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DETERMINATION OF THE RELATIONSHIPS BETWEEN QUALITY PARAMETERS AND YIELDS OF FODDER OBTAINED FROM INTERCROPPING SYSTEMS BY CORRELATION ANALYSIS

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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 yield traits of fodder. Ten treatments as detailed in materials and methods section were tested in three replications following randomized block design. The analysis of data indicated that all cell wall structural components (NDF/ADF/hemicelluloses) showed positive correlation with each other. NDF and ADF were existed negative association with cell content, CP content, DDM, DMI, TDN, RFV, NEl and mineral content. CP content was significantly and positively associated with DDM, DMI, TDN, RFV and NEl while negative association with cell wall structural components (ADF/NDF/hemicellulose). DDM was positive correlation with cell content, DM content, CP content, DMI, TDN, RFV, NEl and mineral content. DMI and RFV were negative association with cell wall structural components. The CPY and DDMY were positively and significantly correlated with DM content, cell content, CP content, DDM and mineral content. DM content was positively correlated with all yields (GFY, DFY, DDMY and CPY) and this association was significant. The CPY and DDMY were positively and significantly correlated with DM content, cell content, CP content, DDM and mineral content. Association of cowpea with sweet sorghum improved the quality of fodder. Sweet sorghum+cowpea system provided higher green fodder, dry fodder, crude protein and digestible dry matter yield under *Tarai* agro climatic situation of Uttarakhand.

Key words : Correlation, crude protein content, dry matter intake, hemicellulose, net energy

Livestock and agriculture are complementary to each other and both are crucial for overall food security. India supports about 20 per cent of the world's livestock population and 16.8 per cent human population on a land area of only 2.3 per cent. India is leader in cattle (16%) and buffalo (55%) population Kumar *et al.* (2012) and having world's second largest goat (20%) and fourth largest sheep (5%) population (Prajapati *et al.,* 2016). Livestock is the sub-sector of agriculture which contributes about 4.5 per cent to total GDP and 25.8 per cent to the agriculture GDP (GOI, 2017). According of IGRFI Vision 2050, there is a net deficit of 61.1% green fodder, 21.9% dry crop residues and 64% feeds (Kumar *et al.,* 2018). As we all know that feeding management plays a very significant role in exploiting the full potential of dairy animals. India has recently emerged as largest producer of milk (165.4 million tonnes) in the world but livestock productivity is very low as compared to the developed countries. Malnutrition or under nutrition due to large gap in demand and supply of feed and fodder in the country is the main reason for the low productivity of our livestock. The available fodders are poor in quality, being deficient in available energy, protein and minerals. Therefore to compensate the low productivity of the livestock, farmers maintain a large herd of animals. Hence the milk production in country can be increased by providing adequate and nutritive fodder having good quality. Fodder yield and quality of crops are a complex cause of several effects and influenced by many component traits. Thus, study of correlation provides an opportunity to assess the

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magnitude and direction of association between yield and quality with its direct and indirect components, which are essential for formulating an effective and efficient crop improvement scheme (Chandra *et al.*, 2012). To improve the quality and yield of fodder crops, it is imperative to know the association of different quality traits with the yield traits of fodder crops. In this view, the present study was undertaken to identify inter-relationship of quality traits and their association with the yield and quality traits of fodder.

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 Instructional Dairy Farm is situated in the *Tarai* belt of Shivalik range of Himalayas with humid sub-tropical type of climate at latitude of 29°N and longitude of 79.3°E and situated at an altitude of 243.84 m above the mean sea level. 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

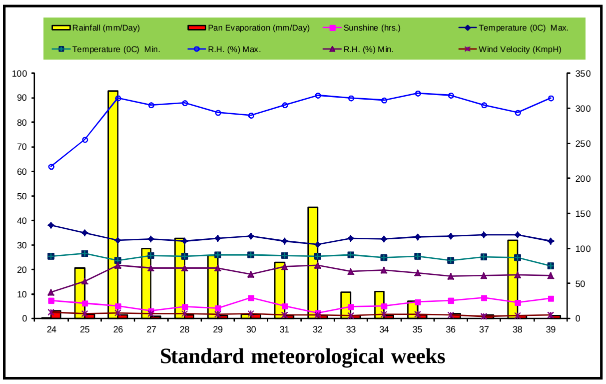

Fig. 1. Weekly weather parameters at Pantnagar during the crop period (*Kharif*, 2015).

