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QUALITY ANALYSIS OF WINTER SEASON FORAGE CROPS[1]

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SUMMARY

Field experiments were conducted during **rabi** season of 2012-13 at Instructional Dairy Farm, G. B. P. U. A & T., Pantnagar (India) to evaluate quality parameters and correlation of **rabi** season forage crop (imported and indigenous) varieties. The treatments consisted of seven crop varieties i.e. some imported varieties of these crops like Genie oat variety of Oat and Baralfa IN variety of Lucerne, Makkhan grass variety of Rye grass and Barduro variety of Red clover from Netherland have been tested in the present investigation with Mescavi variety of Berseem, UPO-212 variety of Oat and local Rye grass. The analysis of data indicated that among leguminous **rabi** season forage crops lucerne, among oat varieties UPO-212 and among rye grasses varieties Makkhan grass, were found to have high quality of fodder.

Key words : Dry matter content, cell content, hemicellulose, rye grass, digestibility

The agriculture and livestock sector provides employment to 52 per cent of the work force. Even being highest livestock population (529.7 million) in India (Anonymous, 2011-12), and supporting nearly 20 per cent of the world livestock and 16.8 per cent human population on a land area of only 2.3 per cent, India faces a net deficit of 62.7 per cent green fodder, 21.9 per cent dry crop residues and 64 per cent feeds. During 2010, supply of green forages and roughages was 395.2 and 451 million tonnes against the demand of 1061 and 589 million tones, respectively (ICAR, 2012). The situation is further aggravated due to increasing population of livestock coupled with poor quality fodder leading to low productivity. 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. Availability and quality of **rabi** season forages is a limiting factor leading to decline in potential of dairy sector. The yielding potential of local **rabi** season forage crops is declining day by day also due to abiotic and biotic stresses. In view, the present work was undertaken aiming to introduce and evaluate qualitative new **rabi** season forage crops/varieties.

MATERIALS AND METHODS

The experiment was conducted at Forage Agronomy Block of Instructional Dairy Farm (IDF), Nagla of the Govind Ballabh Pant University of Agriculture & Technology, Pantnagar, Udham Singh Nagar (Uttarakhand), India during **rabi** season of 2012-13. The soil of experiment site was silty clay loam neutral in reaction (7.2 pH) with 0.86 per cent organic carbon, 284.48, 21.80 and 232 kg/ha available N, P and K, respectively. The treatments consisted of seven crop varieties including imported varieties of these crops like Genie oat variety of Oat and Baralfa IN variety of Lucerne, Makkhan grass variety of Rye grass and Barduro variety of Red clover from Netherland were tested in the present investigation with Mescavi variety of Berseem, UPO-212 variety of Oat and local Rye grass in **rabi** season in a randomized block design with five replications. Oat (100 kg/ha seed) was sown in 4 cm deep, rows opened at 25 cm, while Rye grass and Makkhan grass (25 kg/ha seed) at 40 cm, Berseem (30kg/ha seed) at 20 cm, Red clover (10 kg/ha seed) at 25 cm and Lucerne (25 kg/ha seed) at 20 cm row to row spacing were sown in 2 cm deep furrows opened with the help of hand hoe. Half quantity of the total dose of nitrogen through urea @ 120 kg N/ha (grasses), 25 kg N/ha (legumes), 60 kg P_2O_5/ha through single super phosphate and 40 kg K_2O/ha through muriate of potass as basal were applied uniformaly. Rest 50 per cent nitrogen was top dressed. The crops were harvested at 55 days after sowing (first cut) with the help of sickle leaving stubble height of 5-6 cm from ground for uniform and quick re-growth. Subsequent cuttings were taken 30 days after

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each cutting till crops stop to re-growth. The harvested herbage was weighted immediately for green forage yield and 500 g fresh sample from each net plot was taken to determine dry matter content. The samples were dried at $70^0C \pm 2$ in hot air oven for moisture loss. The finely grinded dry samples using 2 mm sieve were used for nitrogen content by Micro kjeldahl method (Jackson, 1973). The crude protein content was determined by multiplying nitrogen per cent with 6.25 (AOAC, 1965) and digestible dry matter content by the nylon bag method (Mehrez and Orskov, 1977).

