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Evaluation of nutritional quality and yield of winter forages prevalent in Punjab

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Abstract

The experiment was conducted to evaluate winter forage legumes (*Trifolium alexandrium, Trifolium respinatum, Medicago sativa, Trigonella foenum-graecum, Melilotus indica*) and non-legumes *(Avena sativa, Lolium perenne, Brassica juncea*) on the basis of various nutritional and anti-nutritional attributes, green fodder yield (GFY), dry matter yield (DMY) and crude protein yield (CPY). The legume crops showed significant variation for nutritional components and the mean values (%) of CP, NDF, ADF, TDN and ash content were 21.2, 37.1, 26.9 67.1 and 13.7, respectively. The corresponding values in non-leguminous crops were 13.3, 41.0, 30.4, 67.0 and 11.5%, respectively. Mean values (mg/g) of total phenol, tannin, non-tannin phenol, flavonoid and saponin in leguminous crops were 3.6, 1.1, 2.5, 11.3 and 23.0, respectively while in non-leguminous crops were 4.9, 1.4, 3.5, 12.6 and 18.9, respectively. It was observed that GFY and CPY were highest in *Trifolium alexandrium* and DMY was maximum in *Lolium perenne*. The green forage production efficiency for these winter forages ranged from 2.6-5.3 q/ha/day. These results suggested that *Medicago sativa* and *Brassica juncea* were best in nutritional attributes among leguminous and non-leguminous crops, respectively, while the crops like *Trifolium alexandrium* and *Lolium perenne* had high values of GFY, CPY and DMY.

Keywords: Dry fodder yield, Forages, Green fodder yield, Nutritional composition, Tannin

Introduction

India is an agricultural country and about 70% of its population lives in villages. Livestock sector play an important role in socio economic development and the national economy of the country. The contribution of this sector to the national economy in terms of Gross Value Added was 3.9% during 2013-14.The availability of good quality forages for feeding livestock population is still not sufficient. In India, the ruminant diet comprises primarily of poor quality roughages and shortage of quality fodder is always felt (Dikshit and Birthal, 2010). There is large gap in production and requirement of green fodder. Promotion of suitable and nutritionally better forage species could be a practical approach for reducing this fodder scarcity (Tripathi *et al.,* 2009).

Nutrient balance of an animal is dependent on nutrient requirement, nutritional quality of feed stuffs, amount consumed and its digestibility. Protein is needed by livestock and rumen bacteria for enhancing growth and milk production. Phenolic compounds are most widely distributed plant secondary products that are found in many plants used as food and feeds. The importance of phenolics in plants is not known clearly, but some phenolic compounds are structural polymers, UV screens, antioxidants, attractants and others are involved in non specific defense mechanisms (Papoulias *et al.,* 2009). Tannins are the secondary plant compounds which help in natural defense mechanism against bacteria, insects, fungi and therefore assist in the survival of the plants (Bharathidhasan *et al*., 2013). Apart from these benefits, polyphenolic compounds have a variable effect in decreasing digestibility of proteins in rumen. Several cases of livestock death have been associated with high tannin content of some foliage (Bharathidhsan *et al.,* 2013).

The nutritional quality and yield potential of forage crops are known to be influenced by soil nutrient status (Tessema *et al.,* 2010) and management aspects (Vander Westhuizen *et al.,* 2005). Variations exist among the published reports which call for further evaluation of feed resources. In Punjab, important *Rabi* forage crops include berseem (*Trifolium alexandrium*), shaftal (*Trifolium respinatum*), raya (*Brassica juncea*), lucerne (*Medicago sativa*), oats (*Avena sativa*), rye grass (*Lolium perenne*), metha (*Trigonella foenum-graecum*) and senji (*Melilotus indica*). The present study was undertaken to evaluate the nutritional, anti-nutritional attributes, yield and forage productivity per day of *Rabi* forage crops under one production system using same soil nutrient status and management aspects.

Materials and Methods

Experimental material and design: A set of eight winter forage crops (*Trifolium alexandrium, Trifolium respinatum, Medicago sativa, Trigonella foenum-graecum, Melilotus indica, Avena sativa, Lolium perenne, Brassica juncea*) were grown at Forage Research Farm of Department of Plant Breeding and Genetics, Punjab Agricultural University (PAU), Ludhiana in a randomized block design (RBD) with three replications in two environments. The two environments were created by sowing the experimental material in *Rabi* seasons of the year 2014-15 and 2015-16. The plot size for each entry was 4 m × 3 m. The field experiment was raised as per the package of practices for *Rabi* crops, PAU, Ludhiana. Fodder samples harvested at the appropriate stage of each crop were dried in hot air oven at a temperature of 55^o-65^o C to constant weight and then grinded for further analysis of nutritional and antinutritional components.