(231 kg/ha) obtained by following Walkley and Black, 1934, Subbiah and Asija, 1956, Olsen *et al.*, 1954 and Jackson, 1973 methods, respectively. Nitrogen was applied at the rate of 80 kg/ha (Intercropping) in three splits viz. half of total nitrogen at sowing, subsequent dose of fertilizer by top dressing @ 1/4th of N after 35 and 60 days after sowing. A uniform application of 60 Kg P_2O_5 and 40 kg K_2O was done in each treatment as basal at the time of sowing along with first dose of nitrogen. 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

TABLE 1

Quality (%) and Yields (q/ha) of intercropping systems (Average of two years)

Treatments	Dry matter content	Crude protein content	Digestible dry matter content	Green fodder yield (q/ha)	Dry fodder yield (q/ha)	Crude protein yield (q/ha)	Digestible dry matter yield (q/ha)
Single cut sorghum+Cowpea	22.16	13.07	59.23	629.15	139.39	18.22	82.56
Sweet sorghum+Ricebean	25.60	10.76	57.98	632.86	162.01	17.43	93.93
Sweet sorghum+Phillipesara	22.29	10.29	55.61	592.64	132.07	13.59	73.44
Sweet sorghum+Cowpea	26.71	12.19	62.06	647.13	172.86	21.07	108.18
Pearl millet+Ricebean	20.61	8.79	58.13	509.44	104.99	9.23	61.03
Pearl millet+Phillipesara	18.75	8.24	57.25	467.13	87.59	7.22	50.15
Pearl millet+Cowpea	21.11	9.42	59.93	521.57	110.11	10.37	65.99
Maize+Ricebean	21.81	12.87	60.62	586.79	127.95	16.47	77.56
Maize+Phillipesara	20.80	11.29	58.76	544.39	113.21	12.78	66.52
Maize+Cowpea	24.01	13.29	62.58	615.03	147.64	19.62	91.63
S. Em	0.88	0.21	0.66	8.92	7.14	0.73	4.04
C. D.	2.64	0.63	1.97	26.49	21.38	2.18	12.08

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_l= (1.044 - (0.0119 X %ADF)) X 2.205. The data was subjected for correlation analysis to using technique the statistical programme OPSTAT (www.hau.ernet.in/opstat.html) to draw inference of the results. Valid conclusions were drawn only on significant differences at 5% and 5% level of probability.

RESULTS AND DISCUSSION

Quality

Dry matter content : The highest dry matter content was obtained in sweet sorghum+cowpea intercropping system which was significantly more than remaining intercropping systems except sweet sorghum+ricebean treatment. The dry matter content obtained from sweet sorghum+cowpea intercropping system increased by 17.03, 4.16 and 16.55 per cent respectively over single cut sorghum+cowpea, sweet sorghum+ricebean and sweet sorghum+phillipesara intercropping system. Legumes intercropped with cereals are complementary to each other and providing significant amount of nutrients, water and solar energy which ultimately enhanced dry matter content through increased growth parameters. Current finding are in consistent with those of Akman *et al*. (2013) and Nasri *et al*. (2014).

Crude protein content : The crude protein content of maize+cowpea fodder was significantly more than remaining intercropping systems except fodder obtained from single cut sorghum+cowpea and maize+ricebean registering an increase of 33.86, 38.00 and 30.47 per cent over pearl millet+ ricebean, pearl millet+ phillipesara and pearl millet+cowpea respectively. Fodder obtained from maize crop has comparatively higher crude protein content than fodder of sweet sorghum and pearl millet and incorporating of legumes with cereals enhanced crude protein content of mixture (Liu *et al*., 2006).