RESULTS AND DISCUSSION

Dry Matter Content

Among leguminous **rabi** season forage crops, dry mater content of berseem (Mescavi) was at par with lucerne (Baralfa IN) at 1st cutting. Increased dry matter content of berseem (Mescavi) from 1st to 6th cuttings (Table 1) might be due to taller plants and better growth attributes. Positive correlation of berseem dry matter with stem weight, leaf weight and plant height observed by earlier worker **(**Tiwana *et al*., 2003 and Alfred, 2012). Dry matter per cent of red clover (Barduro) was significantly lower compared to remaining crops except Genie oat at 1st cutting which might be due to unfavourable environmental conditions which led to low accumulation of dry matter but with advancement in crop age, dry matter content increased till May because of the better growth on account of favourable temperature as the crop require higher temperature for better growth. There existed positive association between dry mater and cell fibers at later stages (Table 4), and also the higher cell fiber content at later stages (Table 2) might have attributed to higher dry matter. The results corroborated with the findings of (Hakl *et al*., 2003 and Homolka *et al*., 2012). Dry matter content of red clover (Barduro) was statistically at par with genie oat at 5th and 6th cuttings, while dry matter content of lucerne (Baralfa IN) was significantly higher compared to other *rabi* season forage crops at 2nd, 4th, 5th, 6th and 7th cuttings but at 3rd cutting, dry matter content of red clover (Barduro) was significantly higher compared to remaining crops (Table 1). Increased dry matter content of lucerne (Baralfa IN) from 2nd to 7th cuttings (except 3rd cutting) might be due to better drought tolerance capacity of the crops on its deep tap roots system absorbed water and nutrients from deeper soil layers (McDonald *et al*., 2003 and Jasjeet *et al*., 2011). Among oat varieties, dry matter content of UPO-212 was significantly higher compared to Genie oat at all the cuttings except at 1st cutting where both the oat varieties had statistically similar dry mater content (Table 1). Superiority of UPO-212 over other oat genotypes was also reported by earlier worker (Roy, 2005). Among rye grasses, dry matter content of makkhan grass was significantly higher compared to local rye at 1st and 4th cuttings, while at 5th cutting, local rye grass overyielded makkhan grass. Dry matter per cent of both rye grass varieties increased with advancing age of crop till 5th cutting but later decreased due to senescence of leaves and degeneration of roots on account of increase in temperature. Variation in nutritive values of rye grass throughout the growing season was reported earlier (Johnston *et al*., 1993). In the present investigation, higher cell wall content at later stages (Table 3) might have enhanced dry matter content as there existed positive correlation too between cell wall and dry matter contents (Table 4).

Digestible Dry Matter Content

Among leguminous, **rabi** season forage crops, dry matter digestibility of red clover (Barduro) was significantly higher compared to lucerne and berseem from 2nd to 6th cuttings. It might be due to comparatively lower acid detergent fibre and neutral detergent fibre in red

TABLE 1
Dry matter content and digestibility of different forage crops at different cuttings

Treatment	Dry matter content (%)						Dry matter digestibility (%)					
	Cuttings											
	1	2	3	4	5	6	1	2	3	4	5	6
Lucerne (Baralfa IN)	11.6	14.6	13.5	20.2	21.9	24.4	86.0	85.6	80.8	74.4	63.6	58.8
Red clover (Barduro)	10.0	13.3	17.0	15.8	16.8	18.4	89.6	88.8	86.0	84.8	81.6	75.6
Berseem (Mescavi)	12.0	13.0	13.0	16.5	20.4	22.2	91.2	80.0	75.6	68.0	60.0	51.6
Oat (Genie oat)	10.7	12.0	14.0	14.6	18.1	18.1	88.4	80.8	78.8	69.2	62.4	60.4
Oat (UPO-212)	11.2	13.0	16.0	16.6	21.2	21.0	88.8	78.0	76.8	66.4	61.6	57.6
Rye grass (Makkhan grass)	13.3	13.4	16.0	17.5	21.4	21.4	82.8	89.2	88.8	86.8	72.8	66.0
Rye grass (Local rye)	12.3	13.6	15.9	15.6	24.7	22.6	90.4	89.2	87.2	86.4	72.0	65.2
S. Em±	0.3	0.2	0.2	0.5	0.5	0.5	0.9	0.8	0.9	0.8	0.8	1.1
C. D. (P=0.05)	0.8	0.7	0.6	1.3	1.4	1.6	2.6	2.6	2.8	2.3	2.2	3.1

