ISSN Print: 2664-6064
ISSN Online: 2664-6072
NAAS Rating (2026): 4.69
IJAN 2026; 8(4): 19-22
www.agriculturejournal.net
Received: 09-01-2026
Accepted: 13-02-2026

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Evaluation of fodder yield, chemical composition and prediction of nutritive value of some leguminous fodder crops by SEDS

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DOI: https://www.doi.org/10.33545/26646064.2026.v8.i4a.368

Abstract
The experiment was conducted to evaluate leguminous fodder crops: Horsegram, Field bean, Cluster bean, Cowpea for their green fodder yield (GFY) and dry matter yield (DMY). The same were subjected for proximate, fibre fraction andenergy values were calculated by summative equations of detergent system. The highest GFY and DMY was for cowpea. Dry matter percentage in Horsegram and Cluster bean ranged from 19.6 to 21.7 but in Field bean and Cowpea, the dry matter percentage was around 16. The CP content was significantly (p<0.01) higher in Cowpea and the lowest CP was seen in Cluster bean. Significantly (p<0.01) lower ether extract was noticed in Cluster bean however not much variation in NFE content among leguminous annual fodders. highest CP yield was observed in Cowpea followed by Field bean, Horsegram and Cluster bean. NDF content of Field bean was significantly (p<0.01) higher than other leguminous fodder crops whereas, the same fodders also had significantly (p<0.01) higher ADF. Predicted true digestible dry matter (TDDM), apparent digestible dry matter (ADDM), Metabolizable energy (ME) and total digestible nutrients (TDN) by SEDS were highest in Horsegram and were comparable in other fodder crops. Based on agronomical parameters and chemical composition if more green fodder yield is required among leguminous fodder crops studied, Cowpea can be recommended. As energy values and CP are comparable, based on Total digestible nutrients Horsegram can be recommended to include in the diets of ruminants to meet requirements for growth and milk production.

Keywords: Horsegram, Field bean, Cluster bean, Cowpea, green fodder yield, dry matter yield

Introduction
Livestock forms an integral component of the agricultural production system and plays a vital role in the nation's economy. However, severe feed shortages in India have become a critical constraint, limiting livestock productivity and the ability to meet domestic demand. One promising approach to mitigate this scarcity is the cultivation of high-quality fodder crops. Among these, legumes are particularly valuable, as they provide animals with essential nutrients, including high-quality protein, minerals, and vitamins. Notably, sugarcane trash has been found to possess a nutritional composition comparable to common crop residues. When treated with urea ammoniation, sugarcane trash demonstrated a voluntary intake of 2% of body weight, highlighting its potential as a viable forage resource (Jaishankar *et al*., 2021) [10]. Incorporating leguminous forages into straw-based rations has been shown to improve feed digestibility and overall ruminant performance (Khan *et al*., 1992; Akbar *et al*., 2003) [11, 2]. Legume crops are versatile, cultivated not only for grains, pulses, and vegetables but also as high-quality fodder for livestock. They exhibit rapid growth and consistently produce nutrient-dense biomass. A study was undertaken to evaluate the green fodder yield, dry matter yield, proximate composition, and fiber fractions of selected annual leguminous fodder crops, including Horsegram (*Macrotyloma uniflorum*), Cluster bean (*Cyamopsis tetragonoloba*), Field bean (*Vicia faba*), and Cowpea (*Vigna unguiculata*). For dairy cows, precise assessment of the energy density of feed is essential to ensure consistent performance (Robinson, 2007) [17]. The study also aimed to assess the suitability of the Summative Equations of the Detergent System (SEDS) for predicting the nutritive value of

these leguminous fodders, as SEDS is widely recognized for evaluating ruminant feedstuffs (Nataraja *et al*., 1998).

Materials and Methods

Some leguminous fodder crops, such as Horsegram (*Macrotyloma uniflorum*), Cluster bean (*Cyamopsis tetragonoloba*), Field bean (*Vicia faba*), and Cowpea (*Vigna unguiculata*), were sown in separate plots (5 x 12 m^2) on open furrows spaced 60 cm apart. The total quantity of fertilizer, which included phosphorus and nitrogen in the form of triple super phosphate and urea, was applied at the time of sowing. Every other conventional farming method was implemented in the same way to every plot. Depending on the amount of rainfall, sprinklers were used to irrigate the fodder crops every three to four days. The fodder was hand-harvested at the appropriate stage for use as green fodder. Green fodder and dry matter yields were calculated using sample harvests at one square meter in four different sections of the plot. The fodder yield derived from the net plot area converted into ton ha^{-1}, and sampling was carried out using the quartering method (Campos-M and Campos-C, 2017). Following harvesting, a sample of the fodder crops was taken, dried in a forced-air oven at 60 °C until the weight remained constant, and then ground using a Willey mill through a 1 mm screen. The ground samples were kept in airtight receptacles until a further examination.

