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IMPROVING FODDER QUALITY THROUGH INCLUSION OF LEGUME IN DIFFERENT GRASS BASED INTERCROPPING SYSTEMS

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SUMMARY

A field experiment entitled "Improving fodder quality through inclusion of legume in different grass based intercropping systems" was conducted at Research Farm, Department of Agronomy, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh during 2018-19 to 2019-20, both consecutive year with eight grass based cropping systems. The recommended dose of fertilizer 150 kg N, 80 kg P_2O_5 and 40 kg K_2O/ha was applied through urea, single super phosphate and muriate of potash. Among the different grass based cropping systems pearlmillet napier hybrid sole crop was exhibit significantly higher dry fodder yield (39.63 and 40.75 t/ha) over the guinea grass (GG) sole cropping (22.92 and 23.42 t/ha) during both the year respectively. Highest crude protein yield was in pearlmillet napier hybrid sole cropping (4.93 and 5.08 t/ha) significantly superior to the guinea grass sole cropping (2.27 and 2.32 t/ha) during both the year respectively. Maximum crude yield (12.05 and 12.41 t/ha) were under pearlmillet napier hybrid sole cropping and significantly superior over GG in paired rows + *Sesbania grandiflora* (5.79 and 6.00 t/ha) during both the year respectively.

Key words : Crude protein, crude fibre, dry fodder yield and grass based cropping system

India with only 2.29 % of land area of the world, is maintaining nearly 17.4 % of world human population and 10.7 % of livestock (more than 510 million heads) creating a huge pressure on land, water and other resources. The major feed resources for livestock in our country are grasses, community grazing on common lands and harvested fields, crop residues and agricultural by-products, cultivated fodder, edible weeds, tree leaves from cultivated and uncultivated lands and agro-industrial by-products. Crop residues include fine straws, coarse straws, leguminous straws, sugarcane tops *etc*. are the single largest bulk feed material available easily to the farmers for feeding ruminants. Feed cost accounts for about 70-75 per cent of the total cost of livestock production, particularly in milch animals. So to increase the margin of profit from livestock/dairy farming, proper feeding strategies need to be followed with proper inclusion of green and nutritious fodder. Livestock sector plays a significant economic role in developing countries and is essential for the food security of their population. The productivity of farm animals in India is generally low, mainly due to poor quality and inadequacy of available feeds (Sonawane *et al.* 2019 and Kumhar *et al.*, 2020). The forage resources in India are mainly derived from crop residues, cultivated forages and grazing from pastures and grasslands. Chronic shortage of feeds and forages together with poor nutritive value of available feeds has lowered the productive capacity and fertility of Indian live-stock. One of the main impediments in the way of improvement of livestock production is quantitative and qualitative insufficiency of fodder. Cereal fodder and crop residues are major sources of forage but the nutritive value of these forage is not adequate for getting high milk production (Pathan *et al.* 2012). Availability of quality feed and forages has been considered as the major bottleneck in harnessing the potential of the livestock sector in India. Cultivated fodder is limited to less than 4.5 per cent of the total cropped area. At present, country faces a net deficit of 63 per cent green fodder, 24 per cent dry crop residues and 64% feeds. Projections show a further increase in demand by 2025 due to changing feeding and more dietary reliance on livestock and its products (Kumar *et al.*, 2012.). Normally, perennial grasses are planted in wider rows and a considerable portion of the incident solar radiation remains un-intercepted due to poor canopy development because of its slow growth during the winter season. Slow crop growth during the winter months provide ample opportunity to the growth of weeds. Maintenance of adequate crop cover turns the competition in favour of crop. Intercropping itself has been found helpful in limiting weed population by way of cutting light to them. So inclusion of legume forage may be introduced between the rows of perennial grass. Intercropping of legumes with perennial grasses has been found to give yield advantage owing to efficient utilization of growth resources and maintenance of soil health (Mishra, 2014). The shortage of dry fodder, green fodder and concentrate are 64.21, 63.50 and 46.75 % as against the requirement of 609, 1097 and 139 million tonnes for current livestock population (2012) respectively in India. While, in Madhya Pradesh similar pattern has been observed in dry fodder, green fodder and concentrate *i.e.* 35.04, 40.71 and 40.21 % as against the requirement of 37.41, 19.65 and 9.7 million tonnes for current livestock population Indian Fodder Scenario: Redefining State Wise Status (2019). Therefore, it is very essential to increase the production and availability of fodder. This will help in increasing the productivity and profitability of live stocks. This can be achieved by utilizing the existing cropping system to augment fodder production. Many short duration crops can be grown in various existing systems in *kharif, rabi, zaid* and as catch crop. Suitable fodder crops and varieties can be identified for utilizing the residual moisture of rice fallows. Inter-cropping of fodder crops with regular grain crop like maize sorghum bajra will go a long way in bridging green fodder deficit. Considering the huge gap between the demand and supply of green nutritious fodder and quality dry matter along with the static or decreasing land availability, it is essential to bridge this gap through intensifying forage production per unit area per unit time, which can be achieved through improved high yielding crops and better management practices. Uniform supply of green fodder throughout the year is necessary to increase the productivity of livestock. To meet the shortfall in quantity and quality of forage required for the vast livestock population in the state, it is necessary to evolve agro-techniques by which the animal feed units could be increased along with supply of quality fodder for balanced nutrition. Only way to meet the fodder needs is to look for increased productivity per unit land area and also through integration of fodder crops in the cropping system.

