Review Article

Intensification of Forage Production and Quality Parameters- A Review

Abstract

India supports nearly 20 per cent of the world's livestock population on just 2.2 per cent of the world's geographical area. The fodder production in the country is not sufficient to meet the requirement of growing livestock population and country faces a net deficit of 61.1% in green fodder, 21.9% in dry crop residues and 64% in feeds (Agarwal *et al*. 2008). This puts a tremendous pressure to increase fodder and forage production to meet the diet demands of increasing livestock population. Intensification of fodder and forage can be done by increasing productivity per unit area that can be achieved by integration of fodder crops in the cropping systems as intercrops, round the year forage production and introduction of fodder and forage crops in tree crops as alley crops. In addition to the intensification, the quality parameters of forage are equally important to be stressed upon. Important components that determine forage quality include fats, carbohydrates, crude protein, percent dry matter, pH etc. Anti-nutritional factors (ANF) in plants reduce the intake or nutrient utilization and determines the extent of uing those plants a fodder for livestock. The presence of anti- nutritional components *viz.,* nitrates, tannins, oxalates, mimosine, cyanogens, Saponins, BOAA (Benzo-oxalic acetic acid) limit the forage and fodder consumption. For the lean periods in which land may not be accessible for forage production, forage conservation is the best measure to meet the fodder demands. The forage conservation methods include hay making and silage making. These strategic measures will ensure food and nutritional security by supplying quality food and nutritional security by supplying quality fodder and forage for animals.

Keywords: Forage, Anti-nutritional factors, Fodder, Quality parameters

Introduction

India being home to world's largest livestock population, livestock plays a significant role in its economy as it provides draught power, rural transport, manure, fuel, milk and meat and more often, livestock is the only source of cash income for subsistence farms and also serves as insurance during crop failure. India supports nearly 20 per cent of the world's livestock population on just 2.2 per cent of the world's geographical area. The fodder production in the country is not sufficient to meet the requirement of growing livestock population and country faces a net deficit of 35% in green fodder, 10.95% in dry crop residues and 44% in feeds (IGFRI Vision, 2050). To meet the current level of huge livestock population and its growth annually, the deficit in all components of fodder and forage, dry crop residues, feeds and concentrates has to be met by either increasing production per unit area per unit time, utilizing unexplored feed resources, increasing land area (not possible due to human pressure on food crops) or through imports. Intensification of fodder and forage can be done by increasing productivity per unit area that can be achieved by integration of fodder crops in the cropping systems as intercrops, round the year forage production and introduction of fodder and forage crops in alleys formed between the tree crops, intensive irrigated systems, multiple cropping, round the year forage production systems, association of perennial grasses with forage legumes. Merely intensification of fodder production will not meet the feed requirements of livestock but there is a dire need to improve the quality of forage. Factors that influence forage quality include palatability *(will animals eat the forage?)* , intake(*How much will they eat?),* digestibility (*how much of the forage will be digested?*), nutrient content (*once digested, will forage provide an adequate level of nutrients?*) , anti- nutritional factors and finally the animal performance. Important components that determine forage quality include fats, carbohydrates, crude protein, percent dry matter, pH etc. The presence of anti- nutritional components *viz.*, nitrates, tannins, oxalates, mimosine, cyanogens, Saponins, BOAA (Benzo-oxalic acetic acid) limit the forage and fodder consumption.

FORAGE AND FODDER

Forage is the plant or plant parts that are eaten by grazing animals while as fodder refers to food and feed given to animals, rather than that which they forage for themselves. The most important forage crops include grasses (Poaceae) and legumes (Leguminaceae). The tropical grasses include Napier grass (*Pennisetum purpureum), Brachiaria* and *Panicum* species. The temprate grasses include Bentgrass (*Agrotis sp*.), fescue (*Festuca sp*.), Ryegrass (*Lolium sp*.) and orchard grass (*Dactylis sp*.) or hybrids of these. The most commonly cultivated legumes include Medicago (Medicago sp.), clover (Trifolium sp.), vetches (Vicia sp.) and trefoil (Lotus corniculatus) (Nicola *et al*.,2018.

