



## Quality characteristics and nutrient yields of maize and legume forages under changing intercropping row ratios

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### ABSTRACT

Availability of green fodder with improved quality to animals is the key to success for sustainable livestock production. It is difficult to maintain the health and milk production of the livestock without supply of the quality green fodder. Therefore, the study was carried out to evaluate the forage quality of maize and legumes as influenced by varying intercropping combinations. This experiment was laid out in randomized complete block design (RCBD) with seven treatments consisting of three different forage crops, viz. maize, cowpea and guar sown in sole as well as in 1:1 and 2:1 intercropping combinations of forage cereal with legume crop components in three replications. Experimental results showed that the highest dry matter yield (94.89 q/ha) was obtained in maize+ cowpea (2:1) intercropping combinations. The quality parameters of different forage crops, viz. Organic Matter, Crude Protein, Ether Extract, Ash Content, Neutral Detergent Fiber, Acid Detergent Fiber, Acid Detergent Lignin, NDICP and ADICP were influenced significantly and favourably with inclusion of both legumes. Among intercropping combinations Maize: legume (1:1) was better over Maize: legume (2:1) and sole maize. The CP, EE and Ash yield were influenced significantly and maximum value were observed 10.74, 1.99 and 9.4 q/ha, respectively in forage maize+ cowpea (2:1) ratio. Among the different forage crops, the fiber fractions were observed minimum in (1:1) intercropping ratio of maize with legume components as compares to their sole component as well as (2:1) intercropping combinations. The insoluble crude protein content was found minimum in (1:1) intercropping combination and influenced significantly with their respective (2:1) or sole crop.

**Key words:** Cluster bean, Cowpea, Forage quality, Intercropping, Maize

Agriculture sector is considered as backbone of Indian economy which contributes nearly 17.9% of GDP. Furthermore, 52% of the population is directly or indirectly dependent on agriculture and its allied activities for their livelihood. Livestock play an important role in the rural economy of India by providing employment and supplementary family income. Animal performance is mainly dependent on its feeding. Forages particularly green fodder is the mainstay of animal wealth. It is well known fact that about 65–70% of the total cost of livestock farming is attributed to feeding (Anonymous 2015). However, it is also emphasised that green fodder production is a good way in order to curtail the cost of feed and fodder resources for sustainable livestock production. But, the fodder production in the country is not sufficient to meet the requirements. At present, the country is facing a net deficit of 35.6% green fodder, 10.95% dry crop residues and 44% concentrate feed ingredients (Anonymous 2015). At the current level of growth in forage resources, there will be 18.4% deficit in

green fodder and 13.2% deficit in dry fodder by the year 2050 (Anonymous 2015).

Quality forage production and availability of green fodder with improved quality to animals is the key to success of dairy enterprises. Both quality and quantity of fodder are influenced due to plant species, stage of growth and agronomic practices. The growing of fodder crops in mixture with legumes enhanced fodder palatability and digestibility. It is well established fact that livestock feed should contain enough protein to maintain their health. A minimum protein content of 5–6% is required for maintenance and 14% for productive purposes. When legumes are used as intercrops, they provide beneficial effect on soil fertility by fixing atmospheric nitrogen, increasing forage protein content, quality, palatability and profitability, best utilization of nutrients, moisture, space, solar energy per unit area and time.

Maize has the potential to supply large amounts of energy-rich forage for animal diets, and its fodder can safely be fed at all stages of growth without any danger of oxalic acid, prussic acid or ergot disease poisoning. Hence, it is widely known as “ready-made fodder crop”. Cowpea enhances the fodder productivity and improves nutritive value of whole ration. It has around 13–18% protein, 18–

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26% crude fibre and 2–3% crude fat. Guar fodder roughages contain 25% crude protein. Its principal uses include green manuring, edible pod, grains and cattle feed.