Analytical methods: The ash content, crude protein, crude fibre were estimated as per AOAC (2005) and cell wall components by the method of Van Soest (1991).Total soluble sugars were estimated by Dubois *et al.*(1956). The concentration of total sugars was calculated from glucose standards (10-50 µg). For total phenols, 0.5 ml folin-phenol reagent (1:1 v/v with H_2O) and 1 ml of saturated solution of sodium carbonate was used (Swain and Hills, 1959). The standard curve was prepared by using tannin acid equivalents in the range of 10-50 µg. Tannins were extracted and estimated by protocol given by Sadasivam and Manickam (1992). The amount of tannin was calculated from the standard curve using tannic acid (10-100 µg) as a standard. Flavonoid was estimated as per Chang *et al.* (2002). The results were expressed as mg of rutin equivalents (RE)/g dry weight. For saponin content, 1 ml of reagent A (0.5 ml anis aldehyde mixed with 99.5 ml of ethyl acetate) and 1 ml concentrated sulphuric acid were used (Fenwick and Oakenfull, 1983). The standard curve was prepared using saponin (10-60 µg). The values were statistically analyzed by multifactor ANOVA (Statgraphics plus version 2.1). Values are presented as a means ± standard deviation (n = 3 or more).

Results and Discussion

Nutritional quality: A significant (P<0.05) difference was observed among different *Rabi* forage crops with regard to quality traits (Table 1). The leguminous crops possessed higher (P<0.05) crude protein content than the non-leguminous crops (Datt *et al.,* 2008).The crude protein content (% DM) in leguminous and non-leguminous crops was in the range of 18.5-23.8 and 9.8-15.5, respectively. These are in agreement with Prusty *et al*. (2013) who reported that crude protein content of *Trifolium alexandrum* and *Avena sativa* was 20.0 and 12.2%, respectively. Crude protein content varied from 9.67-29.01% and 8.48-19.60% in leguminous and non-leguminous top feeds of tree species, respectively (Nag *et al*., 2017). Maximum crude protein (CP) content was observed in *Medicago sativa* and *Brassica juncea* among leguminous and non-leguminous crops, respectively. In a recent study, *Trifolium alexandrium* and *Lolium perenne* possessed maximum crude protein among leguminous and non-leguminous crops (Prajapati *et al.,* 2016). The variation in nutrient composition in different studies might be attributed to the stage of harvest, agro-climatic condition, soil nutrient profile, collection and processing of the samples (Teka *et al.,* 2012). Dietary fibre plays an important role in ruminants to maximize DM intake, stimulate chewing and rumen fermentation activities. But beyond a threshold limit, both ADF and NDF decreases digestibility of forages. In the present study, average ADF and NDF content was higher in non-leguminous forage crops than in leguminous crops. The ADF and NDF content ranged from 23.5-30.4% and 33.8-43.8%, respectively in leguminous crops and the corresponding values were 26.6-34.3% and 35.4-45.7% in non-leguminous crops. Among all forage crops, *Avena sativa* achieved maximum ADF (34.3) and NDF (45.7) content. Minimum ADF and NDF level was recorded in *Medicago sativa* and *Trifolium respinatum,* respectively. Prusty *et al.* (2013) reported that NDF (%) in *Avena sativa* and *Trifolium alexdandrum* was 45.7% and 41.7%, respectively. The percent total digestible nutrient (TDN) of forages lied in the range from 62.2 to 70.8. Among non-leguminous crops, TDN content was high in *Brassica juncea* (70.8%) and low in *Avena sativa* (62.2%). The mean TDN content in leguminous and non-leguminous tree leaves was 60.7% and 60.9%, respectively (Gupta *et al.,* 2016). Ash measures the total mineral content of forages. The mean ash content (%) in leguminous and non-leguminous crops was recorded 13.7 and 11.5%, respectively. Among leguminous crops, highest ash content was recorded in *Medicago sativa* (15.9%) and lowest in *Trigonella foenum-graecum* (9.0%). Significant differences for total sugar content were observed among forage crops. The sugar content (mg/g) varied from 32.2-41.4 in leguminous crops and corresponding values were 30.8-69.0 in non-leguminous crops. The leguminous crop *Lolium perenne* recorded maximum total sugar level than other crops.