TABLE 2
Neutral and acid detergent fibre content of different forage crops at different cuttings

Treatment	Neutral detergent fibre content						Acid detergent fibre content					
	Cuttings											
	1	2	3	4	5	6	1	2	3	4	5	6
Lucerne (Baralfa IN)	39.0	42.0	44.0	55.0	58.0	56.0	25.6	26.4	29.8	34.8	37.2	35.4
Red clover (Barduro)	41.0	44.0	46.0	47.0	52.0	50.0	26.0	27.0	30.0	31.6	35.4	33.4
Berseem (Mescavi)	38.0	43.0	51.0	61.0	66.0	64.0	29.4	32.6	33.4	34.8	39.4	37.2
Oat (Genie Oat)	47.0	50.0	56.0	63.0	68.0	64.0	27.0	29.0	32.4	33.8	35.8	34.2
Oat (UPO-212)	46.0	48.0	52.0	61.0	68.0	65.0	26.6	27.0	31.6	33.0	35.8	34.8
Rye grass(Makkhan grass)	44.0	47.0	52.0	64.0	68.0	66.0	27.2	29.0	33.0	36.8	39.0	38.0
Rye grass (Local rye)	43.0	45.0	49.0	65.0	69.0	66.0	26.2	28.0	32.0	36.6	38.0	35.8
S. Em±	1.3	2.7	3.1	2.9	3.1	1.9	0.6	0.4	0.6	0.6	0.5	0.5
C. D. (P=0.05)	3.8	NS	NS	8.6	9.1	5.5	1.7	1.2	1.6	1.9	1.6	1.6

NS–Not Significant.

clover (Barduro) compared to Mescavi and Baralfa IN (Table 1). There was negative association between presence of cell wall components and digestibility. Higher cell wall components act as physical barrier to microbial enzyme leading to reduced digestibility. When red clover and lucerne are of almost similar fibre content, red clover is more digestible than lucerne providing more energy-dense forage to the diets of lactating dairy cows and also has higher concentrations of readily fermentable carbohydrate (soluble sugars and pectin) and lower concentrations of structural carbohydrate (Hakl *et al*., 2003). The nutritive value of lucerne, in terms of digestibility and protein content, decreases with advancing maturity by 0.3-0.5 per cent per day from early flowering to near maturity stage (*McDonald et al., 2003* and ICAR, 2012). Dry matter digestibility of both the oat varieties was statistically similar at all the cuttings except 2nd and 4th cuttings. It might be due to almost similar fibre content (Table 1). Observations made by earlier workers (Joshi *et al*., 2005 and Roy, 2005) supports these findings. At 2nd and 4th cuttings, dry matter digestibility of Genie oat was significantly higher compared to UPO-212 (Table 1).

Cell Wall Contents

Neutral detergent fibre content

Neutral detergent fibre of all crops was non-significant at 2nd and 3rd cuttings. At 1st cutting, Red clover (Barduro) had higher neutral detergent fibre but it was at par with leguminous cool season forage crops at 1st cutting. The neutral detergent fibre of berseem (Mescavi) was statistically at par with lucerne (Baralfa IN) at 4th and 5th cuttings but significantly higher compared to lucerne and red clover variety at 6th cutting. Neutral detergent fibre of red clover (Barduro) was statistically at par with lucerne (Baralfa IN) at 4th cutting, while it was significantly lower compared to other crops at 5th and 6th cuttings. In general, neutral detergent fibre content of leguminous **rabi** season forage crops (berseem, lucerne and red clover) increased which might be due to progressively increased hemicelluloses content in plant with advancement of crop age till 5th cutting