SUPPLY AND DEMAND SCENARIO OF FODDER AND FORAGE

India faces a net deficit of 35% in green fodder, 10.95% in dry crop residues and 44% in feeds (IGFRI Vision, 2050). The situation is further aggravated due to increasing growth of livestock particularly that of genetically upgraded animals. The available forages are poor in quality, being deficient in available energy, protein and minerals. To compensate for the low productivity of the livestock, farmers maintain a large herd of animals, which adds to the pressure on land and fodder resources. To meet the current level of livestock production and its annual growth in population, the deficit in all components of fodder, dry crop residues and feed has to be met from either increasing productivity, utilizing unexplored feed and fodder resources or through imports.

Table 1. Demand and supply estimates of dry and green forages (million tonnes)

Year	Demand		Supply		Deficit as % of demand	
	Dry	Green	Dry	Green	Dry	Green
2010	508.9	816.8	453.2	525.5	55.72 (10.95)	291.3 (35.66)
2020	530.5	851.3	467.6	590.4	62.85 (11.85)	260.9 (30.65)
2030	568.1	911.6	500.0	687.4	68.07 (11.98)	224.2(24.59)
2040	594.9	954.8	524.4	761.7	70.57 (11.86)	193.0 (20.22)
2050	631.0	1012.7	547.7	826.0	83.27(13.20)	186.6 (18.43)

Source: IGFRI Vision:2050

INTENSIFICATION OF FORAGE AND FODDER

Since lot of research is being carried out for food crops to fulfill the present and future needs of increasing human population, but there has been limited research on forage crops despite being equally important to help improve feed and food values in the diet of animals and has enormous potential to improve food security and political stability. Farmers maintain large herds of animals to compensate for the low productivity, which adds to the pressure on fodder and other natural resources (Palsaniya *et al.*, 2008; Palsaniya *et al.*, 2009; Palsaniya *et al.*, 2010a). Hence, there is an urgent need to go for forage research to find ways to improve productivity and quality of fodder and forage. Enhancing the productivity per unit land area through efficient natural resource management and also integration of fodder crops in the existing cropping system are only viable options to meet the growing fodder needs of livestock sector (Sunil Kumar *et al.*, 2012). The recent crop diversifcation where commercial crops replacing the traditional cereal crops especially the coarse cereals, is likely to have an impact on the availability of crop residues for animal production (Ghosh and Palsaniya, 2014a). Here we are going to focus on intensification of fodder production. Methods of intensification of fodder production include:

- **Round the year fodder production**
- **Intensive irrigation system**
- **Multiple cropping (Intercropping)**
- **Association of perennial grass with legume components**
- **Lands that are steep, difficult to manage or with shallow soils can be used for forage crops.**
- **Forage production during lean period**

ROUND THE YEAR FODDER PRODUCTION

Continious cropping systems developed at the Indian Grassland and Fodder Research Institute (IGFRI), Jhansi, to fulfill the needs of farmers for green fodder availability throughout the year and for small farmers requiring maximum forage from a unit of land consisted of raising berseem, inter-planted with Napier hybrid in spring and intercropping the inter-row spaces of the grass with cowpea during summer after the final harvest of berseem as shown in Table. 2.

Table.2: Round the year fodder production systems

Crop sequence	**Green fodder yield (tones/ha/year)**
Napier x Bajra hybrid + Cowpea – Berseem	260
MP Chari + Cowpea – Berseem + Japanese rape	**184**
Napier x Bajra hybrid + Cowpea – Berseem – Cowpea	**255**

Similarly under Kashmir conditions it has been found that, the cropping sequence oat-maize-turnip recorded higher mean fresh fodder production, dry matter accumulation and crude protein productivity as found out by Waseem Raja *et al*., 2011. In addition to these overlapping cropping system developed involving seasonal and perennial forage crops like guinea grass and Napier bajra hybrid intercropped with cowpea during summer and *Kharif* and berseem in *Rabi*, has the capability of providing round the year green fodder (200-300 t/ha) to the dairy animals also small farmers having limited land holdings for food and forage production. Figure 1. Dana Rama *et al* (2016).

Figure 1: NB hybrid+cowpea-berseem round the year fodder production system

- **INTENSIVE IRRIGATED SYSTEMS**

Efficient utilization of limited agricultural inputs and other resources to obtain best harvest per unit area and per unit time is the first and most important objective of intensive forage production system. Improved crop sequences and crop management practices for irrigated and rainfed conditions should be developed to ensure the maximum use efciency of available resources (Ghosh *et al.,* 2015). Intensive cropping is the only alternative to boost forage yield from irrigated lands and overall productivity. Cereals are grown with a proper management and properly irrigated, so fodder legumes can be intercropped in between the cereal crops, which will help utilize irrigation water in a proper manner. Under assured irrigation multiple crop sequences like Sorghum (multicut) + cowpea - berseem + mustard – maize + cowpea and sorghum (multicut) + cowpea - berseem +

mustard are promising (Figure 2) Dana Rama *et al* (2016).

