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EFFECT OF FODDER BASED INTERCROPPING SYSTEMS ON QUALITY OF FODDER

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SUMMARY

The experiment was conducted at sorghum Agronomy block of Instructional Dairy Farm, Nagla, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Udham Singh Nagar, Uttarakhand (India) during *kharif* seasons of 2015 and 2016 to evaluate fodder based intercropping systems for various quality and nutritive traits of fodder. Ten treatments as detailed in materials and methods section were tested in three replications following randomized block design. Among quality traits, content of dry matter was significantly more in fodder from sweet sorghum+cowpea compared to remaining intercropping systems except sweet sorghum+ricebean and maize+cowpea. Other quality parameters viz. crude protein and digestible dry matter content were highest in fodder of maize+cowpea intercropping system. The fodder obtained from pearl millet+phillepsara contained higher NDF and hemicellulose, from sweet sorghgum+ phillepsara contained higher ADF. The fodder obtained from sweet sorghum+cowpea contained higher dry matter intake, cell content, total digestible nutrient, relative feed value, net energy and mineral content. Thus sweet sorghum+cowpea and maize+cowpea intercropping systems were best to get higher quality fodder during *Kharif* season.

Key words : Cell content, crude protein content, hemicellulose, maize, sorghum

Fodder rich in qualitative and nutritive traits can only solve problem of malnutrition in animals. Most of the fodder crops grown on marginal lands with monoculture are deficient in these traits. Considering country highest livestock population in the world (20% of the world livestock population), net deficit of 63 % green fodder, 24 % dry crop residues and 64% feeds, (Kumar *et al*., 2012) and increasing population of livestock coupled with poor quality fodder leading to low productivity. Fodder cereal crops have a high content of digestible starch, water-soluble carbohydrates and fibre creating a high energy feed for livestock when harvested at the recommended stage of crop (Nadeau *et al*., 2010). However, supplementations of protein feed to high producing ruminants are required since the crude protein content of fodder cereal crops is relatively low. Cereal+legume intercropping system may improve fodder quality and yield on a given land area by making more efficient use of the available resources (Lithourgidis and Dordas, 2010). In intercropping system, cereal crops provide structural support for fodder legumes, improve light interception whereas legume crops leads to higher protein content which improved the quality of fodder. Availability of quality and nutritive fodder is a limiting factor leading to decline in potential of dairy sector. In view, the present work was undertaken aiming to improve fodder quality and nutritive value through intercropping in *kharif* season.

MATERIALS AND METHODS

Aiming to obtain qualitative and nutrient rich fodder, the experiment was conducted at sorghum Agronomy block of Instructional Dairy Farm Nagla, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Udham Singh Nagar, Uttarakhand (India) during *kharif* seasons of 2015 and 2016 using randomized block design. The treatments consisting of 10 treatments *i.e.* single cut sorghum+ cowpea, sweet sorghum+ricebean, sweet sorghum+phillipesara, sweet sorghum+cowpea, pearl millet+ricebean, pearl millet+phillipesara, pearl millet+cowpea, maize+ricebean, maize+phillipesara and maize+cowpea were tested in three replications. The soil of experimental site was silty clay loam with neutral reaction (7.2 pH). The nutritional status of soil was rich in organic carbon (0.84 %), available nitrogen (282 .48 kg/ha), available phosphorus (21.70 kg/ha) and available potassium (231 kg/ha) obtained by following Walkley and Black, 1934, Subbiah and Asija, 1956, Olsen *et al*., 1954 and Jackson, 1973 methods, respectively. The crop was sown on 15th June of 2015 and 20th June of 2016. Cereal fodder crops were harvested at soft dough stage and fodder legume crops were harvested along with main crops. Fodder legumes were intercropped with cereals in 1:1 row ratio (additive series). 500 g fresh sample from each net plot was taken to determine dry matter content. The samples were dried at 70^0 C ± 2 in hot air oven for moisture loss, grounded with a Wiley mill to pass through 1 mm screen and analyzed for quality components. Total N was determined using the CHNS analyzer and crude protein was calculated by multiplying nitrogen per cent with 6.25 (AOAC, 1965). Total digestible nutrients (TDN), digestible dry matter (DDM), dry matter intake (DMI), relative feed value (RFV) and net energy for lactation (NE_l) were estimated according to the following equations adapted from Horrocks and Vallentine (1999):