TABLE 3
Hemicellulose and cell content of different forage crops at different cuttings

Treatment	Hemicellulose (%)						Cell content (%)					
	Cuttings											
	1	2	3	4	5	6	1	2	3	4	5	6
Lucerne (Baralfa IN)	13.6	15.6	14.2	20.2	19.8	20.6	60.8	58.0	56.0	45.0	42.0	44.0
Red clover (Barduro)	15.2	17.0	16.0	15.4	16.6	17.2	58.8	56.0	54.0	53.0	48.0	50.0
Berseem (Mescavi)	8.6	10.2	17.6	24.4	26.6	28.8	62.0	56.8	49.0	34.0	33.0	36.0
Oat (Genie oat)	20.0	20.8	23.2	29.2	32.2	29.8	53.0	50.0	44.0	37.0	32.0	36.0
Oat (UPO-212)	19.6	21.0	20.4	28.0	32.2	30.2	53.8	52.0	48.0	39.0	32.0	35.0
Rye grass(Makkhan grass)	16.8	18.0	18.8	27.2	29.0	31.0	56.0	53.0	48.0	36.0	32.0	31.0
Rye grass (Local rye)	16.6	16.8	17.0	28.4	31.0	30.2	57.2	55.0	51.0	35.0	33.0	34.0
S. Em±	1.3	2.6	3.1	3.2	3.1	1.9	1.5	2.7	3.1	2.9	3.1	1.9
C. D. (P=0.05)	3.9	NS	NS	NS	9.1	5.8	4.3	NS	NS	8.6	9.1	5.5

NS–Not Significant.

and later on decreased (Table 2) due to degeneration of plant parts (Hakl *et al*., 2003). However, these results contradict with the findings of Yahana (1996). NDF content was slightly higher in present investigation which might be due to slight variation in different growth stage under environment condition, especially variation in temperature (Moore and Jung, 2001). Among oat varieties, neutral detergent fibre content of Genie oat was higher but it was statistically at par with UPO-212 at 1st, 4th, 5th and 6th cuttings. Comparatively lower fibre content in UPO-212 than Genie oat might be due to less hemicelluloses content in plant (Table 1). The results are in accordance with the results reported by Mohammad *et al.* (1994). Among rye grasses, both the varieties had statistically similar NDF at 1st, 4th, 5th and 6th cuttings and increased with advancement in crop age due to increase in hemicelluloses content in plants. Higher NDF content of makkhan grass at early stage might be due to its low temperature tolerance capacity (5^0C) which can grow better than local rye (Table 2). Higher NDF content in the present investigation might be due to variation in environmental conditions especially variation in temperature. It was observed earlier that the nutritive value of perennial ryegrass varied throughout the growing season (Johnston *et al*., 1993).

Acid detergent fibre content : Among leguminous **rabi** season forage crops, acid detergent fibre in berseem (Mescavi) was significantly higher compared to lucerne (Baralfa IN) and red clover (Barduro) at all the cuttings except at 4th cutting (Table 2). In general, acid detergent fibre of leguminous **rabi** season forage crops (berseem, lucerne and red clover) increased with age which might be due to progressively increased cellulosic and lignifications in plant with advancement of crop age till 5th cutting. Inverse relationship of advancing forage maturity and declining of forage quality was reported by Hakl *et al*. (2003). Among oat varieties, acid detergent fibre in Genie oat was higher but it was statistically at par with UPO-212 at all the cuttings except at 2nd cutting where acid detergent fibre of Genie oat was significantly higher compared to UPO-212. Comparatively lower acid detergent fibre of UPO-212 than Genie oat might be due to less hemicellulose (Table 2) and lignin content in plants but in both the oat varieties ADF content increased with advancement in crop age. The results are in accordance with the results reported by Sohail *et al.* (2007). Among rye grass, acid detergent fibre of makkhan grass was higher but it was statistically at par with local rye at all cuttings except at 6th cutting where acid detergent fibre of makkhan grass was significantly higher compared to local rye (Table 2). Neutral detergent fibre of both rye grasses might have increased with advancement in crop age due to more lignifications of cells at later stages of growth. Higher ADF content of makkhan grass at all cuttings might be due to its genetic makeup. The results are in accordance with the results reported by Smith *et al.*, (2005).