MATERIALS AND METHODS

A field experiment entitled "Improving fodder quality through inclusion of legume in different grass based intercropping systems" was conducted at Research Farm, Department of Agronomy, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh during 2018-19 to 2019-20 both consecutive year with eight grass based cropping systems *i.e.* pearlmillet napier (PN) hybrid sole crop (T_1), guinea grass sole crop (T_2), PN hybrid in paired rows + ricebean (k*harif*) - egyption clover (*rabi*) (T_3), PN hybrid in paired rows + *Desmanthus* (T_4), PN hybrid in paired rows + *Sesbania grandiflora* (T_5), guinea grass in paired rows + ricebean (*kharif*) - egyption clover (*rabi*) (T_6), guinea grass in paired rows + *Desmanthus* (T_7) and guinea grass in paired rows + *Sesbania grandiflora* (T_8) under three replication in randomized block design in *Vertisol*. The recommended dose of fertilizer 150 kg N, 80 kg P_2O_5 and 40 kg K_2O/ha was applied through urea, single super phosphate and muriate of potash (Table 1). Nitrogen in the form of urea was applied as split dose after each cut whereas, phosphorus and potash were applied as basal in the form of single super phosphate and muriate of potash. Total six cuts were taken, at different time interval. All the observations were recorded and common package of practices was as recommended by Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh.

Crop establishment and management

Both guinea grass and pearl millet napier hybrid was planted through rooted slips at a spacing of 50 cm × 50 cm on June 01, 2016. Inter row space was utilized for the planting of the Hedge lucern, *Sesbania* and Ricebean in rainy season (July–September) and Egyption clover in winter season (November–March), respectively. Two rows of hedge lucern, *Sesbania* and ricebean at 30 cm spacing were sown between rows of guinea grass and pearlmillet hybrid napier in the month of July every year. Rainy season (July–October) crops were grown while in winter (November–March) season the crops were irrigated as per need. Guinea grass and pearlmillet hybrid napier were harvested 6 times (normally 95–96 days interval in winter season and 42–62 days interval in other season) in a year using serrated sickle up to 5.00 cm above ground surface. Guinea grass and PN hybrid remained dormant during winter season (November–March). The space between rows of

TABLE 1
Physico-chemical properties of the experimental field at initial of the experiment

S. No.	Particulars	Value
A. Mechanical composition		
1.	Sand (%)	37.3
2.	Silt (%)	21.1
3.	Clay (%)	41.6
4.	Bulk Density (mg/m^3)	1.38
B. Chemical composition		
5.	Organic carbon (g/kg)	6.5
6.	Available nitrogen (kg/ha)	190.0
7.	Available phosphorus (kg/ha)	19.50
8.	Available potassium (kg/ha)	275.5
9.	Soil pH (1:2.5 suspension)	7.02
10.	Electrical conductivity (dS/m^2)	0.20

guinea grass and PN hybrid were utilized by sowing of Hedge lucern, *Sesbania*, Egyption clover and Ricebean (Table 2).