TDN= (-1.291 X ADF) + 101.35, DMI= 120/ % NDF dry matter basis, DDM=88.9-(0.779 X % ADF, dry matter basis), RFV= % DDM X % DMI X 0.775, NE_1= (1.044 - (0.0119 X %ADF)) X 2.205. The metabolizable energy (ME) was calculated from the equation of Menke and Steingass (1988): ME (MJ kg/ DM) = 14.78 – 0.0147ADF. The data was subjected to analysis of variance (ANOVA) technique using the statistical programme OPSTAT (www.hau.ernet.in/ opstat.html) to draw inference of the results. Valid conclusions were drawn only on significant differences between treatment means at 5% level of probability.

RESULTS AND DISCUSSION

Dry matter content

The fodder obtained from sweet sorghum+cowpea intercropping system significantly enhanced dry matter content compared to fodder of remaining intercropping systems except sweet sorghum+ricebean and maize+cowpea intercropping systems during both the years. The dry matter content obtained from sweet sorghum+cowpea increased by 24.05, 30.68, 21.09, 19.72, 22.25, 10.51 per cent (2015) and 21.74, 28.81, 20.93, 17.09, 21.59, 9.88 per cent (2016) respectively over dry matter obtained from pearl millet+ricebean, pearl millet+phillipesara, pearl millet+cowpea, maize+ricebean, maize+phillipesara and maize+cowpea intercropping systems. It might be due to legumes intercropped with cereals providing significant amount of nutrients which ultimately enhanced dry matter content through increased growth parameters (Ali and Mohammad, 2012).

Crude protein content (CPC)

Crude protein content of maize+cowpea intercropping system was significantly more compared to remaining intercropping treatments except single cut sorghum+cowpea and maize+ricebean during both the years. It increased by 33.36, 38.00, 29.08 and 13.87 per cent respectively over pearl millet+ricebean, pearl millet+phillipesara, pearl millet+cowpea and maize+phillipesara intercropping systems during 2016. Incorporating of legumes with cereals enhanced crude protein content of mixture (Liu *et al*., 2006). Maize crop has comparatively higher crude protein than sweet sorghum because of dilution factor leading to linear decrease in crude protein with increase in dry matter per cent (Beck *et al*., 2007).

Digestible dry matter (DDM)

Digestible dry matter content was statistically similar under sweet sorghum+cowpea and maize+cowpea intercropping systems and these had significantly higher digestible dry matter over remaining treatments during both the years. The digestible dry matter content of maize+cowpea mixture increased by 6.98, 8.21, 4.09 (2015) and 7.26, 8.84, 5.64 (2016) per cent respectively over dry matter digestibility obtained from pearl millet+ricebean, pearl millet+phillipesara and pearl millet+cowpea, intercropping systems. It might be due to more juicy stalk and sugar content in sweet sorghum as well as more crude protein content of mixture due to cowpea which get easily digest by microbes in rumen (Salama and Zeid, 2016).

Dry matter intake (DMI)

The fodder obtained from sweet sorghum+cowpea intercropping system significantly enhanced dry matter intake compared to remaining intercropping systems except single cut sorghum+cowpea, sweet sorghum+ricebean, pearl millet+ricebean, pearl millet+cowpea, maize+ricebean and maize+cowpea respectively intercropping treatments during 2015 while this difference was not significant during 2016. The dry matter intake of sweet sorghum+cowpea increased by 4.86, 6.48, 6.88, 14.98 and 10.93 per cent respectively over fodder obtained from single cut sorghum+cowpea, sweet sorghum+ricebean, pearl millet+ricebean, pearl millet+phillipesara and maize+phillipesara intercropping treatments during 2015. It might be due