Chemical analysis

Samples of various leguminous fodders were examined for their chemical and proximate compositions. A thorough analysis was conducted on the following contents: dry matter (DM), organic matter (OM), ether extract (EE), crude protein (CP), crude fiber (CF), nitrogen free extract (NFE), and total ash (AOAC, 2016). The techniques outlined by Van Soest *et al*. (1991) were used to determine the neutral detergent fiber (NDF) and acid detergent fiber (ADF). Summative equations were used to determine the total digestible nutrients, metabolisable energy (ME), apparent digestible dry matter (ADDM), and true digestible dry matter (TDDM) for fodder crops (Goering and Van Soest, 1970; Van Soest, 1971). The conversion factor from TDN to ME was 0.15.

TDDM = (NDSx0.98)+(NDF x ((147.3-(78.9log10((L+BS) x 100/ADF)))/100))-(SSx1.4)
ADDM = TDDM – (365.7 – 0.275 TDDM)
TDN = ADDM – (TA-TS) + 1.25EE + 19
1 kg TDN = 15.1 MJ of ME or 18.45 MJ of DE, ME = 0.82 DE

Where, ME = Metabolisable energy (MJ kg^{-1} DM), TDDM, ADDM, TDN, EE, NDS, NDF, BS, ADF, SS, TS and TA are true digestible dry matter, apparent digestible dry matter, total digestible nutrients, ether extract, neutral detergent solubles, neutral detergent fibre, biogenic silica, acid detergent fibre, sand silica, total silica and total ash respectively in g kg^{-1} DM.

Results and Discussion

Forage yield

The green fodder yield (GFY) (t/ha) and dry matter yield (DMY) (t/ha) of some leguminous annual fodder crops are presented in Table-1. GFY (t/ha) and DMY (t/ha) of Horsegram, Field bean, Cluster bean and Cowpea were 81.33, 24.17 and 4.73; 132.33, 33.27 and 5.6; 117.67, 19.55 and 4.25; 98.33, 38.24 and 6.24, respectively. There is significant difference between the leguminous fodder crops (p<0.01) for GFY and DMY. There was a direct relationship between GFY and DMY. This is because the DM yield was calculated based on the DM content of the green fodder. As the green fodder yield increased, the dry atter yield was also increased. As forages taken for study were of different varieties, these changes do occur with respect to agronomical parameter because of their genetic makeup, nutrition and environmental factors (Cornelissen *et al*., 2003) [4]. Average green fodder and dry matter yield (t / ha) for Cowpea was greater than the yield (27.16 and 5.21) reported by Lohithaswa *et al*. (2013) [14]. Similar green fodder and dry matter yield (t / ha) for Field bean and Cluster bean were noticed in the study conducted by Fraser *et al*. (2001) [6] and Pandey *et al*. (2018) [16] respectively. Variation in yield (green fodder and dry matter) cannot be attributed to single factor where multiple factors are involved influencing the yield (Kusvuran *et al*., 2015) [13].

Chemical composition and composition yield of leguminous annual fodder crops

Dry matter percentage in Horsegram and Cluster bean ranged from 19.6 to 21.7 but in Field bean and Cowpea, the dry matter percentage was around 16. The CP content was significantly (p<0.01) higher in Cowpea and the lowest CP was seen in Cluster bean. Significantly (p<0.01) lower ether extract was noticed in Cluster bean however not much variation in NFE content among leguminous annual fodders. As composition yield was calculated based on the composition of respective nutrients, it varies usually with the either green fodder yield or dry mater yield, hence highest CP yield was observed in Cowpea (1.46 t/ha) followed by Field bean, Horsegram and Cluster bean. The rest of composition yield followed the same trend as that of CP yield. The variation in composition and composition yield among leguminous annual fodder crops was because of the difference in variety or genetic makeup.

Chemical composition (as per cent DM basis) of Cluster bean and Cowpea fodder *i.e* DM, OM, CP, EE, TA obtained in the present study are in in agreement with the chemical composition values reported for the respective fodder crops in earlier studies (Garg *et al.*, 2012; Kumar *et al*., 2015; Suliman *et al*., 2017) [7, 12, 18].

Numerous studies have been conducted on the nutritional composition, processing, and application of common food legumes (Horsegram and Field bean), but information available for the nutritional composition of fodders of Horsegram and Field bean is limited, which can be compared with other annual leguminous fodder crops. OM, CP, EE, TA (as per cent DMB) observed in the current study for Horsegram and Field bean can be compared with chemical composition values of reported by Hasan *et al*. (2010) for Cow pea forage which belongs to the same family (Fabaceae) as that of Horsegram and Field bean.