Supply of forages is inadequate in the country not only in terms of quantity but quality as well. Since the scope of area expansion under cultivated fodder is limited, improving the forage quality, providing stability to production and productivity of fodder crops is to be raised through best utilization of the resources of the prevailing production systems via intercropping systems. Hence, in order to get the best results, a rational approach is required for agronomic information on appropriate row proportion of maize and legumes in an intercropping system.

#### MATERIALS AND METHODS

A field experiment was conducted at the Institute during *kharif* 2017. Karnal has semi-arid climate characterized by hot and dry summer and severe cold during winter season. The annual rainfall of the area is 650 mm. The soil of experimental site was clay loam in texture with 7.2 pH (Jackson 1973), 0.62% organic carbon (Walkley and Black 1934), 0.32 dS/m EC 170 kg/ha available N (Subbiah and Asija 1956), 22.5 kg/ha available phosphorus (Olsen *et al.* 1954) and 270 kg/ha 1 N NH<sub>4</sub>OAC extractable K.

This experiment was laid out in randomized complete block design (RCBD) with seven treatments consisting of Sole Maize, Sole Cowpea, Sole Guar, Maize+ Cowpea (1:1), Maize+ Guar (1:1), Maize+ Cowpea (2:1) and Maize+ Guar (2:1) in three replications. The experimental field was deep tilled and then levelled before starting the experiment. The fodder maize (cultivar J-1006), Cowpea (cultivar C-152) and Guar (cultivar HG-02) were sown with seed rate of 60, 25 and 25 kg/ha, respectively during 29<sup>th</sup> standard meteorological by keeping a row spacing of 30 cm. For accommodating component crops in intercropping treatments replacement series was used. Forage crops were harvested manually at the age of 65 days and fresh forage yield were recorded. Samples were collected from each of the experimental plot and the DM content was estimated by putting the representative fodder samples in hot air oven at 70°C for 48 h. The dried samples were ground to pass through 1 mm sieve and used for chemical analysis. Finally milled sample were analyzed for DM, ash, ether extract and nitrogen (AOAC 2005) and fibre fractions (Van Soest *et al.* 1991). The data were analysed by using Fisher's analysis of variance technique and the least significant difference test at 5% probability level (Gomez and Gomez 1984).

#### RESULTS AND DISCUSSION

Dry matter is the expression of development of different morphological components like stem and number of leaves. Intercropping combinations of different component crops significantly affected total dry matter yield and significantly higher total dry matter yield (94.81 q/ha) was recorded in maize+guar (2:1) followed by maize+cowpea (2:1) intercropping treatments (94.04 q/ha), however, these

treatments were statistically at par to each other (Table 1).

Intercropping of legume crop component either cowpea or guar with maize, cowpea crop proved superior over component crop of guar in varying intercropping combinations. The increase in dry matter yield was also due to increase green forage yield in intercropping treatments. These findings are in agreement with results of Surve *et al.* (2007).

Data (Table 2) indicated that the dry matter content was not significantly influenced by intercropping system of different component crops of intercrop. However, with introduction of intercropping system there was increase in dry matter content with compared to their sole treatment. Among the different forage crop higher dry matter % was observed in maize crop (21.58%) and the lowest in cowpea crop (19.35%). In case of legume component of intercropping system, the dry matter content was decreases when it was intercropped with forage cereal/millet crop component. This might be increasing of succulence when intercropped.

Vital analysis of data in table 2 indicated reduction in organic matter content of different forage crops significantly by intercropping system with the lowest value obtained at 1:1 row ratio of intercropping combinations. Within the

Table 1. Effect of intercropping combinations on green fodder and dry matter yield

Treatment	Dry matter yield (q/ha)			
	Maize	Cowpea	Guar	Total
Sole Maize	94.09			94.09
Sole Cowpea		58.13		58.13
Sole Guar			60.31	60.31
Maize + Cowpea (1:1)	57.13	31.82		88.96
Maize + Guar (1:1)	56.93		32.85	89.79
Maize + Cowpea (2:1)	69.51	24.53		94.04
Maize + Guar (2:1)	69.44		25.37	94.81
SEm ±	0.53	0.28	0.23	0.53
CD at 5%	1.23	0.77	0.64	1.16

