International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2017; 5(6): 834-838

Received: 21-09-2017
Accepted: 23-10-2017

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Production potential of fodder based intercropping systems

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Abstract
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 2015 and 2016 to evaluate suitable fodder based intercropping for quality fodder production. Randomized block design was used with three replications consisting of 10 treatments as detailed in materials and methods. Sweet sorghum+cowpea out yielded over other intercropping systems. Highest value of crude protein and digestible dry matter content were in the fodder obtained from maize+cowpea. Pearl millet+phillipesara could not perform better. Thus sweet sorghum+cowpea intercropping system was best to get higher yield and quality fodder during *Kharif* season.

Keywords: Crude protein, digestible dry matter, green fodder yield, mineral content

Introduction

Fodders as a group of crops differ from food and commercial crops as they are primarily grown for the fresh green vegetative biomass. Cereal fodder crops such as maize, sorghum, pearl millet, oat, barley and rye grass give higher fodder yield but are deficient in protein content. Fodder legumes such as ricebean, phillipesara, soybean, cowpea, cluster bean etc. are rich sources of protein but their fodder yield is lower than cereal fodder (Iqbal *et al*., 2015) [1]. The concept of intercropping is to get increased total fodder productivity per unit area and time besides equitable and judicious utilization of land resources and inputs (Marer *et al*., 2007) [2]. Intercropping of fodder legumes contribute to enhancement in fodder productivity of cereal crops when grown as intercrops (Giller and Wilson, 1991) [3]. Cowpea (*Vigna unguiculata* L.), is commonly grown with maize and sorghum. Fodder cowpea being deep rooted crop and slow growing in early growth stage, during which the more rapidly growing wide spaced crops like sweet sorghum for fodder, can be conveniently intercropped to utilize the natural resources more efficiently. Cowpea enhances the fodder productivity and improves nutritive value of fodder. Ricebean (*Vigna umbellata* L.), is fodder legume, intercropped with wide spaced row crops, is a promising multipurpose legume with a good potential to be used as food, fodder, green manure and cover crop (Ayub *et al.,* 2004) [4]. Phillipesara (*Phaseolus trilobus* L.) another fodder legume, a native of India, is an annual herbaceous, runner growing up to 40-90 cm height with indeterminate growth habit. It is widely used as fodder, ground cover legume, pulse and green manure crop. At present country 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 fodder and roughages was 395.2 and 451 mt against the demand of 1061 and 589 mt, respectively (ICAR, 2012 and Chaudhary *et al.,* 2012) [5-6]. Hence, efforts need to be made to intensify fodder productivity and production per unit area and time to achieve maximum qualitative yield. Keeping this in view, the experiment was conducted to find out suitable intercropping for availability of good quality fodder.

Materials and Methods

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 2015-2016 and 2016-2017 in randomized block design with three replications 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, maize+cowpea.

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 [7-10] 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 harvested along with main crops. Fodder legumes were intercropped with cereals in 1:1 row ratio (additive series). The harvested herbage was weighted immediately for green fodder yield and 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) [11]. The digestible dry matter content was estimated on dry weight basis following the equation DDM= 88.9-(0.779 x % ADF) adapted from Horrocks and Vallentine (1999) [12]. Total mineral was calculated as per ISI (1975) [13] standards.

$$Mineral\ (\%) = \frac{Weight\ of\ ash}{Weight\ of\ sample\ taken\ for\ ashing}\ x\ 100$$

The pooled over 2 years quality and yield data were 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

Growth parameters of main crops

Plant height: Among sorghum based intercropping systems, the plant height of sweet sorghum was significantly more when intercropped with cowpea over other sorghum based intercropping systems during both the years registering an increase of 5.80, 7.23 per cent during 2015 and 5.84, 7.28 per cent during 2016 over single cut sorghum+cowpea and sweet sorghum+phillipesara. Better growth of sweet sorghum in terms of height might be due to utilization of resources more efficiently where sweet sorghum was intercropped with cowpea (Ahmad *et al.*, 2007) [14] and also longer duration of harvesting compared to maize and pearl millet (Chaudhary *et al*., 2012) **[6]**. Among pearl millet based intercropping systems, the plants of pearl millet were significantly taller in pearl millet+cowpea intercropping system over other treatments and registering an increment in plant height upto 11.90 and 11.96 per cent over pearl millet+ phillipesara during 2015 and 2016. Among maize based intercropping systems, the plant height of maize was significantly more under maize+cowpea compared to maize+phillipesara during both the years. Better height of main crops under these intercroppings might be due to more compatibility of cow pea with main crops.

