.8	179.7	823	458	1267	850	9.7	4.3	25.6	13.2	4.5	2.6	10.4	5.8	9700	4310	25600	13203	-2533	-7923	13367	971	0.79	0.35	2.09	1.08
T_2	201.1	155.3	189.6	182.0	1005	694	1456	1052	10.7	5.1	21.5	12.4	7.5	2.6	10.3	6.5	10700	5090	21500	12430	-2283	-7893	8517	-553	0.82	0.39	1.66	0.96
T_3	190.3	160.3	197.7	182.8	840	475	1385	900	18.6	6.2	25.6	16.8	5.5	2.4	10.9	6.3	18600	6210	25600	16803	6867	-5523	13867	5071	1.59	0.53	2.18	1.43
T_4	61.9	56.9	93.8	70.9	154	123	375	217	3.8	2.4	11.9	6.0	1.5	1.2	6.2	3.0	3800	2370	11900	6023	-7611	-9041	489	-5388	0.33	0.21	1.04	0.53
T_5	51.4	50.7	96.6	66.2	782	412	1175	790	9.2	3.5	15.3	9.3	2.8	1.2	7.4	3.8	9200	3480	15300	9327	278	-5442	6378	405	1.03	0.39	1.71	1.05
T_6	63.3	57.2	95.8	72.1	797	385	1062	748	6.0	4.1	19.6	9.9	4.5	1.9	9.9	5.4	6000	4070	19600	9890	-4330	-6260	9270	-440	0.58	0.39	1.90	0.96
T_7	88.4	80.6	103.1	90.7	336	215	695	415	11.4	7.2	18.2	12.3	5.7	2.3	9.3	5.8	11400	7220	18200	12273	-1011	-5191	5789	-138	0.92	0.58	1.47	0.99
T_8	85.4	78.4	97.6	87.1	715	364	1024	701	7.9	3.2	15.2	8.8	4.0	1.4	7.1	4.2	7900	3240	15200	8780	-3828	-8488	3472	-2948	0.67	0.28	1.30	0.75
T_9	130.7	116.1	124.5	123.8	725	382	1085	731	6.0	4.2	24.7	11.6	4.3	1.4	10.0	5.3	6000	4170	24700	11623	-6228	-8058	12472	-604	0.49	0.34	2.02	0.95
SEm±	4.22	3.48	4.75	3.57	18.3	16.8	27.2	19.1	0.67	0.27	0.93	1.69	0.13	0.11	0.27	0.18	-	-	-	-	-	-	-	-	-	-	-	-
CD	12.7	10.6	13.8	10.8	55	51	82	58	2.1	0.8	2.8	5.1	0.4	0.3	0.8	0.5	-	-	-	-	-	-	-	-	-	-	-	-
(P=0.05)																												

T_1: Fodder sorghum; T_2: Fodder maize; T_3: Fodder bajra; T_4: Clusterbean; T_5: Fodder cowpea; T_6: Fieldbean; T_7: Browntop millet; T_8: Horsegram; T_9: Sunhemp.

fodder bajra had the highest B:C ratio (2.18), followed by fodder sorghum (2.09) and sunhemp (2.02). Pooled data revealed that fodder bajra realized the highest B:C ratio (1.43), followed by fodder sorghum (1.08) and fodder cowpea (1.05). Clusterbean recorded the lowest B:C ratio (0.53) in pooled data.

CONCLUSION

The present study identifies that fodder bajra, fodder sorghum and fodder maize are the potential forage cereals as they could produce higher quantity and quality fodder besides ensuring net monetary returns. Fodder cowpea and sunhemp are the next best suitable forage legumes under late-sown conditions in the semi-arid tropics of India.

ACKNOWLEDGEMENT

The authors are thankful to Project Coordinator Unit, All India Coordinated Research Project for Dryland Agriculture, ICAR-Central Research Institute for Dryland Agriculture, Hyderabad for supporting the research work and providing suggestions during the study.

Conflict of interest: None.

REFERENCES

Anonymous. (2018a). National Accounts Statistics 2016. Central Statistical Organization, GOI. http://mospi.nic.in/ publication/ national-accounts-statistics-2016.

Anonymous. (2018b). IGFRI Vision 2050. http:// www.igfri.res.in/ 2013/Vision-2050.pdf.

Brar, N.S., Kumar, B., Kumar, A., Singh, P. and Shashipal. (2016). Performance of cultivars of *kharif* fodder maize under late sown conditions in Punjab. International Journal of Farm Sciences. 6(4): 299-304.

Chaudhary, D.P., Kumar, A., Kumar, R., Singode, A., Mukri, G., Sah, R.P., Tiwana, U.S and Kumar, B. (2016). Evaluation of normal and specialty corn for fodder yield and quality traits. Range Management and Agroforestry. 37: 79-83.

Gangaiah, B. and Kundu, S. (2020). Introduction and evaluation of single and multicut fodder crops for augmenting fodder supplies in Andaman and Nicobar Islands for supporting dairy farming. Forage Research. 45(4): 289-294.

Jackson, M.L. (1973). Soil Chemical Analysis. Prentice Hall of India. Pvt. Ltd., New Delhi. pp. 111-204.

Kaushik, N., Deswal, R.P.S and Malik, S. (2015). Agroforestry systems for fodder production under rainfed conditions. Ecology, Environment and Conservation. 21(2): 901-904.

Kumar, B., Dhaliwal, S.S., Singh, S.T., Lamba, J.S and Ram, H. (2016). Herbage production, nutritional composition and quality of teosinte under Fe fertilization. International Journal of Agriculture and Biology. 18(2): 319 329.

Kumar, S., Agrawal, R.K., Dixit, A.K., Rai., Arvind, K. and Rai, S.K. (2012). Forage crops and their management. Indian Grassland and Fodder Research Institute, Jhansi, Uttar Pradesh, India. pp 60.

Kumari, V.V., Gopinath, K.A., Venkatesh, G., Sarathchandran, M.A. and Srinvasa Rao Ch. (2017). Fodder constraints in rainfed areas of India: Constraints and strategies. Forage Research. 43(2): 81-88.

Meena, H., Meena, P.K.P., Singh, P. and Kumhar, B.L. (2017). Assessment of hybrid fodder sorghum (Sugar graze) quality parameters. International Journal of Pure and Applied Bioscience. 5(2): 92-95.

Mohan, S., Dar, E.A. and Singh, M. (2017). Fodder quality of teosinte fodder as influenced by nitrogen, phosphorus and zinc application. International Journal of Pure and Applied Biosciences. 5: 596-604.

Patel, S.B., Patel, A.G., Chavda, J.N. and Patel M.A. (2017). Effect of time of sowing and nitrogen levels on yield attributes, yield and quality parameters of *rabi* forage maize (*Zea mays* L.). International Journal of Chemical Studies. 5(3): 868-871.

Ramachandrappa, B.K., Thimmegowda, M.N., Dhanpal, G.N., Savitha, M.S., Srikanth Babu, P.N., Gopinath, K.A., Ravindra Chary, G., Srinivasa Rao, Ch. (2019). Productivity and economics of fodder crops-chickpea double cropping system as influenced by varieties and fertilizer levels in chickpea under *alfisols* of eastern dry zone of Karnataka. Indian Journal of Dryland Agricultural Research and Development. 34(2): 32-37.

Saimaheswari, K., Prathima, T., Subramanyam, D. and Latha, P. (2020). Agronomic evaluation of fodder sorghum varieties under different dates of sowing. Current Journal of Applied Science and Technology. 39(9): 25-32.