Hemicellulose (%) : Hemicellulose of all crops was statistically similar at 2nd, 3rd and 4th cuttings. It increased in subsequent cuttings till 6th cut. Among leguminous rabi season forage crops, hemicellulose in red clover (Barduro) was statistically at par with lucerne (Baralfa IN) at 1st, 5th and 6th cuttings, while in berseem (Mescavi) it was significantly lower compared to all other crops at 1st cutting and was statistically at par with lucerne (Baralfa IN) at 5th cutting and significantly higher compared to other leguminous rabi season forage crops (lucerne and red clover) at 6th cutting (Table 3). Lower

TABLE 4
Correlation among quality characteristics of cool season forage crops.

Quality characters	Cuttings					
	1	2	3	4	5	6
Between dry matter and fiber contents						
NDF	-0.088^{ns}	-0.771*	-0.105^{ns}	-0.215^{ns}	0.526^{ns}	0.190^{ns}
ADF	0.305^{ns}	-0.435^{ns}	-0.250^{ns}	0.235^{ns}	0.545^{ns}	0.561^{ns}
Hemicellulose	-0.196^{ns}	-0.344^{ns}	-0.017^{ns}	-0.347^{ns}	0.396^{ns}	0.062^{ns}
Between dry matter digestibility and cell traits						
NDF	-0.201^{ns}	-0.327^{ns}	-0.283^{ns}	-0.134^{ns}	-0.517^{ns}	-0.537^{ns}
ADF	0.265^{ns}	-0.317^{ns}	-0.151^{ns}	0.364^{ns}	-0.173^{ns}	-0.400^{ns}
Hemicellulose	-0.269^{ns}	-0.069^{ns}	-0.315^{ns}	-0.244^{ns}	-0.483^{ns}	-0.486^{ns}
Between cell content and fiber contents						
NDF	-0.999**	-1.000**	-0.996**	-0.962**	-0.991**	-0.987**
ADF	0.242^{ns}	0.008^{ns}	-0.792*	-0.704^{ns}	-0.426^{ns}	-0.671^{ns}
Hemicellulose	-0.950**	-0.790*	-0.943**	-0.888**	-0.952**	-0.981**

Table value at (n-2) df 5% = 0.754 and 1%=0.874. NS–Not Significant.

the value of hemicelluloses give better quality of forage and fodder. Lower hemicelluloses of berseem (Mescavi) at 1st cutting might be due to more succulent plant parts and good nutritional value (Fraser et al., 2004). Less hemicelluloses of red clover (Braduro) at 4th cutting might be due to variation in growth under changing temperature towards advancement in cutting which enhanced the proportion of cell wall components viz., cellulose, hemicellulose, and lignin (Bosch et al., 1992). Hemicellulose of lucerne (Baralfa IN) at 3rd and 5th cuttings decreased slightly. Reduction in hemicellulose of lucerne (Baralfa IN) at the later stage was reported by Kaushal (2006). Hemicellulose of both the oat varieties was statistically similar at 1st, 5th and 6th cuttings but hemicellulose content of UPO-212 was slightly decreased at 3rd cutting in the present investigation which corroborates the findings of Jaiswal and Joshi (2006). Hemicellulose of both the rye grass varieties was statistically similar at all the cuttings indicating that both the rye grass varieties response in similar ways for producing hemicellulose in their cell wall (Johnston et al., 1993). In the present investigation also the cell wall content of both the rye grass varieties was similar at all the cuttings.