Dry matter accumulation: Among sorghum, pearl millet and maize based intercropping systems, dry matter accumulation of main crops was significantly higher when associated with cowpea compared to remaining intercropping systems during both the years. The dry matter accumulation in sweet sorghum increased by 8.64, 6.25, 14.33 per cent (2015) and 8.14, 5.33, 13.75 per cent (2016) over single cut sorghum+cowpea, sweet sorghum+ricebean and sweet sorghum+phillipesara respectively. The increase in dry matter accumulation by pearl millet was 7.37 and 16.35 per cent over pearl millet+ricebean and pearl millet+ phillipesara during 2015. Comparatively longer duration for harvesting of sweet sorghum might have resulted in more dry matter accumulation as more time is available for development of plant parts (Singh, 2009) [15]. Dry matter accumulation per plant also followed the trend similar to dry matter accumulation on area basis.

Leaf to stem ratio: L:S ratio of single cut sorghum, being at par with sweet sorghum under sweet sorghum+cowpea, was significantly higher due to single cut sorghum+cowpea intercropping system over sweet sorghum+phillipesara during 2015 registering an increase of 47.92 per cent over sweet sorghum+phillipesara while during 2016, L:S ratio of sweet sorghum under sweet sorghum+cowpea was significantly higher compared to sweet sorghum under sweet sorghum+phillipesara intercropping and remained at par with other main crops under different intercropping systems. It might be due to vigorous growth of leaves of main crops when intercropped with cowpea. On the other hand least L:S ratio of main crops in association with phillipesara might be due to its indeterminate growth habit and more trailing in nature restricting leaf growth of main crops.

Growth parameters of intercrops

Plant height

Cowpea plants grew significantly taller under sweet sorghum+cowpea intercropping system compared to remaining cowpea associated with different fodder cereals during 2016 while during 2015, it was significantly taller than cowpea in pearl millet+cowpea intercropping system. It increased by 5.08, 11.18 and 4.01 per cent respectively over single cut sorghum+cowpea, pearl millet+cowpea and maize+cowpea intercropping systems during 2016. It might be due to shoot to root ratios of cowpea increased with crop age and indicated that shoots have tendency to photosynthesis for longer period and priority for photosynthate accumulation for proper growth and development (Fageria, 1992) [16]. Plants of ricebean were significantly taller under sweet sorghum+ricebean intercropping system compared to ricebean in pearl millet+ricebean system during both the years. There was non-significant difference of plant height of phillipesara under different intercropping system during 2015 while during 2016, phillipesara had significantly taller plants in maize+phillipesara intercropping system over pearl millet in pearl millet+phillipesara system.

Leaf to stem ratio: Among cowpea and ricebean as component crop of different intercropping systems, L:S ratio of cowpea and ricebean was significantly higher compared to other intercropping systems when associated with sweet sorghum during both the years. The increase in leaf to stem ratio of cowpea by 13.04, 13.77 and 11.59 per cent respectively over single cut sorghum+cowpea, pearl millet+cowpea and maize+cowpea intercropping system during 2015. These results corroborate with findings of Fageria (1992) [16]. However, L:S ratio was non-significant in phillipesara associated with different fodder cereal crops during both the years. Among different intercropping systems branches per plant of intercrops were also found the trend similar to L:S ratio during both the years.

Total dry matter accumulation (g/m^2 row length): Total dry matter accumulation by cowpea was significantly more in sweet sorghum+cowpea system compared to remaining cowpea based intercropping systems except single cut sorghum+cowpea intercropping system during both the years. The increase in total dry matter accumulation by cowpea was 3.88, 14.84, 13.01 per cent (2015) and 4.25, 14.63, 12.34 per cent (2016) over single cut sorghum+cowpea, pearl millet+cowpea and maize+cowpea intercropping systems. These results corroborate with the findings of Singh (2009) [15]. Dry matter accumulation of ricebean and phillipesara was significantly higher over other intercropping system when it associated with sweet sorghum during both the years.

Quality

Crude Protein Content: The crude protein content of maize+cowpea fodder was significantly higher over fodder of other intercropping systems except 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. It might be due to inclusion of maize and cowpea crops which have higher crude protein content than sweet sorghum and pearl millet (Gupta, 2004) [17].