Crude protein yield (t/ha)

The forage samples which were used for determination of dry matter content under each treatment, were first chaffed, grinded and later treatment wise homogenous samples were prepared. Crude protein (CP) was calculated by multiplying the N content by 6.25. Total N uptake was computed by multiplying yield with respective N concentration in different crops and was expressed in (t/ha), (Choudhary *et al*. 2018). The crude protein yield was calculated by the following formula, by method as described by Sadasivam and Manickam (1992).

$$\text{CPY (t/ha)} = \frac{\text{N content in plant (\%) x 6.25 x DMY (t/ha)}}{100}$$

CPY-Crude protein yield, DMY-Dry matter yield

Crude fibre yield (t/ha)

The crude fibre content was determined with the help of fibre plus analyzer in the laboratory of Plant Physiology Department. The crude fibre yield was calculated by the following formula.

$$\text{CFY (t/ha)} = \frac{\text{CFC (\%) in plant x DMY (t/ha)}}{100}$$

CFY-Crude fibre yield, CFC-Crude fibre content, DMY-Dry matter yield

RESULTS AND DISCUSSION

Dry fodder yield (t/ha)

Data presented in Table 3 exhibited significantly variation among the different grass based cropping systems. Pearlmillet napier hybrid sole cropping was exhibited significantly higher dry fodder yield (39.63 and 40.75 t/ha) followed by PN hybrid in paired rows + *Desmanthus* (34.82 and 35.36 t/ha) which was at par with PN hybrid in paired rows + ricebean - egyptian clover (34.49 and 35.04 t/ha) and PN hybrid in paired rows + *Sesbania grandiflora* (31.05 and 31.46 t/ha) followed by GG in paired rows + *Desmanthus* (27.99 and 28.36 t/ha) and it was at par with GG in paired rows + ricebean - egyption clover (27.87 and 28.33 t/ha) and GG in paired rows + *Sesbania grandiflora* (25.38 and 26.01 t/ha) over the guinea grass (GG) sole cropping (22.92 and 23.42 t/ha) during both the year respectively. There are evidences that intercropping of short-growing grain legumes with tall cereals give higher productivity than corresponding sole crops (Rao and Willey, 1983).

Crude protein yield (t/ha)

Crude protein yield (t/ha) was significantly

TABLE 2
Details of varieties, application of fertilisers and seed rates/slips below used under grass based cropping systems

S. No	Name of crops	Variety	Nutrient ($N : P_2O_5 : K_2O$ kg/ha)	Seed rate
1.	PN hybrid	NB 21	150:80:40	40000 root slips/ha
2.	Guinea grass	BG 2	150:80:40	40000 root slips/ha
3.	Ricebean	JRB 2	-	15 kg/ha
4.	Egyption clover	BG 5	-	08 kg/ha
5.	*Desmanthus (*Hedge lucern)	Velismasal	-	06 kg/ha
6.	*Sesbania grandiflora*	Local	-	06 kg/ ha

TABLE 3

Dry fodder yield (t ha^{-1}) as influenced by different grass based cropping system

	Cropping Systems	2018-19	2019-20	Mean
T_1	Pearlmillet Napier (PN) hybrid sole cropping	39.63	40.75	40.19
T_2	Guinea grass (GG) sole cropping	22.92	23.42	23.17
T_3	PN hybrid in paired rows + Ricebean - Egyption clover	34.49	35.04	34.77
T_4	PN hybrid in paired rows + *Desmanthus*	34.82	35.36	35.09
T_5	PN hybrid in paired rows + *Sesbania grandiflora*	31.05	31.46	31.26
T_6	GG in paired rows + Ricebean - Egyption clover	27.87	28.33	28.10
T_7	GG in paired rows + *Desmanthus*	27.99	28.36	28.18
T_8	GG in paired rows + *Sesbania grandiflora*	25.38	26.01	25.70
SEm ±		1.480	1.198	1.339
CD ($p=0.05$)		4.170	3.320	3.745