TABLE 1
Effect of different intercropping systems on quality of fodder

Treatments	Dry matter content		Crude protein content		Digestible dry matter content		Dry matter intake (DMI)	
	2015	2016	2015	2016	2015	2016	2015	2016
Single cut sorghum+Cowpea	21.57	22.78	12.82	13.33	59.82	58.65	2.35	2.27
Sweet Sorghum+Ricebean	24.97	26.21	10.53	11.00	58.52	57.45	2.31	2.15
Sweet Sorghum+Phillipesara	21.27	22.37	10.01	10.60	56.96	55.53	2.15	2.09
Sweet Sorghum+Cowpea	26.07	27.32	11.79	12.59	63.19	60.93	2.47	2.32
Pearl millet+ Ricebean	19.80	21.38	8.54	9.03	58.78	57.48	2.30	2.14
Pearl millet+ Phillipesara	18.07	19.45	8.08	8.40	58.00	56.50	2.10	2.11
Pearl millet+Cowpea	20.57	21.59	9.24	9.61	60.60	58.48	2.40	2.24
Maize+Ricebean	20.93	22.65	12.62	13.11	61.12	60.12	2.35	2.20
Maize+Phillipesara	20.27	21.42	10.91	11.67	59.56	57.96	2.20	2.21
Maize+Cowpea	23.33	24.62	13.03	13.55	63.19	61.98	2.42	2.26
S. Em±	1.08	1.13	0.20	0.22	0.56	0.63	0.06	0.07
C. D. (P=0.05)	3.22	3.37	0.60	0.66	1.68	1.86	0.17	NS

TABLE 2
Effect of different intercropping systems on quality of fodder

Treatments	NDF		ADF		Hemicellulose		Cell content	
	2015	2016	2015	2016	2015	2016	2015	2016
Single cut sorghum+Cowpea	51.26	53.03	37.33	38.83	13.93	14.20	48.74	46.97
Sweet Sorghum+Ricebean	52.15	56.03	39.00	40.38	13.15	15.66	47.85	43.97
Sweet Sorghum+Phillipesara	55.99	57.65	41.00	42.84	14.99	14.81	44.01	42.35
Sweet Sorghum+Cowpea	48.67	51.90	33.00	34.56	15.67	17.33	51.33	48.10
Pearl millet+ Ricebean	52.26	56.51	38.67	40.33	13.59	16.18	47.74	43.49
Pearl millet+ Phillipesara	57.29	57.18	39.67	41.59	17.63	15.59	42.71	42.82
Pearl millet+Cowpea	50.15	53.03	36.33	39.05	13.82	13.98	49.85	46.97
Maize+Ricebean	51.12	54.66	35.67	36.95	15.45	17.71	48.88	45.34
Maize+Phillipesara	54.80	54.84	37.67	39.72	17.13	15.12	45.20	45.16
Maize+Cowpea	49.66	53.52	33.00	35.90	16.66	17.62	50.34	46.48
S. Em±	1.28	1.79	0.72	0.81	1.28	1.87	1.28	1.79
C. D. (P=0.05)	3.86	NS	2.15	2.43	NS	NS	3.86	NS

to low NDF content as there exists negative relationship between NDF and DMI (Horrocks and Vallentine, 1999). Addition of legumes to fodder cereals has been found to can reduce the fiber concentrations indicating potential for increasing fodder intake (Lauriault and Kirksey, 2004).

Neutral detergent fibre (NDF)

NDF was significantly lower under sweet sorghum+cowpea intercropping system over remaining intercropping systems except fodder mixture of single cut sorghum+cowpea, sweet sorghum+ricebean, pearl millet+ricebean, pearl millet+cowpea, maize+ricebean and maize+cowpea respectively during 2015 while it was statistically at par with all intercropping systems during 2016. It might be due to ad-dition of legumes to fodder cereals can reduce the fiber concentrations (Lauriault and Kirksey, 2004).