Figure 2: Sorghum +Cowpea cropping system

- **MULTIPLE CROPPING**

It consists of growing two or more appropriate forage crops as sole crops in mixed stands (graminaceous and leguminous) in a single agricultural year to improve herbage quality substantially and to enhance forage productivity per unit area. It also helps maintain sustaied soil fertility due to addition of root organic matter. The degree of its success depends upon agro-climatic conditions, crop and soil management practices followed and availability of inputs. Selection of appropriate crops/varieties and adoption of scattered sowing and harvesting schedules ensure the regular supply of the quality forage.

Table:3. Multiple cropping system under Kashmir conditions

Maize+cowpea
Maize+soybean
Sorghum+soybean
Sorghum+cowpea
Maize+cowpea-Forage turnip-Fodder oats
Sorghum+cowpea/Soybean-Forage turnip-Fodder oats

Waseem *et al*., 2011 and Waseem *et al*., 2020

- **ASSOCIATION OF PERENNIAL GRASSES WITH LEGUME COMPONENTS**

The association of legumes improve the herbage quality in terms of protein and minerals and help to economise the use of nitrogenous fertilizers. In addition to this, such production systems are less expensive and offer continuous employment potential. The component crops of the system can be changed depending upon inputs availability and yield indices of the crops in a region. Similarly, cultural management practices like crop geometry, spacing, planting pattern, etc. could be adjusted to facilitate use of appropriate farm machinery and effective utilization of irrigation water.

- **Lands that are steep, difficult to manage or with shallow soils can be used for forage crops.**

Lands that are steep, barren, difficult to manage can be better used to grow forage grasses which help bind soil particles to prevent erosion and in addition to make forage grass available to livestock. Eg, under temperate conditions of Kashmir which is mostly hilly and sloppy, so it is more susceptible to erosion hence can be grown with fodder and forage crops.

Forage production systems	References
❖ **MULTIPLE CROPPING** **Example: Sorghum + soybean (2:1)**	**Umaisa *et al., 2020***
❖ **Orchard based production system** **Example: Orchard grass+ white clover in apple plantation**	**Suheel *et al., 2018***
❖ **Perennial crop based forage-food production system** **Example: Guinea grass/ para grass/ hybrid Napier in coconut plantation**	**Chandra *et al.*, 2011**

FORAGE QUALITY

Forage quality is defined in various ways but is often poorly understood. It can be defined as an expression of characteristics that affect consumption, nutritional value and the resulting animal performance (Amigot *et al.,* 2005). It has also been defined as how well animals consume forage and how well forage is converted into animal products (Twidwell and Wegenhoft 1999 and , Taysom 2002). Factors that influence forage quality include the following: Palatability: will animals eat the forage? Intake: How much will they eat? Digestibility: How much of the forage will be able to pass through the animal rumen? Nutrient content: Once the forage is digested, will the forage provide an adequate level of nutrients? The chemico- fermentative parameters to check forage quality include dry matter(DM), pH, crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), lignin and ash. Energy values are then extracted from these core analysis including total digestible nutrients (TDN), net energy and relative feed values (RFV) Amigot *et al* (2007).

The chemico- fermentative parameters to check forage quality are as:

1. DRY MATTER: It corresponds to the percentage which is not water. It can be determined by drying forages at high temperature.
2. pH: It is considered to be the individual parameter that determines forage quality.
3. Crude protein: The term crude protein is used to represent all forms of nitrogen including non-protein nitrogen such as nitrates, ammonia, urea and amino acids. Crude protein is represented by the total amount of nitrogen and multiplied by a factor of 6.25. This is actually based on the assumption that true protein contains 16% Nitrogen.
4. FIBERS: The fiber fraction of forage is divided into two components that nutritionists use to prepare various feeds are neutral detergent fiber and acid detergent fiber (Van Soest PJ., 1994).
    - Neutral detergent fiber (NDF): It is the total fiber content of forage including cellulose, hemi-cellulose and lignin. NDF is the insoluble part of feed in detergent under neutral conditions (Bruno *et al* 1998). NDF values are used to predict feed intake. A high NDF value indicates low intake of forage and a low NDF value has more feed intake.
    - Acid detergent fiber (ADF): It indicates measurement of cellulose and lignin content of forage. ADF is also partially digestible and it also indicates feed intake. Higher the ADF values, less is the feed intake and if ADF value is low the feed intake is more.
5. Minerals:
    - Ash: The total mineral content of forage is called ash and it represents 3-12% of dry matter. Minerals can be divided into macro-nutrients (Ca, P, K, Mg etc) and micro-nutrients (Co, Cu, Mn,Zn etc).