Table 1. Pooled data of different *Rabi* forage crops for nutritional composition

Botanical name	Common name	CP (%)	NDF (%)	ADF (%)	TDN (%)	Ash (%)	Total sugars (mg/g)
Leguminous crops							
Trifolium alexandrium	Berseem	18.5±0.30	39.6±1.00	30.4±2.33	65.2±1.82	15.7±0.15	39.2±1.07
Trifolium respinatum	Sheftal	20.6±0.20	33.8±1.94	27.8±2.19	67.3±1.70	15.9±0.20	41.4±2.56
Medicago sativa	Lucerne	23.8±0.46	34.1±2.63	23.5±1.67	70.6±1.30	15.9±0.15	37.1±1.50
Trigonella foenum-graecum	Metha	21.3±0.40	43.8±2.95	28.8±1.46	66.4±1.14	9.0±0.10	32.2±1.01
Melilotus indica	Senji	21.8±0.31	34.4±1.04	23.8±1.48	66.0±1.09	12.1±0.17	36.4±1.49
Mean		21.2	37.1	26.9	67.1	13.7	37.2
CD (5%)		1.1	4.1	3.8	3.0	0.5	3.0
Non-leguminous crops							
Avena sativa	Oat	9.8±0.20	45.7±2.92	34.3±0.77	62.2±0.59	9.8±0.20	33.3±3.00
Lolium perenne	Rye grass	14.7±0.25	41.8±1.86	26.6±1.52	68.2±1.18	11.4±0.15	69.0±1.55
Brassica juncea	Raya	15.5±0.27	35.4±0.85	30.2±3.29	70.8±2.56	13.3±0.11	30.8±1.48
Mean		13.3	41.0	30.4	67.0	11.5	44.4
CD (5%)		0.34	3.07	5.1	4.0	0.3	4.9

Table 2. Pooled data for anti-nutritional traits (mg/g) of different *Rabi* forage crops

Botanical name	Total Phenols	Tannins	Non-tannin phenols	Flavonoids	Saponins
Leguminous crops					
Trifolium alexandrium	3.9±0.20	0.8±0.05	3.1±0.04	15.4±0.30	18.6±0.84
Trifolium respinatum	3.8±0.36	1.4±0.08	2.4±0.04	13.6±0.25	30.4±0.79
Medicago sativa	3.7±0.23	1.2±0.05	2.6±0.02	6.9±0.04	14.4±1.25
Trigonella foenum-graecum	3.7±0.18	1.3±0.05	2.4±0.03	9.7±0.03	24.6±0.61
Melilotus indica	3.0±0.20	1.0±0.03	2.0±0.03	11.3±0.02	27.3±0.58
Mean	3.6	1.1	2.5	11.3	23.0
CD (5%)	0.5	0.1	0.1	0.3	1.7
Non-leguminous crops					
Avena sativa	6.5±0.32	1.7±0.05	4.9±0.07	18.6±0.25	23.6±0.79
Lolium perenne	5.0±0.09	1.8±0.04	3.2±0.04	9.4±0.03	20.4±0.61
Brassica juncea	3.1±0.21	0.8±0.02	2.4±0.02	9.9±0.05	12.7±1.20
Mean	4.9	1.4	3.5	12.6	18.9
CD (5%)	0.4	0.1	0.1	0.3	2.5

Table 3. Pooled data of different *Rabi* fodder crops for yield and green forage production efficiency

Botanical name	Green fodder yield(q/ha)	Dry matter yield(q/ha)	Crude protein yield (q/ha)	Green forage production efficiency (q/ha/day)
Leguminous crops				
Trifolium alexandrium	757.1±4.02	122.5±0.61	23.0±0.35	4.0±0.06
Trifolium respinatum	445.2±5.03	61.5±0.3	12.9±0.05	2.6±0.1
Medicago sativa	476.7±3.51	88.3±0.2	19.5±0.05	2.6±0.05
Trigonella foenum-graecum	326.1±8.01	74.4±0.3	16.4±0.13	2.9±0.05
Melilotus indica	355.6±1.85	75.7±0.2	16.5±0.25	2.8±0.08
Mean	469.5	84.5	17.7	3.0
CD (5%)	15.8	20.3	5.7	1.4
Non-leguminous crops				
Avena sativa	559.7±2.01	117.7±0.15	12.8±0.13	4.3±0.05
Lolium perenne	743.9±3.70	145.2±0.31	21.3±0.14	4.5±0.2
Brassica juncea	524.6±2.51	69.3±0.40	8.6±0.14	5.3±0.1
Mean	613.8	110.7	14.2	4.7
CD (5%)	21.9	20.5	3.4	0.4