Acid detergent fibre (ADF)

ADF of fodder obtained from sweet sorghum+cowpea intercropping system was significantly lower over remaining intercropping systems except fodder from maize+cowpea during 2015 while during 2016 it was at par with mixed fodder of maize+ricebean and maize+cowpea intercropping systems. Addition of fodder legumes with fodder cereals can improve fodder quality of mixture and reduce the fiber content (Njoka-Njiru *et al.*, 2006).

ADF content of sweet sorghum+phillipesara was significantly higher over remaining intercropping systems except sweet sorghum+ricebean and pearl millet+phillipesara during 2015 and pearl millet+phillipesara during 2016.

Hemicellulose

During both the years, hemicellulose content was not affected significantly by intercropping systems. However, lowest hemicelluloses content was due to sweet sorghum+ricebean during 2015 and pearl millet+cowpea during 2016 compared to other intercropping systems. Hemicellulose content was more in pearl millet+phillipesara intercropping system compared to other intercropping treatments during 2015. Earlier workers also found that pearl millet crop has higher fiber content compared to maize and sorghum (Keshavarz *et al*., 2012).

Cell content

Sweet sorghum+cowpea intercropping system caused significantly higher cell content of mixed fodder over fodder from sweet sorghum+phillipesara, pearl millet+phillipesara and maize+ phillipesara intercropping systems during 2015 while during 2016 it was at par with remaining intercropping systems. Intercropping of protein rich leguminous crops with sweet sorghum have been found to improve the cell content (Shankaranaryann *et al.,* 2005).

Total digestible nutrients (TDN)

TDN of fodder was statistically similar in fodder obtained from sweet sorghum+cowpea and maize+cowpea intercropping systems, however, TDN was significantly higher compared to remaining intercropping treamtents during 2015 while sweet sorghum+cowpea intercropping system caused significantly higher TDN in fodder over remaining intercropping systems during 2016 except in fodder from maize+ricebean and maize+cowpea intercropping systems which increased TDN by 9.71, 13.24, 18.84, 13.13, 16.00 and 10.20 per cent respectively over fodder mixture of single cut sorghum+cowpea, sweet sorghum+ricebean, sweet sorghum+phillipesara, pearl millet+ricebean, pearl millet+phillipesara and pearl millet+cowpea intercropping systems during 2016. It might be due to lower ADF content of fodder mixture (Table 2) (Nadeem *et al*., 2010).

Relative feed value (RFV)

RFV of fodder due to sweet sorghum+cowpea intercropping system was significantly higher compared to remaining intercropping systems except pearl millet+cowpea and maize+cowpea intercropping systems during 2015 and single cut sorghum+cowpea, pearl millet+cowpea, maize+ricebean and maize+cowpea intercropping systems during 2016. Fodder mixture of sweet sorghum+cowpea system increased RFV by 13.11, 21.87, 6.88, 7.82 and 16.10 per cent respectively over pearl millet+ricebean, pearl millet+phillipesara, pearl millet+cowpea maize+ricebean and maize+phillipesara during 2015. Addition of fodder legume crops enhanced feeding value RFV which might be due to reduced fiber contents.