FACTORS AFFECTING FORAGE QUALITY:

- Plant factors: It includes plant species, plant parts, stage of maturity.

1. **Plant species**: There are substantial differences in forage quality between those of grasses and legumes which are generally related to differences in fiber and protein content, digestibility, etc., which have a negative impact on consumption and animal productivity (Twidwell and Wegenhoft 1999; Cherney JH 2000). Legumes generally produce higher quality forage than grasses. This is because legumes usually have less fiber and favor higher intake than grasses. A comparison of timothy and alfalfa from the second cut of a mixed stand (figure 2) illustrates typical species differences in quality. Alfalfa, at early bloom, had 16% crude protein (CP) compared with 9.5% in timothy. However, applying substantial amounts of nitrogen fertilizer to grasses can make their CP levels comparable to legume forage. In the same comparison, timothy had considerably higher levels of neutral detergent fiber (NDF) than alfalfa.

2. **Plant parts:** The plant parts also vary in quality. Eg, leaves are more palatable as compared to stem.

3. **Stage of maturity:** It is the most important factor affecting forage quality. Forage crops should be harvested at their proper maturity stage. Eg, the succulence of leaves and stem decreases if harvesting is delayed after their maturity stage.

- Animal factors: It includes palatability, digestibility, anti- quality factors.

a. **Palatability:** Animals select one forage over other based on smell, feel, taste etc.
b. **Digestibility**: Digestibility is the extent to which a forage is absorbed as it passes through animal's digestive tract. Eg, immature leafy plants may be 80- 90% digested while as mature stemmy material may be 50% digested.
c. **Anti- quality factors:** Various compounds may be present in forage that lower the animal performance. Thes include tannins, oxalates, nitrates, cyanogens etc.

ANTINUTRITIONAL FACTORS IN FORAGES AND FODDER

Plants contain many chemical substances that are toxic to animals, which are actually the defense mechanism by these plants (Elhandour et al., 2018). In addition to this plants also secrete some substances that protect them from various bacterial fungal and insect attacks and helps in their survival (Reddy *et al*., 2020). Consumption of such type of plant material in large quantities results in degradation of health or productivity of animals apart from exhibiting toxicity symptoms. In few cases, the acute toxicity may lead to the death of animals. Although, green fodder, hay and silage contains good nutritional values, but there maintenance, ways of consumption and presence of some toxic material also alarm us. Among the different quality controlling aspects anti quality materials or substances are also of prime importance Wadhwan VM *et al* 2014. Anti- nutritional factors affecting the animals include nitrates, tannins, oxalates, cyanogens, etc. These are briefly described below.

Nitrates: The nitrate when consumed by animals along with fodder is converted from nitrate to nitrite to ammonia inside the rumen, but when forage has a high concentration of nitrate the animal cannot complete the conversion and hence nitrite accumulates. The nitrite is passed into blood stream and combines with haemoglobin and forms methaemoglobin and hence oxygen cannot be carried. The animal with nitrate poisoning dies because of lack of oxygen (Benjamin, 2006). The nitrate accumulation is maximum in stem followed by leaves and least in grain (Singh *et al*., 2000).

Oxalates: Oxalate rich fodder when consumed by animals reacts with calcium reducing calcium absorption. This leads to change in Calcium: Phosphorus ratio resulting in mobilization of bone minerals to alleviate hypocalcemia and if it remains for a longer time it can cause hyperthyroidism or osteodystrophy fibrosa (Rahman *et al.*, 2011).

Cyanogens: Cyanogens are the sugar glycosides and cyanide which contain aglycone which can be hydrolyzed by enzymes to release HCN by enzymes that are found in cytoplasm. Prussic acid poisoning occurs when livestock are fed with forage sorghum, sudan grass, sweet sorghum , etc. The prussic acid inside ruminants cause asphyxiation that inhibits the linking of oxygen with red blood cells (Allison, 2002). It has been reported that HCN content is lower in mature plants as compared to that in young plants (Sultan, 2004).