Digestible dry matter content (DDMC): Among different fodder based intercropping systems, fodder obtained from sweet sorghum+cowpea system caused significantly higher DDMC compared to fodder of remaining intercropping systems except maize+ricebean and maize+cowpea. It also increased 5.35, 7.35, 11.61, 7.11, 8.52 and 4.23 per cent respectively over fodder from single cut sorghum+cowpea, sweet sorghum+ricebean, sweet sorghum+phillipesara, pearl millet+ricebean, pearl millet+phillipesara and pearl millet+cowpea intercropping systems. More juicy stalk and sugar content in sweet sorghum as well as least fiber content might have increased digestibility (Broderich and Radloff, 2003) [18].

Mineral Content: The mineral content in fodder obtained from sweet sorghum+cowpea intercropping system was significantly higher over fodder from sweet sorghum+phillipesara, pearl millet+ricebean, pearl millet+phillipesara, pearl millet+cowpea and maize+phillipesara system. It registered an increase of 14.05, 13.19, 18.11 and 10.46 per cent respectively over fodder from single cut sorghum+cowpea, sweet sorghum+ricebean, maize+ricebean and maize+cowpea intercropping systems. Better association between sweet sorghum and cowpea for absorption of nutrients and other resources might have enhanced mineral content (Li *et al*., 2003) [19].

Yield

Green Fodder Yield: Among different fodder based intercropping systems, significantly higher green fodder yield was obtained following sweet sorghum+cowpea intercropping system 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 taller plants and more dry matter production due to sweet sorghum+ cowpea association (Table 1).

Dry Fodder Yield: The dry fodder yield was significantly higher under sweet sorghum+cowpea compared to remaining intercropping systems except sorghum+ricebean registering an increase of 19.36, 23.60, 25.98, 34.53 and 14.59 per cent respectively over single cut sorghum+ cowpea, sweet sorghum+phillipesara, maize+ricebean, maize+phillipesara and maize+cowpea. 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) [17].

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 crude protein yield by 13.53, 17.28, 35.50 and 27.83 per cent respectively over single cut sorghum+ cowpea, sweet sorghum+ricebean, sweet sorghum+phillipesara and maize+ricebean. The crude protein yield due to pearl millet+phillipesara was significantly lower compared to remaining intercrops 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 fodder intercropping systems, significantly higher digestible dry matter yield was obtained following sweet sorghum+cowpea 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) [20].

Total mineral yield: The mineral yield was significantly higher under sweet sorghum+cowpea intercropping system over other intercropping systems except sweet sorghum+ricebean. sorghum+cowpea system increased the mineral yield by 30.16, 44.05, 39.90, 52.93 and 23.90 per cent respectively over single cut sorghum+cowpea, sweet sorghum+phillipesara, maize+ricebean, maize+phillipesara and maize+cowpea. The mineral yield was significantly lower under pearl millet+phillipesara compared to remaining intercropping systems except pearl millet+ricebean, pearl millet+cowpea and maize+phillipesara intercropping systems.

Table 1: Growth parameters of main crops as influence by intercropping systems at harvest stage

Treatments	**Plant height (cm)**		**Dry matter accumulation (g/m^2)**		**Dry matter accumulation/plant (g/plant)**		**L:S**	
	2015	2016	2015	2016	2015	2016	2015	2016
	Sorghum							
Single cut sorghum+ Cowpea	351.67	356.31	433.67	457.18	220.00	224.99	0.96	0.96
Sweet sorghum+Ricebean	357.67	362.56	445.00	471.12	226.00	237.78	0.85	0.94
Sweet sorghum+Phillipesara	346.33	350.84	406.67	429.28	214.33	223.62	0.50	0.53
Sweet sorghum+Cowpea	373.33	378.42	474.67	497.69	241.67	252.65	0.91	1.01
SEm±	4.42	4.54	5.25	2.56	4.10	2.80	0.05	0.03
CD at 5%	14.64	15.04	17.37	8.47	13.57	9.27	0.17	0.09
	Pearl Millet							
Pearl millet+ Ricebean	302.00	306.06	326.67	352.14	86.00	104.36	0.30	0.33
Pearl millet+ Phillipesara	279.00	282.63	295.00	312.50	75.33	95.67	0.27	0.30
Pearl millet+Cowpea	316.67	321.02	352.67	372.98	90.00	108.08	0.36	0.37
SEm±	5.97	6.26	3.45	2.51	2.42	0.95	0.01	0.02
CD at 5%	24.05	25.21	13.89	10.13	9.77	3.84	0.04	NS
	Maize							
Maize+Ricebean	328.67	333.03	421.33	453.14	224.00	230.54	0.62	0.64
Maize+Phillipesara	318.33	322.56	386.67	404.84	214.00	220.86	0.40	0.51
Maize+Cowpea	337.33	341.81	443.33	475.46	229.33	240.55	0.69	0.71
SEm±	2.26	2.31	2.63	2.06	2.12	1.74	0.04	0.04
CD at 5%	9.09	9.34	10.61	8.31	8.53	7.00	0.16	NS