Digestible dry matter content : Among different intercropping systems, the highest digestible dry matter content was obtained in sweet sorghum+cowpea system compared to fodder of remaining intercropping systems except maize+ricebean and maize+cowpea. It also increased 11.61, 7.11, 8.52 and 4.23 per cent respectively over fodder from sweet sorghum+phillipesara, pearl millet+ricebean, pearl millet+phillipesara and pearl millet+cowpea intercropping systems. Juicier stalk and sugar content in sweet sorghum as well as least fiber content might have increased digestibility of fodder (Broderich and Radloff, 2003).

Yield

Green fodder yield : Among different fodder

TABLE 2

Correlation study between different quality parameters (Average of two years)

Quality Parameters	NDF	ADF	Hemicellulose	Cell content	DM	CP	DDM	DMI	TDN	RFV	NE
ADF	0.887**										
Hemicellulose	0.528^{NS}	0.469^{NS}									
Cell content	-1.000**	-0.887**	-0.579^{NS}								
DM	-0.617^{NS}	-0.574^{NS}	0.063^{NS}	0.617^{NS}							
CP	-0.622^{NS}	-0.680*	-0.592^{NS}	0.621^{NS}	0.565^{NS}						
DDM	-0.871**	-0.993**	0.485^{NS}	0.871**	0.542^{NS}	0.698*					
DMI	-0.997**	-0.912**	-0.878**	0.997**	0.638*	0.641*	0.893**				
TDN	-0.887**	-1.000**	0.470^{NS}	0.887**	0.573^{NS}	0.680*	0.993**	0.911**			
RFV	-0.975**	-0.966**	-0.681*	0.975**	0.624^{NS}	0.667*	0.952**	0.986**	0.966**		
NE	-0.882**	-0.999**	0.475^{NS}	0.883**	0.566^{NS}	0.658*	0.990**	0.907**	0.999**	0.964**	
MC	-0.854**	-0.788**	0.074^{NS}	0.854**	0.914**	0.590^{NS}	0.746*	0.870**	0.788**	0.855**	0.783**

NDF= Neutral detergent fiber, ADF= Acid detergent fiber, DM= Dry matter content, CP= Crude protein, DDM= Digestible dry matter, DMI= Dry matter intake, TDN= Total digestible nutrient, RFV= Relative feed value, NE=Net energy, MC=Mineral content

* and ** Significant at 5 % and 1 % level, respectively.

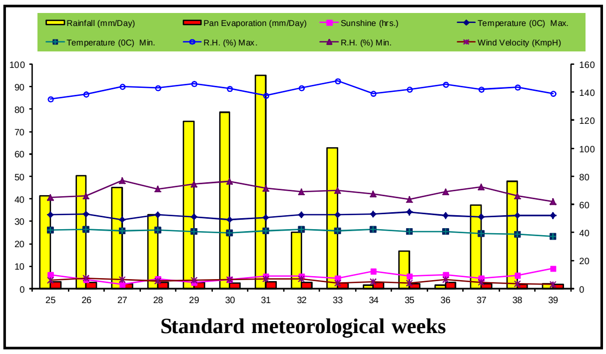

Fig. 2. Weekly weather parameters at Pantnagar during the crop period (*Kharif*, 2016).

based intercropping systems sweet sorghum+cowpea caused significantly higher green fodder yield compared to remaining intercropping systems except single cut sorghum+ cowpea and sweet sorghum+ricebean which increased by 21.28, 27.82, 19.40 and 9.32 per cent over pearl millet+ricebean, pearl millet+phillipesara, pearl millet+cowpea and maize+ricebean respectively. It might be due to a lower intra specific competition between plants and also better use of resources such as water, nutrients and solar energy due to more canopies (Nasri *et al*., 2014).