Tannins: Tannins are water soluble compounds with molecular weight greater than 500 and are able to precipitate proteins. The leaves of shrubs and trees contain tannins (Reddy, 2001). Tannins form a less digestible complex and binds with and inhibit the endogenous proteins (Cheeke, 1995).

Anti-nutritional substances in forage crops

S. No.	Anti-nutritional substance	Fodder Crops
01.	Nitrates	Sudan grass, Pearl millet, Oats
02.	Oxalates	Paddy straw, Bajra, Guinea grass, Hybrid Napier
03.	Saponins	Lucerne
04.	Tannins	Fodders trees, Shrubs
05.	Glucosinolates	Cabbage, Turnip, Rapeseed, Mustard
06.	Mimosine	Subabul
07.	β-N-oxalyl-L-α, β-di-amimo propionic acid (β-ODAP or BOAA)	Lathyrus
08.	Cyanogens	Sorghum, Jhonson grass, Sudan grass

Ramchandra *et al.*, 2019

Prussic acid (HCN) and Nitrate concentration in forages

HCN Conc. (ppm)		Potential effect on livestock
Dry matter	Fresh harvested	
0-500	0-100	Safe
500-1000	100-200	Potentially toxic. Fed at restricted rate
> 1000	>200	Very toxic. Can cause death.

Nitrate Conc. (ppm)	Potential effect on livestock
0-1000	Safe
1000-1500	Safe with limited use
1500-2000	Feed use limited to 50% of ration’s total dry matter
2000-3500	Feed use limited to 35-40% of ration’s total dry matter
3500-4000	Feed use limited to 25% of ration’s total dry matter
>4000	Toxic. Do not feed.

12

Ramchandra *et al.*, 2019

Conclusion:

These strategic measures will certainly ensure the increased availability of feed and fodder as well as their effective utilization for improved milk and meat production to provide valuable animal protein sources for human population.

References

Agarwal R K, Kumar S, Tripathi R K, Sharma R K and Singh K A.2008. Agro-Economic analysis of fodder based cropping system. *Indian journal of fertilizers* **4** (4) : 121-31

Allison, 2002. Prussic acid poisoning in livestock. Guide B-808, www.cahe.nmsu.edu.

Amigot, S., Romero, L and Gaggitotti, M. 2007 Forage quality: Techniques for testing. Global science books 1(2):121-131

Amigot, SL., Basilico, JC, Bottaih, MLZ., Fulgueria, CL., 2005. Estrategias para mejorar la Calidad de forages. Inproceedings of theXth Argentine Congress of Micology, Buenos, Aires, Argentina, 125.

Balwinder, K., Brari, H.K., Kumar, A and Singh, R. 2018. Nutritious feed for farm animals during lean period: Silage and Hay_ A Review. *Forage Research*. 45**(1):** 10- 22.

Benjamin, D.N. (2006). Effects of fertilizer application and cutting interval on nitrate accumulation in Bermuda grass. M.sc(*Agri) thesis*:Univ Tennessee, Martin.

Bernardes, T.F., J.L.P. Daniel, A.T. Adesogan, T.A. McAllister, P. Drouin, L.G. Nussio, P. Huhtanen, G.F. Tremblay, G. Belanger and Y. Cai, 2018 : Silage review: Unique challenges of silage made in hot and cold regions. *J. Dairy Sci.* **101**: 4001-1019.

Bruno OA, Leon RJ, RomeroLA, Quaino RO (1998). Varieties evaluation of Lucerne (Medicago sativa) with different winter dormancy class. In proceedings of the XVI international congress Nice France, 463-464

Cheeke, P.R., 1995. Endogenous toxins and mycotoxins in forage grasses and their effect on livestock. Prstd Symposium, Fescue and other toxic grasses: effect on livestock production. 909-916.

Elghandour, M, M,M.Y., Reddy, P.R.K., Salem, A.Z.M., Reddy, P.R., Hyder, I., Barbabosa-Pliego, A and Yasaswini, D. (2018). Plant bioactives and extracts as feed additives in horse nutrition. Journal of equine veterinary science, 69:66-67.

Ghosh P K and Palsaniya D R 2014a. Crop diversifcation for sustainable intensifcation and carbon management. In *National symposium on agricultural diversifcation for sustainable livelihood and environmental security*, PAU, Ludhiana, 18-20 November, 2014, pp. 3-5

Ghosh P K, Palsaniya D R, Rai A K and Sunil Kumar 2015. Strategies for higher nutrient use efciency and productivity in forage crops. In: *Nutrient use efciency: from basics to advances*, Rakshit A, Singh HB and Sen A (eds.), Springer India, pp. 329-42.