Table 2. Effect of intercropping combinations on Dry matter and Organic matter

Treatment	Dry matter (%)			Organic matter (%)		
	Maize	Cowpea	Guar	Maize	Cowpea	Guar
Sole Maize	21.54			91.32		
Sole Cowpea		19.40			88.88	
Sole Guar			21.24			88.18
Maize + Cowpea (1:1)	21.58	19.35		90.79	89.07	
Maize + Guar (1:1)	21.58		21.19	90.78		88.37
Maize + Cowpea (2:1)	21.56	19.37		90.88	89.14	
Maize + Guar (2:1)	21.56		21.20	90.89		88.41
SEm ±	0.03	0.05	0.03	0.07	0.07	0.09
CD at 5%	NS	NS	NS	0.16	0.19	NS

intercropping combinations there was no significance difference in OM content. Significantly higher organic matter content was found in sole treatment of different forage crops as compared to their respective intercropping combinations. This might be due to corresponding increase in ash content in forage crops as introducing in intercropping system.

Data (Table 3) indicated that crude protein percent improved significantly in intercropping combinations as compares to their respective sole crops. Both component crops of intercropping produce higher CP content at their 1:1 intercropping combinations. Significantly higher CP content was recorded in 1:1 intercropping row ratio followed by 2:1 row ratio. In forage maize, which was intercropped with cowpea/guar in 1:1 or 2:1 row ratio, significantly higher CP content (8.90%) was recorded in maize+guar 1:1 intercropping combination, which was 6.84% more than sole treatment of maize crop. The lowest significant crude protein % was observed in their respective sole treatments. Similar finding regarding crude protein content were observed by Baghdadi *et al.* (2016).

Ether extract is the term used to refer the crude mixture of fat-soluble material present in a sample. Ether extracts also known as the Crude fat or the free lipid content, is the traditional measure of fat in food products. Significant

Table 3. Effect of intercropping combinations on Crude protein and Ether extract

Treatment	Crude protein (%)			Ether extract (%)		
	Maize	Cowpea	Guar	Maize	Cowpea	Guar
Sole Maize	8.33			1.65		
Sole Cowpea		16.24			2.33	
Sole Guar			16.81			2.38
Maize + Cowpea (1:1)	8.86	16.68		1.97	2.58	
Maize + Guar (1:1)	8.90		17.05	1.96		2.62
Maize + Cowpea (2:1)	8.65	16.51		1.83	2.46	
Maize + Guar (2:1)	8.63		16.96	1.84		2.49
SEm ±	0.05	0.07	0.06	0.05	0.06	0.05
CD at 5%	0.11	0.20	0.17	0.11	0.17	0.13

higher ether extract % was found in 1:1 intercropping row proportion (Table 3). Within the intercropping combinations there was also significant difference in ether extract percent. In legume component of intercropping system guar crop proved better than cowpea crop. In terms of ether extract content legume component of intercropping system was better than forage cereal/millet component. Intercropping of forage maize with legume component of guar prove better than cowpea crop. These results are also support the finding of Chauhan and Dugarwal (1980).