Cell Content (%)

Cell content of all crops was non-significant at 2nd and 3rd cuttings. Cell content of berseem (Mescavi) was statistically at par with lucerne (Baralfa IN) and red clover (Barduro) but significantly more than other crops at 1st cutting. Cell content of berseem (Mescavi) was significantly lower compared to other leguminous **rabi** season forage crops at 4th and 6th cuttings. Higher cell content in berseem (Mescavi) at 1st cutting might be due to lower NDF as inverse relationship existed between cell content and NDF (Table 2). There was negative association between and cell wall components and cell contents. It might be due to secondary wall deposition and lignifications at late stage. More cell content indicated better quality of crops (Bosch *et al.,* 1992). Cell content of all crops decreased till 5th cutting, while at 6th cutting slightly increased cell content of all **rabi** season forage crops might be due to better moisture availability as the crop was raised under assured irrigation and temperature effect (Ranjhan, 1991). In general, cell content of all the forage crops decreased till 5th cutting. This might be due to increased NDF with increase in temperature (Xiangyu *et al.*, 2015). Cell content of red clover (Barduro) was significantly higher compared to all other crops at 6th cutting. At 4th and 5th, cuttings it was statistically at par with lucerne (Baralfa IN) but significantly more than berseem (Mesacvi) (Table 3). The results indicate that even after having less dry matter at later stages the red clover (Braduro) can be better option as it has higher digestibility (Table 1) at later stages compared to other clovers.

Correlation Studies

Dry matter of fodder showed negative association with NDF and Hemicellulose at early stages (1 to 4th cuttings) but positive correlation was observed at 5th and 6th cuttings, while ADF was negatively correlated at 2nd and 3rd cuttings and positively at rest of the cuttings. However, this association was not significant. In fodder grasses and legumes, all plant cells are surrounded by a primary wall which is rich in cellulose and has relatively random cellulose microfibril orientation. Lesser amount of hemicelluloses is present in primary cell wall and lignin being absent at initial stages of crop growth. Some plant tissues like mesophyll and phloem tissues in grasses and legumes develop only thin primary wall (Wilson, 1993). Thus, negative correlation of dry matter content with fibers and hemicelluloses at early stages might be due to absence of secondary cell wall and least lignification.

Dry matter digestibility was negatively correlated with fiber contents at all the cuttings except ADF at 1st and 4th cuttings. This might be due to the fact that the accumulated cell wall contents are always less digestible than cell soluble and also cell wall contents simply act as physical barrier to microbial enzymes reacting their target polysaccharides (Sohail *et al.*, 2007). Thus, digestibility was reduced with the presence of cell wall components and negative correlation existed. NDF and ADF were used for measurement of fiber which impacted digestibility of plant organic matter (cell contents) viz., protein, carbohydrates and lipids used for providing energy to livestock's. Higher the fibers, the cell contents digestibility is reduced. The hemicellulose is structural carbohydrate that can be digestible to some extent by rumen bacteria.

The cell content showed significant negative correlation with NDF and hemicellulose at all the the cuttings, while ADF was positively correlated with cell content at early stages (1st and 2nd) cuttings and negatively at later stages (rest of the cuttings). The cell wall is formed by the transport of cell contents viz., sugar matrix components from the golgibodies that are the sugar donors for cell wall component viz. Hemicellulose, cellulose, fibers, lignin etc (Taiz and Zeiger, 2002). Thus, if cell wall contents increases, the cell content decreases showing a negative correlation between cell wall and cell contents. Secondary wall deposition and lignification do not begin until complete cell growth and elongation. Secondary cell wall are rich in cellulose and hemicellulose (Moore and Hatfield, 1994). The main

factor impacting the cell wall concentration and composition of forage is plant maturation process. Overall forage cell wall concentration increases with increase in the stem to leaf ratio. During maturation cell wall concentration of cellulose, hemicellulose, detergent fibers, lignin increase and pectin reduces. These changes in composition reflect more toward composition of secondary walls. Lignin is the most important factor that limits cell wall digestion (Engels and Jung, 2005).

On the basis of the present investigation, it was concluded that among leguminous **rabi** season forage crops lucerne, among oat varieties UPO-212 and among rye grass varieties Makkhan grass, were found to have high quality of fodder and, therefore, can be suggested to cultivate under *tarai* region of north India.

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