JHA, S.K and TIWARI, N., *Evaluation of intensive fodder cropping systems for round the year green fodder production in Chhatisgarh* ,2018. 44 (2) : 115-118

Mojumdar, A.B., 2009 : Technologies of quality silage and hay making from forages. In: Forage for sustainable livestock production (N. Das, A.K. Misra, S.B.Maurt, K.K. Singh and M.M. Das eds.). SSPH, New Delhi. pp. 361-375.

Nicola, M., Capstaff and Miller, A.J.2018 Improving the yield and nutritional quality of forage crops. *Frontiers in*10.3389:00535.

Ozata, E., S. U. Ikincikarakaya and A. Ozturk. 2018 : The determination of silage yield and quality traits of candidate maize hybrids. *Ekin J.* **4** : 31-40.

Palsaniya D R, Ramakrishnan , S 2016. Forage research in India: Issues and strategies. *Agricultural Research Journal* **53** (1) : 1-12

Palsaniya DR, Singh Ramesh, Venkatesh A, Tewari RK and Dhyani SK 2010a. Grass productivity and livestock dynamics as influenced by integrated watershed management interventions in drought prone semi arid Bundelkhand, India. *Range Management and Agroforestry* Symposium issue (A), pp. 4-6.

Palsaniya DR, Singh Ramesh, Yadav RS, Tewari RK, Dwivedi RP, Kumar RV, Venkatesh A, Kareemulla K, Bajpai CK, Singh Rajendra, Yadav SPS, Chaturvedi OP and Dhyani SK 2009.

Participatory agro-ecosystem analysis and identifcation of problems in Garhkundar-Dabar watershed of Central India. *Indian J. Agroforestry* **11**(1): 91-98.

Palsaniya DR, Tewari RK, Singh Ramesh, Yadav RS and Dhyani SK2010b. Farmer – agroforestry land use adoption interface in degraded agro-ecosystem of Bundelkhand region, India. *Range Management and Agroforestry* **31**(1): 11-19.

Rahman, M.M., Nimmy, Y., Ishii and Kawamura, O. (2006). Effect of season, variety and botanical fractions on oxalate content of napier grass (*Pennisetum perpureum*). *Grassland Sciences*. 52: 161- 166.

Rai S K, Kumar Sunil, Rai A K, Satyapriya and Palsaniya D R 2014. Climate change, variability and rainfall probability for crop planning in few districts of central India. *Atmospheric and Climate Sciences* **4**: 394-403.

Reddy, D.V., 2001. Principles of animal nutrition and feed technology. Oxford IBM publishing company pvt. Ltd., New Delhi.

Reddy, P. R. K., Elghandour, M. M. M. Y., Salem, A. Z. M., Yasaswini, D., Reddy, P. P. R., Reddy, A. N., & Hyder, I. (2020). Plant secondary metabolites as feed additives in calves for antimicrobial stewardship. *Animal Feed Science and Technology*, 264, 114469.

Singh, A., Tiwana, U.S., Tiwana, M.S and Puri, K.P. (2000). Effect of application method of first level of nitrogen fertilizer on nitrate content in oat fodder. *Indian Journal of Animal Nutrition*. **17**: 315- 319.

Sultan, S.I., 2003. Sorghum halpanses and its cyanide content. Pakistan Journal of Nutrition. 2(3): 123- 124.

Thomas, C.G., 2008 : Forage Preservation. In: Forage crop production in the tropics. Kalyani Publishers, New Delhi. pp. 280-296.

Twidwell E, Wegenhoft K(1999) Relative forage quality.

Van Soest PJ(1994) Nutritional ecology of ruminants, Cornell university of press, Ithaca,USA, 212-214

Wadhwan VM. “Toxicants in Feed stuffs: Impact on health. Recent Advances in Animal Nutrition Edited by M.P.S. Bakshi and M.Wadhwa. SSPH, New Delhi. (2014): 231-241.

Zhang, F., X. Wang, W. Lu, F. Li, and C. Ma, 2019 : Improved Quality of Corn Silage When Combining Cellulose-Decomposing Bacteria and Lactobacillus buchneri during Silage Fermentation. Bio Med Research International: 1- 11 https://doi.org/10.1155/2019/4361358.