Antinutritional quality: Significant (P<0.05) variations were observed among different *Rabi* forage crops with regard to antinutritional/bioactive compounds (Table 2).The total phenol content (mg/g) was maximum in non-leguminous crop *Avena sativa* (6.5) and minimum in leguminous crop *Melilotus indica* (3.0).The total phenol (mg/g) in the top feeds of tree species were in the range from 2.9 to 13.0. Phenols are generally regarded as antinutritional compounds. However, plants with low phenol content acts as antioxidants and protect against infection and injuries (Xu and Chang, 2008). Average non-tannin phenol content was high in non-leguminous crops (3.5 mg/g) than in leguminous crops (2.5 mg/g). The highest non-tannin phenol was found in *Avena sativa* (4.9) and lowest in *Melilotus indica* (2.0). A previous study reported higher level of phenol and non-tannin phenol content in forage crops (Bharathidhasan *et al.,* 2013). These variations could be due to variation in season and stage of maturity (Ramirez *et al.,* 2009). Low level of dietary tannin (2-3%) is generally beneficial to animals against bloat and also augmenting by-pass protein (Wang and Daun, 2006). Beyond the recommended limit, tannins interact with proteins to form tannin-protein complexes resulting in reduced dry matter intake and digestibility (Khandelwal *et al.,* 2010). The tannin level in the present study was well within the range of threshold limit in both leguminous and non-leguminous crops. The maximum tannin content (mg/g) was observed in *Lolium perenne* (1.8) and minimum in *Brassica juncea* (0.8) and the level was quite low compared to that of forest tree leaves in temperate sub-Himalayan region (Sahoo *et al.,* 2016). Saponin content (mg/g) among leguminous crops was observed maximum in *Trifolium respinatum* (30.4) and minimum in *Medicago sativa* (14.4). Similar value of saponin was observed in *Medicago sativa* (Joanna and Oleszek, 1994) and *Trifolium alexandrium* (Fernandes and Waditake, 2006). In non-leguminous crops, highest value of saponin content was observed in *Avena sativa* (23.6). Saponins are considered to be deleterious compound from nutrition point of view. Saponins disturb the fluidity of membranes and reduce absorption of nutrients by binding with enzymes and cause systemic toxicity (Alexander *et al.,* 2009). Flavonoids combat oxidative stress in plants by quenching and inhibiting the generation of reactive oxygen species (Agati *et al.,* 2012). Average flavonoid content (mg/g) was comparatively high in non-leguminous crop (12.6) than in leguminous crop (11.4).The maximum flavonoid level (mg/g) was achieved in *Avena sativa* (18.6) and minimum level was found in *Brassica juncea* (12.7). The accumulation of flavonoids in external cells acts as UV-screen and protects plants against harmful solar wavelengths.

***Yield**:* The GFY, DMY, CPY and green forage production efficiency varied significantly among forage crops (Table 3) The green fodder yield (q/ha) was observed maximum in *Trifolium alexandrium* (757.4) followed by *Lolium perenne* (743.7). Similar observations were recorded in forage crops by Prajapati *et al.* (2016). The dry fodder yield (q/ha) varied significantly from 61.5 (*Trifolium respinatum*) to 145.2 (*Lolium perenne*). The crude protein yield (q/ha) revealed significant variation and ranged from 8.6 to 23.1. The crude protein yield was maximum in *Trifolium alexandrium* and minimum in *Brassica juncea.* In a recent study on forage crops, maximum crude protein yield was observed in *Medicago sativa* followed by *Trifolium alexandrium* (Prajapati *et al.,* 2016). Highest green forage production efficiency (q/ha/day) was observed in *Brassica juncea* (5.3) followed by *Lolium perenne* (4.5).

Conclusion

Based on the nutritional attributes *Medicago sativa* and *Brassica juncea* were top among leguminous and non-leguminous crops for high crude protein and low ADF, NDF values. On the basis of GFY and DMY, *Trifolium alexandrium* in leguminous and *Lolium perenne* in non-leguminous fodder crops were adjudged as best forage crops. The antinutritional content among *Rabi* forages was quite low and may exert beneficial effect on nutrient utilization and health attributes in animals.

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