The total crude protein yield in different forage crops were recorded significantly higher in intercropping combinations (Table 4). Among the intercropping treatments of different forage crops, Maize+guar (1:1) row ratio recorded significantly highest crude protein yield of maize and guar (5.07 and 5.60 q/ha) over rest of other treatments. However, Maize + Cowpea (1:1) row ratio (5.06 and 5.31 q/ha) were statistically influenced with Maize + guar (1:1). Intercropping ratio of 1:1 had more proportion of legume crop component which might cause more availability of nitrogen to the cereal/millet crop. The highest total crude protein yield of 1:1 row proportion might be due to higher crude protein content and higher dry matter accumulation. With increasing the legume component there is significant improvement in CP content in forage crops. The sole treatment of different forage crops and the amount of total crude protein yield was significantly lower than intercropping system. The improvement of quality of maize in fodder maize+legume might possibly the result of fixation of higher amount of nitrogen either by direct excretion from the legume nodule root system or by decomposition of nodule and root debris. The legume intercrops were able to grow better, fixing greater amount of atmospheric N and its transformation in the form of proteins. Some part of which might have become available to cereal crop. This might be the possible reason for obtaining higher crude protein content of cereal/millet in 1:1 rows ratio. These results are in line with findings of Kumar and Venkateswarlu (2013).

The total ether extract yield was significantly influenced by intercropping combination of forage maize+ legume crop and the highest value of ether extract yield (1.98 q/ha) was observed in treatment maize+ guar (1:1) intercropping row

Table 4. Effect of intercropping combinations on Crude protein and Ether extract yield

Treatment	Crude protein yield (q/ha)				Ether extract yield (q/ha)			
	Maize	Cowpea	Guar	Total	Maize	Cowpea	Guar	Total
Sole Maize	7.84			7.84	1.55			1.55
Sole Cowpea		9.44		9.44		1.35		1.35
Sole Guar			10.14	10.14			1.44	1.44
Maize + Cowpea (1:1)	5.06	5.31		10.37	1.12	0.82		1.94
Maize + Guar (1:1)	5.07		5.60	10.67	1.12		0.86	1.98
Maize + Cowpea (2:1)	6.01	4.05		10.06	1.27	0.60		1.88
Maize + Guar (2:1)	5.99		4.30	10.30	1.28		0.63	1.91
SEm ±	0.06	0.05	0.06	0.08	0.03	0.02	0.03	0.04
CD at 5%	0.14	0.15	0.16	0.17	0.08	0.07	0.07	0.08

Table 5. Effect of intercropping combinations on ash content and yield

Treatment	Ash (%)			Ash yield (q/ha)			Total
	Maize	Cowpea	Guar	Maize	Cowpea	Guar	
Sole Maize	8.68			8.17			8.17
Sole Cowpea		11.12			6.47		6.47
Sole Guar			11.82			7.13	7.13
Maize + Cowpea (1:1)	9.21	10.93		5.26	3.48		8.74
Maize + Guar (1:1)	9.22		11.63	5.25		3.82	9.07
Maize + Cowpea (2:1)	9.12	10.86		6.34	2.66		9.00
Maize + Guar (2:1)	9.11		11.59	6.33		2.94	9.27
SEm ±	0.07	0.07	0.09	0.04	0.03	0.03	0.04
CD at 5%	0.16	0.19	NS	0.10	0.08	0.09	0.09

ratio. The second highest value of total ether extract yield (1.94 q/ha) was recorded in treatment of maize+ cowpea (1:1) row ratio. But this treatment was statistically at par from the highest value. The lowest total ether extract yield was recorded in sole cowpea treatments (1.35 q/ha). The reason of lowest EE yield was lower amount of total dry matter yield in cowpea crop due to its more succulence.

Significantly higher value of ash content was recorded in 1:1 row ratio with respect to other combinations. Within the intercropping combinations all recorded observations were also significant in their respective intercropping ratio of 1:1 and 2:1. Ash content was quite higher in legume component as compared to forage cereal/millet crops. Among the different forage crop the highest value of ash % was observed in guar crop followed by cowpea and the lowest value was recorded in maize crop. Similar significant impact of intercropping treatments on ash content was earlier reported by Ibrahim *et al.* (2006). The highest total ash yield (9.27 q/ha) was obtained in maize+guar (2:1) row ratio. The lowest significant total ash yield was observed in sole cowpea (6.47 q/ha). In forage maize crop, with the introduction of legumes as component crop in intercropping system there was (6.9, 11.01, 10.15 and 13.46%) increment in total ash yield over sole maize from forage maize+cowpea/guar (1:1/2:1) intercropping combination, respectively. Increase in total ash of forage maize by growing in mixture with legumes has been reported Ibrahim *et al.* (2006).