Dry fodder yield : The dry fodder yield of sweet sorghum+cowpea intercropping system was significantly higher than remaining treatments except sorghum+ricebean registering an increase of 25.98, 34.53 and 14.59 per cent respectively over maize+ricebean, maize+phillipesara and maize+cowpea intercropping systems. The dry fodder yield was significantly lower under pearl millet+phillipesara compared to remaining intercropping system except pearl millet+ricebean. It might be due to more trailing growth habit of phillipesara and ricebean restricting development of pearl millet crop which comes in harvesting stage (soft dough) much earlier than maize and sorghum (Gupta, 2004).

Crude protein yield : The crude protein yield was significantly higher due to sweet sorghum+cowpea intercropping system compared to remaining intercropping systems except maize+cowpea. This system caused an increase of 17.28, 35.50 and 27.83 per cent crude protein yield over sweet sorghum+ricebean, sweet sorghum+phillipesara and maize+ricebean respectively. The crude protein yield of pearl millet+phillipesara system was significantly lower than remaining intercropping systems except pearl millet+ricebean. Since crude protein yield is a function of crude protein content and dry fodder yield, higher values of these parameters enhanced crude protein yield under sweet sorghum+cowpea intercropping system.

Digestible dry matter yield : Among different intercropping systems, the highest digestible dry matter yield was obtained in sweet sorghum+cowpea system compared to remaining intercropping systems. This intercropping system led to 23.68, 13.18, 32.11, 28.31 and 38.51 per cent increase in digestible dry matter yield over single cut sorghum+cowpea, sweet sorghum+ricebean, sweet sorghum+phillipesara, maize+ricebean and maize+phillipesara respectively. Since digestible dry matter yield is a function of digestible dry matter content and dry fodder yield, the higher value of dry fodder yield and digestible dry matter content led to highest digestible dry matter yield. These results corroborate with the findings of Joshi *et al*. (2012).

Correlation

Among quality parameters : NDF had significant positive association with ADF and hemicellulose content but it had non significant association. However non significant negative association CP content was noticed. It showed significant negative correlated with DDM, DMI, TDN, RFV, NE_l, mineral and cell content. ADF showed significant negative association with CP content, DDM, DMI, TDN, RFV, NE_l, mineral and cell content.

TABLE 3
Correlation study between quality parameters and yields
(Average of two years)

Quality Parameters	Yield(q/ha)			
	GFY	DMY	CPY	DDMY
NDF	-0.553NS	-0.584NS	-0.669*	-0.681*
ADF	-0.478NS	-0.531NS	-0.679*	-0.656*
Hemicellulose	-0.021NS	0.033NS	0.193^{NS}	0.119NS
Cell content	0.552NS	0.584NS	0.668*	0.681*
DM	0.875**	0.975**	0.868**	0.976**
CP	0.805**	0.679*	0.891**	0.718*
DDM	0.463NS	0.504NS	0.671*	0.676*
MC	0.772**	0.872**	0.831**	0.925**

NDF= Neutral detergent fiber, ADF= Acid detergent fiber, DM= Dry matter content, CP= Crude protein, DDM= Digestible dry matter, MC=Mineral content

* and ** Significant at 5 % and 1 % level, respectively.