Fibre fraction: leguminous and non leguminous annual fodder crops: NDF content of Field bean was 53.67 per cent, which is significantly (p<0.01) higher than other leguminous fodder crops whereas, the same fodders also had significantly (p<0.01) higher ADF. NDF yield and ADF yield were significantly (p<0.01) higher in Cowpea followed by Field bean, Horsegram and Cluster bean and

this variation in fodders might be due to the difference in varieties and stage of harvest. NDF, ADF and ADL (as per cent DM basis) observed in the current study for Cowpea and Cluster bean are similar to the values reported by Garg *et al.,* (2012) [7] and Pandey *et al*., (2018) [16] respectively, and those of Horsegram and Field bean are within the range of values reported by Dutt *et al*., (2009) for other annual leguminous fodder crops.

Predicted digestibility and energy values

Predicted true digestible dry matter (TDDM), apparent digestible dry matter (ADDM), Metabolizable energy (ME) and total digestible nutrients (TDN) by SEDS are given in Table-2. TDDM, ADDM, ME and TDN were highest in Horsegram and were comparable in other fodder crops.

Table 1: Forage yield, Chemical composition, composition yield, fibre fraction and Fibre fraction yield (t/ha) of some leguminous annual fodder crops

Fodder crop		Horsegram	Field bean	Cluster bean	Cowpea	SEM	P value
Fodder yield (t/ha)	GFY (t/ha)	24.17^{b}	33.27^{c}	19.55^{a}	38.24^{d}	0.158	<0.01
	DMY (t/ha)	4.73^{b}	5.60^{c}	4.25^{a}	6.24^{d}	0.029	<0.01
Composition (%)	DM	19.57^{c}	16.85^{ab}	21.73^{d}	16.30^{a}	0.186	<0.01
	OM	91.5^{c}	91.61^{cd}	88.21^{ab}	87.09^{a}	0.358	<0.01
	ASH	8.92^{a}	9.88^{b}	11.77^{d}	10.96^{c}	0.044	<0.01
	EE	2.60^{b}	3.19^{c}	1.38^{a}	3.98^{d}	0.079	<0.01
	CP	18.44^{c}	17.58^{b}	16.61^{a}	23.40^{d}	0.223	<0.01
	NFE	27.97^{b}	26.96^{ab}	27.43^{b}	25.52^{a}	0.439	<0.01
Composition yield (t/ha)	CP	0.87^{b}	0.99^{c}	0.71^{a}	1.46^{d}	0.01	<0.01
	EE	0.12^{b}	0.18^{c}	0.06^{a}	0.25^{d}	0.005	<0.01
	NFE	1.32^{b}	1.51^{c}	1.17^{a}	1.59^{cd}	0.024	<0.01
Fibre fraction (%)	NDF	46.03^{b}	53.67^{d}	43.92^{a}	49.90^{c}	0.34	<0.01
	ADF	44.87^{c}	45.33^{cd}	36.32^{a}	41.28^{b}	0.369	<0.01
	ADL	8.723^{abc}	8.37^{a}	9.19^{d}	8.68^{ab}	0.113	<0.01
Fibre fraction yield (t/ha)	NDF yield	2.18^{b}	3.01^{c}	1.86^{a}	3.11^{d}	0.029	<0.01
	ADF yield	2.13^{b}	2.54^{c}	1.54^{a}	2.57^{c}	0.018	<0.01

Means with distinct superscripts $^{a, b, c, d}$ within a column, exhibit significant differences at (P<0.01). GFY = Green fodder yield; DMY = Dry matter yield

Table 2: Chemical composition, predicted digestibility and energy values of some leguminous annual fodder crops by SEDS

Fodder crop	Horsegram	Field bean	Cluster bean	Cowpea
SS (%)	4.26	4.76	4.26	4.26
BS (%)	1.6	2.1	1.92	1.52
TDDM (%)	65.27	60.12	62.21	61.8
ADDM (%)	46.65	40.09	42.75	42.28
TDN (%)	48.74	42.92	40.78	43.92
ME (MJ/kg DM)	7.37	6.48	6.16	6.64

Summary and conclusion

Among the selected leguminous annual fodder crops evaluated in the experiment, cowpea recorded the highest yield, with a green fodder yield (GFY) of 38.24 t/ha and a dry matter yield (DMY) of 6.24 t/ha. It also exhibited superior nutritional quality, particularly in terms of crude protein (CP) and ether extract (EE) content. Consequently, cowpea produced the highest crude protein yield (28.18), making it highly suitable for enhancing animal productivity. The overall performance of the leguminous fodders, based on yield and nutrient contribution, followed the order: cowpea > field bean > horsegram > cluster bean. The predicted digestibility and energy values estimated using SEDS were highest in horsegram, although these values were largely comparable among the other three leguminous fodders studied. Based on agronomic performance and chemical composition, cowpea can be recommended when the objective is to maximize green fodder yield. However, considering that energy values and crude protein contents were broadly comparable, horsegram demonstrated relatively higher total digestible nutrient (TDN) value. Therefore, horsegram can be recommended for inclusion in ruminant diets to meet the nutritional requirements for growth and milk production.

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