Intercropping of maize with forage legumes significantly affected the NDF content (Table 6). The lowest significant value of NDF was observed in 1:1 intercropping row ratios of forage crops. While in legume component of intercropping combination 2:1 row ratio proves better than 1:1 and respective sole treatment. Within the intercropping ratio in different treatments all the observations were also influenced significantly. The highest value of NDF which was undesirable observed in their respective sole treatments.

Cereal crop grown along with legumes might have availed better nitrogen nutrition. This higher nitrogen under intercropped situation could have made the cereal component more succulent. There is negative correlation between nitrogen and crude fibre content. Legume fodder developed profuse branching and more leaf matter among

Table 6. Effect of intercropping combinations on NDF and ADF

Treatment	NDF (%)			ADF (%)		
	Maize	Cowpea	Guar	Maize	Cowpea	Guar
Sole Maize	65.60			33.51		
Sole Cowpea		46.97			30.85	
Sole Guar			44.52			30.66
Maize + Cowpea (1:1)	64.72	46.53		32.82	30.42	
Maize + Guar (1:1)	64.66		43.48	32.84		30.35
Maize + Cowpea (2:1)	65.01	45.98		33.00	30.08	
Maize + Guar (2:1)	64.97		42.19	33.03		30.07
SEm ±	0.05	0.04	0.12	0.04	0.05	0.11
CD at 5%	0.12	0.12	0.34	0.10	0.13	0.32

all the intercrops and was highly succulent. This high succulence and more leafiness of legumes could be the possible reason for low fibre content. The presence of leguminous plants in the fodder affected NDF and ADF levels in the present study. There is usually lower concentration of fibres in the DM of legumes in relation to grasses.

There was significant effect of intercropping on ADF content of different forage crops. ADF content was progressively decreased with introducing intercropping combination and lowest value of ADF content in 1:1 intercropping row ratios. All the observation of intercropping combination also influenced significantly by intercropping. These results are in line with findings of Javanmard *et al.* (2009) reported that intercropping of maize with different legumes such as vetch, bitter vetch, berseem and common bean to evaluate the effects of legumes on forage yield and quality. NDF and ADF content significantly reduced with introduction of intercropping system compared to sole maize, thus increasing digestibility of the forage.

Intercropping established no significant effect (Table 7) on hemicellulose percentage of intercropping to their sole treatment except guar crop. The lowest percent of ADL was found in 1:1 row ratios of different forage crops with respect

Table 7. Effect of intercropping combinations on Hemicellulose% and ADL%

Treatment	Hemicellulose (%)			ADL (%)		
	Maize	Cowpea	Guar	Maize	Cowpea	Guar
Sole Maize	32.09			4.79		
Sole Cowpea		16.11			8.99	
Sole Guar			13.86			9.36
Maize + Cowpea (1:1)	31.90	16.11		4.39	8.79	
Maize + Guar (1:1)	31.82		13.13	4.40		9.20
Maize + Cowpea (2:1)	32.01	15.90		4.53	8.70	
Maize + Guar (2:1)	31.93		12.13	4.55		9.06
SEm ±	0.08	0.02	0.22	0.02	0.02	0.03
CD at 5%	NS	0.05	0.60	0.06	0.07	0.09

to their 2:1 and sole treatments. Within the intercropping combination all the observations were found significant with their respective legume intercrop. The maximum value which is undesirable was observed in sole treatment of different forage crops. Intercropping of forage maize with legume component of guar crop proved lower content of Acid Detergent Lignin compared to cowpea component crop. Intercropping of cereal crop grown along with legumes might have availed better nitrogen nutrition. This higher nitrogen could have made the cereal component more succulent in intercropping combination. This higher succulence could be the possible reason for low content of acid detergent lignin in intercrop.