Table 2: Growth parameters of intercrops as influence by intercropping systems at harvest stage

Treatments	Plant height (cm)		L:S		Branches/plant		TDA (g/m^2 row)	
	2015	2016	2015	2016	2015	2016	2015	2016
	Cowpea							
Single cut sorghum+ Cowpea	232.33	240.47	1.20	1.22	12.33	14.00	140.33	142.35
Sweet sorghum+Cowpea	239.67	253.33	1.38	1.40	22.00	22.67	146.00	148.67
Pearl millet+Cowpea	213.33	225.00	1.19	1.22	10.33	11.80	124.33	126.92
Maize +Cowpea	228.33	243.17	1.22	1.24	11.67	13.65	127.00	130.33
SEm±	3.75	2.49	0.04	0.04	1.31	1.19	4.14	4.35
CD at 5%	13.24	8.80	0.13	0.13	4.62	4.20	14.62	15.33
	Ricebean							
Sweet sorghum+Ricebean	239.33	252.33	1.37	1.40	17.67	20.64	134.00	141.67
Pearl millet+ Ricebean	218.00	226.80	1.08	1.10	10.00	12.53	118.33	120.71
Maize+Ricebean	230.00	247.67	1.23	1.25	10.67	15.68	126.00	128.19
SEm±	2.95	2.40	0.03	0.03	0.84	0.97	1.98	1.35
CD at 5%	11.89	9.68	0.11	0.12	3.38	3.92	7.98	5.45
	Phillipesara							
Sweet sorghum+Phillipesara	101.67	108.55	0.70	0.71	13.33	16.50	96.33	97.64
Pearl millet+ Phillipesara	98.00	98.53	0.54	0.55	9.67	11.00	76.00	77.65
Maize+Phillipesara	102.00	114.33	0.62	0.63	10.33	11.83	91.33	93.32
SEm±	2.75	2.88	0.04	0.04	1.04	1.02	3.58	3.66
CD at 5%	NS	10.15	NS	NS	NS	3.61	12.64	12.89

TDA: Total dry matter accumulation

Table 3: Quality (%) and Yields (q/ha) of intercropping systems (Pooled of 2 years)

Treatments	**Crude protein content**	**Digestible dry matter content**	**Mineral content**	**Green fodder yield (q/ha)**	**Dry fodder yield (q/ha)**	**Crude protein yield (q/ha)**	**Digestible dry matter yield (q/ha)**	**Total mineral yield (q/ha)**
Single cut sorghum+Cowpea	13.07	59.23	11.01	629.15	139.39	18.22	82.56	15.35
Sweet sorghum+Ricebean	10.76	57.98	11.12	632.86	162.01	17.43	93.93	18.02
Sweet sorghum+Phillipesara	10.29	55.61	9.50	592.64	132.07	13.59	73.44	12.55
Sweet sorghum+Cowpea	12.19	62.06	12.81	647.13	172.86	21.07	108.18	22.14
Pearl millet+ Ricebean	8.79	58.13	8.74	509.44	104.99	9.23	61.03	9.18
Pearl millet+ Phillipesara	8.24	57.25	8.00	467.13	87.59	7.22	50.15	7.01
Pearl millet+Cowpea	9.42	59.93	9.12	521.57	110.11	10.37	65.99	10.04
Maize+Ricebean	12.87	60.62	10.49	586.79	127.95	16.47	77.56	13.42
Maize+Phillipesara	11.29	58.76	9.25	544.39	113.21	12.78	66.52	10.47
Maize+Cowpea	13.29	62.58	11.47	615.03	147.64	19.62	91.63	16.93
SEm±	0.21	0.66	0.80	8.92	7.14	0.73	4.04	1.44
CD at 5%	0.63	1.97	2.39	26.49	21.38	2.18	12.08	4.27

Conclusion

The present study showed that association of cowpea with sweet sorghum improved the quality of fodder. Sweet sorghum+cowpea system provided higher green fodder, dry fodder, crude protein, digestible dry matter and total mineral yield under *Tarai* agro climatic situation of Uttarakhand.

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