TABLE 3

Effect of different intercropping systems on quality of fodder

Treatments	TDN		RFV		NEl		ME		Mineral content		Organic matter content	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Single cut sorghum+Cowpea	53.15	51.22	109.10	103.55	1.32	1.28	14.23	14.21	9.27	9.33	90.73	90.67
Sweet Sorghum+Ricebean	51.00	49.22	104.64	95.63	1.28	1.24	14.21	14.19	9.63	9.68	90.37	90.32
Sweet Sorghum+Phillipesara	48.42	46.04	95.06	90.16	1.23	1.18	14.18	14.15	8.33	8.40	91.67	91.60
Sweet Sorghum+Cowpea	58.75	56.73	120.78	111.21	1.44	1.40	14.29	14.27	10.90	10.82	89.10	89.18
Pearl millet+Ricebean	51.43	49.28	104.94	95.21	1.29	1.24	14.21	14.19	8.53	8.56	91.47	91.44
Pearl millet+Phillipesara	50.14	47.65	94.37	92.27	1.26	1.21	14.20	14.17	7.93	7.96	92.07	92.04
Pearl millet+Cowpea	54.44	50.94	112.47	102.57	1.35	1.28	14.25	14.21	9.17	9.19	90.83	90.81
Maize+Ricebean	55.30	53.65	111.34	102.34	1.37	1.33	14.26	14.24	9.07	9.10	90.93	90.90
Maize+Phillipesara	52.72	50.07	101.33	99.20	1.31	1.26	14.23	14.20	8.40	8.45	91.60	91.55
Maize+Cowpea	58.75	55.00	118.57	105.89	1.44	1.36	14.29	14.25	9.60	9.66	90.40	90.34
S. Em±	0.98	1.05	3.05	3.50	0.02	0.02	0.01	0.01	0.20	0.18	0.19	0.17
C. D. (P=0.05)	2.77	3.13	9.14	10.48	0.06	0.07	0.03	0.04	0.58	0.53	0.57	0.52

Net energy for lactation (NE_1)

Net energy of fodder from sweet sorghum+cowpea intercropping system was similar with maize+cowpea intercropping system but significantly higher compared to remaining intercropping systems during 2015 while during 2016, it was at par with maize+ricebean and maize+cowpea intercropping systems. Fodder of sweet sorghum+cowpea intercropping system increased net energy by 8.33, 11.11, 14.58, 10.42 and 12.50 per cent respectively over single cut sorghum+cowpea, sweet sorghum+ricebean, sweet sorghum+phillipesara, pearl millet+ricebean and pearl millet+phillipesara intercropping systems during 2015. Addition of legumes with cereal fodder crops can enhances energy value of fodder mixture (Vasilakoglou *et al*., 2008).

Metabolizable energy (ME)

Metabolizable energy of fodder from sweet sorghum+cowpea was significantly higher over remaining intercropping systems during both the years except maize+ricebean and maize+cowpea intercropping systems. Sweet sorghum+cowpea system increased metabolizable energy by 0.56, 0.63 and 0.28 per cent respectively over pearl millet+ricebean, pearl millet+phillipesara and pearl millet+cowpea intercropping systems during 2015. Intercropping of leguminous crops with cereals can enhance the amino acids (methionine and threonine) in fodder mixture which get easily metabolized and provide energy (Pozdisek *et al*., 2011).

Mineral content

Sweet sorghum+cowpea intercropping system caused significantly more mineral content in the fodder mixture compared to remaining intercropping systems during both the years. The mineral content from sweet sorghum+cowpea increased by 21.74, 27.24, 22.94 per cent (2015) and 20.88, 26.83, 21.90 per cent (2016) respectively over pearl millet+ricebean, pearl millet+phillipesara and maize+phillipesara intercropping systems. It might be due to legume crops have tendency to accumulate more minerals (Juknevicius and Sabienc, 2007).

Organic matter content

The fodder obtained from sweet sorghum+cowpea intercropping system contained significantly lower organic matter over remaining intercropping systems during both the years. Organic matter content in fodder was significantly higher under pearl millet+phillipesara compared to remaining intercropping systems except sweet sorghum+phillipesara and maize+phillipesara intercropping systems during both the years registering an increase of 3.11, 1.86 and 1.85 per cent over fodder mixture of sweet sorghum+cowpea, sweet sorghum+ricebean and maize+cowpea intercropping systems during 2016. It might be due higher minerals content in fodder mixture (Table 3) (Manjunatha, 2011).

The present study showed that association of cowpea with maize led to higher crude protein and digestible dry matter content in fodder while dry matter intake, total digestible nutrients, cell content, relative feed value and net energy was significantly higher under sweet sorghum+cowpea over other intercropping systems except fodder mixture of maize+ricebean and maize+cowpea. Thus sweet sorghum+cowpea and maize+cowpea intercropping systems provided higher quality fodder under *Tarai* region Uttarakhand.

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