The minimum value of NDICP on dry matter percentage basis was found in 1:1 intercropping proportion with respective to their 2:1 and sole treatment in forage cereal crop (Table 8). While in case of legume component the lowest significant value of NDICP was found in 2:1 row ratio followed by 1:1 which was at par from the lowest observation. The maximum value which is undesirable was observed in sole treatment of different forage crops. Among

Table 8. Effect of intercropping combinations on NDICP

Treatment	NDICP (DM%)			NDICP (CP%)		
	Maize	Cowpea	Guar	Maize	Cowpea	Guar
Sole Maize	3.15			37.75		
Sole Cowpea		7.82			48.16	
Sole Guar			7.92			47.09
Maize + Cowpea (1:1)	3.06	7.75		34.50	46.44	
Maize + Guar (1:1)	3.06		7.80	34.33		45.78
Maize + Cowpea (2:1)	3.09	7.67		35.69	46.47	
Maize + Guar (2:1)	3.07		7.76	35.60		45.78
SEm ±	0.03	0.02	0.04	0.30	0.18	0.33
CD at 5%	0.06	0.05	0.11	0.69	0.50	0.92

the different forage crop the minimum amount of neutral detergent insoluble crude protein content on DM% basis was recorded in maize crop in intercropping with cowpea/guar 1:1 row ratio (3.06%) and higher amount was observed in legume guar sole crop (7.92%).

Different fodder crops significantly influenced by row proportion of intercropping combinations (Table 8). On % CP basis the lower value of NDICP was found in intercropping ratio as compares to their respective sole crops. Sole fodder crops recorded significantly higher NDICP, which is undesirable and unavailable to the animal compared to other intercropping treatments. Among intercropping treatments 1:1 row proportion of different forage crops recorded significantly lower NDICP (CP% basis). Among the different forage crop the minimum amount of neutral detergent insoluble crude protein content on CP% basis was recorded in forage maize crop and higher amount was observed in legume cowpea crop (48.16%). In case of forage maize sole crop as well as its intercropping with cowpea/guar in 1:1 and 2:1 row ratio, the neutral detergent insoluble crude protein content on CP% basis was decreased in the tune of (8.60%, 9.05% intercropped in 1:1 and 5.45%, 5.69% while intercropped in 2:1 intercropping ratio). The lower values of NDICP in intercropping combinations might be attributed to the lower NDF content in these treatments.

The lowest value of ADICP was recorded in (1:1) row ratio of intercropping combination (Table 9). Within the intercropping combination all the observations were at par to each other. The highest value of ADICP on CP% basis, which is undesirable for animal, was observed in their respective sole crop. Among the different forage crops minimum value of ADICP was found in cowpea followed by maize crop and the highest value was found in sorghum crop. The Acid detergent insoluble crude protein content on CP% basis of forage maize+cowpea/guar intercrop in (1:1) row ratio were decreased to the tune of 4.56, 5.93 12.74 and 12.92 per cent over (2:1) row ratio and sole treatment of forage maize crop. Similar trends of ADICP (CP% basis) were also followed in other forage crops. The

Table 9. Effect of intercropping combinations on ADICP

Treatment	ADICP (DM%)			ADICP (CP%)		
	Maize	Cowpea	Guar	Maize	Cowpea	Guar
Sole Maize	1.38			16.56		
Sole Cowpea		2.62			16.15	
Sole Guar			2.75			16.34
Maize + Cowpea (1:1)	1.28	2.53		14.45	15.15	
Maize + Guar (1:1)	1.28		2.67	14.42		15.66
Maize + Cowpea (2:1)	1.31	2.48		15.14	15.03	
Maize + Guar (2:1)	1.32		2.59	15.33		15.29
SEm ±	0.03	0.03	0.04	0.31	0.22	0.25
CD at 5%	0.07	0.10	0.10	0.72	0.60	0.69

data in Table 9 further revealed that intercropping combination of different forage crop significantly influenced ADICP (DM% basis) and the lowest value in forage maize was registered at 1:1 intercropping row ratio. While in legume component of intercropping significantly lower value was found in 2:1 intercropping combinations. Within the intercropping combination all the observations were at par to each other. Among the different forage crops minimum value of ADICP was found in maize and the highest value was found in guar crop.