A non significant and positive correlation between NDF and hemicellulose was noticed. Association between hemicellulose and DMI, RFV was significant and negative. This might be due to the fact that the accumulated cell wall (NDF/ADF/Hemicellulose) contents are always less digestible than cell soluble and also NDF/ADF/Hemicellulose contents simply act as physical barrier to microbial enzymes reacting their target polysaccharides (Sohail *et al*., 2007). Thus digestibility, cell content and intake are reduced with the presence of cell wall components and negative correlation existed (Prajapati *et al*., 2017). The cell content showed significant negative correlation with NDF and ADF. However non significant positive correlated with DM content and CP content. This showed perfect negative correlation with NDF. Cell content of fodder was significantly and positively associated with DDM, DMI, TDN, RFV, NE_l and mineral content. 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. Thus if cell wall contents increases, the cell content decreases showing a negative correlation between cell wall and cell contents. Dry matter of fodder showed non significant negative association with NDF and ADF but positive correlation with hemicellulose, Cell content, CP content, DDM, TDN, RFV and NE_l. CP content was significantly and positively associated with DDM, DMI, TDN, RFV and NE_l while negative association with ADF, NDF and hemicellulose. Crude protein content decreases while cell wall contents (NDF/ADF/hemicellulose) increases (Jancik *et al*., 2008; Azo *et al*., 2012). It showed non significant positive correlation between Cell content, DM content and mineral content. DDM and DMI was significantly and positively associated with Cell content, CP content, TDN, RFV, NE_l and mineral content. DMI had significantly and negatively association with ADF, NDF and hemicellulose was noticed. Negative correlation between NDF/ADF and DDM/DMI has been observed by earlier workers (Cabarello *et al*., 1995; Horrocks and Vallentine, 1999). TDN, RFV and NE_l were significantly and positively associated with Cell content, CP content, DDM and DMI while significantly and negatively associated with ADF and NDF. Inverse relationship between TDN and ADF was reported by Nadeem *et al*. (2010). RFV is derived from the DDM and DMI (Albayrak *et al*., 2011), Thus if DDM and DMI contents increases, the RFV increases showing a positive correlation between RFV and DDM/DMI. A significant positive correlation of mineral content with cell content, DM content, DDM, DMI, TDN, RFV and NE_l. However significant negative association with ADF and NDF content was noticed.

Quality parameters and yields : The correlation between quality parameters and yields as presented in (Table 3) indicated that DM, CP and mineral content were positively correlated with all yields (GFY, DFY, DDMY and CPY) and this association was significant. Enhancement in dry fodder yield is due to accumulation of dry matter in various plants parts which increases the weight. This factor might have led significant positive correlation with green /dry forage yield (Chandra *et al*., 2012). NDF and ADF was non significant negative associated with GFY and DFY but significantly and negatively associated with CPY and DDMY. Hemicellulose content was non significantly and positively associated with CPY, DFY and DDMY except GFY. Cell content had significant positive association with CPY and DDMY. However non significant positive association with GFY and DMY was noticed. The CPY was positively and significantly correlated with DM content, cell content, CP content, DDM and mineral content while it was negative and significantly correlated with NDF and ADF. Higher values of crude protein content and DFY lead to enhancement in CP yield. A positive association between CP content, DMY, DDMY and CPY in intercropping has been noticed by (Ram and Singh, 2003). The DDMY had significant positive correlation with dry matter content, cell content, CP content, DDM and mineral content which might be due to higher values of dry matter and digestible dry matter. A significant positive association between mineral content and yields was noticed. This suggests that accumulation of nutrients was more with increase in green /dry fodder yield and there by more DDMY and CPY.

On the basis of the present investigation, it is concluded that all cell wall structural components (NDF/ADF/hemicellulose) showed positive correlation with each other. NDF and ADF were existed negative association with cell content, DM content, CP content, DDM, DMI, TDN, RFV, NE_l and mineral content. CP content was significantly and positively associated with DDM, DMI, TDN, RFV and NE_l while negative association with cell wall structural components (ADF/NDF/hemicellulose). DDM was positive correlation with cell content, DM content, CP content, DMI, TDN, RFV, NE_l and mineral content. DMI and RFV were negative association with cell wall structural components. The CPY and DDMY were positively and significantly correlated with DM content, cell content, CP content, DDM and mineral content. Association of cowpea with sweet sorghum improved the quality of fodder. Sweet sorghum+cowpea system provided higher green fodder, dry fodder, crude protein and digestible dry matter yield under *Tarai* agro climatic situation of Uttarakhand. Hence, associated effects between cereals and legumes may improve quality traits of fodder and their relation with yields.

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