Present study demonstrated that the growing of fodder crops in mixture with legumes enhanced fodder quality parameters, viz. CP, EE, Ash content while decreased fibre fractions, viz. NDF, ADF, hemicelluloses and ADL, along with bound proteins. The dry matter and nutrient yields were also increased with inclusion of legumes in both ratios.

#### REFERENCES

- AOAC. 2005. *Official Methods of Analysis*. 18<sup>th</sup> edn. Association of Official Analytical Chemists, Arlington, Virginia, USA.
- Baghdadi A, Halim R A, Ghasemzadeh A, Ebrahimi M, Othman R and Yusof M M. 2016. Effect of intercropping of corn and soybean on dry matter yield and nutritive value of forage corn. *Legume Research-An International Journal* **39**(6): 976–81.
- Barik P, Midhya A, Sarkar B K and Ghose S S. 2006. Wheat chickpea intercropping systems in an additive series experiment, advantages and weed smothering. *European Journal of Agronomy* **24**: 325–32.
- Chouhan G S and Dunganwal H S. 1980. Companion cropping of maize with legumes for forage. *Madras Agricultural Journal* **67**(4): 233–38.
- Gomez K A and Gomez A A. 1984. *Statistical Procedures for Agricultural Research*, p 680. John Willey and Sons, Singapore.
- Jackson M L. 1967. *Soil Chemical Analysis*. Prentice – Hall of India Private Limited, New Delhi, India.
- Javanmard A, Nasab A D M, Javanshir A, Moghaddam M and Janmohammadi H. 2009. Forage yield and quality in intercropping of maize with different legumes as double-cropped. *Journal of Food, Agriculture and Environment* **7**(1): 163–66.
- Kumar K T and Venkateswarlu B. 2013. Babycorn (*Zea mays* L.) performance as vegetable-cum-fodder in intercropping with legume fodders under different planting patterns. *Range Management and Agroforestry* **34**(1): 137–41.
- Licitra G, Hernandez T M and Van Soest P J. 1996. Standardization of procedures for nitrogen fractionation of ruminant feeds. *Animal Feed Science and Technology* **57**(4): 347–58.
- Ibrahim M, Rafiq M, Sultan A, Akram M and Goheer M A. 2006. Green fodder yield and quality evaluation of maize and cowpea sown alone and in combination. *Journal of Agricultural Research* **44**(1): 15–21.
- Olsen S R. 1954. *Estimation of Available Phosphorus in Soil by Extraction with Sodium Hydrogen Carbonate*. United States Department of Agriculture, Washington.
- Subbiah B V and Asija C L. 1956. A rapid procedure for the estimation of available nitrogen in soil. *Current Science* **25**: 258–60.
- Surve V H, Patil P R and Arvadia M K. 2007. Effect of row ratio in cereal-legume fodder under intercropping system on biomass production and economics. *Recent trend in Agriculture, Water and Environment Research* **2**(1): 32–34
- Surve V H, Patil P R and Arvadia M K. 2011. Forage production potential of sorghum (*Sorghum bicolor*), maize (*Zea mays* L.) and cowpea (*Vigna unguiculata*) under sole and intercropping Systems. *Madras Agricultural Journal* **98**(10–12): 372–74.
- Van Soest P J, Robertson J B and Lewis B A. 1991. Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. *Journal of dairy sciences* **74**(10): 3583–97.
- Walkley A and Black C A. 1934. Estimation of organic carbon by chronic acid titration method. *Soil Science*. **37**: 29–38.