affected by various grass based cropping system during two years of investigation are given in Table 4. The crude protein yield varied due to different treatments over the years. It is clear from the data given in Table 2 that the maximum crude protein yield was in pearlmillet napier hybrid sole crop (4.93 and 5.08 t/ha) which was significantly superior as compared to the rest of treatments and it was at par with PN hybrid in paired rows + *Desmanthus* (4.75 and 4.84 t/ha) followed by PN hybrid in paired rows + Ricebean - Egyption clover (4.60 and 4.65 t/ha) followed by PN hybrid in paired rows + *Sesbania grandiflora* (4.08 and 4.11 t/ha) and GG in paired rows + *Desmanthus* (3.77 and 3.82 t/ha) which are at par with GG in paired rows + Ricebean - Egyption clover (3.76 and 3.80 t ha^{-1}) followed by GG in paired rows + *Sesbania grandiflora* (3.32 and 3.41 t/ha) over guinea grass sole cropping (2.27 and 2.32 t/ha) during both the year respectively. The significantly higher value of crude protein yield than other grass based cropping systems due to identical value of dry matter yield and crude protein content of the crops. Similar results were obtained by Radhakrishnan *et al.* (2007), Pathan *et al.* (2012), Shashikanth *et al.* (2013a, & 2013b), Jha and Tiwari (2018) and Hindoriya *et al.* (2019).

Crude fibre yield (t/ha)

Crude fibre yield (t/ha) of different grass based cropping systems was significantly influenced by various cropping system during two years of investigation (Table 4). Maximum significantly higher crude fibre yield was noted in pearlmillet napier hybrid sole cropping (12.05 and 12.41 t/ha) superior as compared to the rest of treatments. The second best cropping system was PN hybrid in paired rows + *Desmanthus* (10.43 and 10.59 t/ha), PN hybrid in paired rows + Ricebean - Egyption clover (9.35 and 9.56 t/ha), GG in paired rows + *Desmanthus* (8.38 and 8.51 t/ha) followed PN hybrid in paired rows + *Sesbania grandiflora* (7.52 and 7.68 t/ha) and GG in paired rows + Ricebean - Egyption clover (7.24 and 7.40 t/ha) which was at par with guinea grass sole cropping (6.74 and 6.93 t/ha) over GG in paired rows + *Sesbania grandiflora* (5.79 and 6.00 t/ha) during both the year respectively. The significantly lowest crude fibre yield was recorded under GG in paired rows + *Sesbania grandiflora* (5.79 and 6.00 t/ha). The maximum crude fibre yield was in pearlmillet napier hybrid sole crop significantly superior as compared to the rest of treatments. It might have been due to almost similar crude fibre and dry matter yield of these cropping system. Similar results were reported by Sonawane *et al.* (2019) and Taku *et al.* (2019). Moreover, inclusion of legumes in cereals have several benefits for intercropping systems such as production of greater yield on a given piece of land by making more efficient use of the available resources, improvement of soil fertility through the addition of nitrogen by fixation and increases soil conservation through greater ground cover than sole cropping. Intercropping of Napier grass with herbaceous perennial legume has significant advantage than growing Napier grass solely in increasing the dry matter yield harvested. (Patil *et al*., 2018). Addition of legumes in cropping systems as intercrop enhanced the quality of fodder also minimizes the use of chemical fertilizers and improves soil health. Inclusion of legumes in cropping systems also improves fertility status of soil and helps in increasing the yield of succeeding cereal crops (Balyan, 1997). Crop mixtures involving legumes and non-legumes provide a balanced diet for animals as legumes are rich in protein and non-legumes are rich in energy (Anonymous, 2013). Intercropping is the alternative method to reduce the gap between the availability and requirement of the fodder crops. It increases the fodder production per unit area per unit time. Green herbage in addition to

TABLE 4

Crude protein and crude fibre yield (t ha^{-1}) as influenced by different grass based cropping system

	Cropping Systems	Crude protein yield (t/ha)		Mean	Crude fibre yield (t/ha)		Mean
		2018-19	2019-20		2018-19	2019-20	
T_1	Pearlmillet Napier (PN) hybrid sole cropping	4.93	5.08	5.01	12.05	12.41	12.23
T_2	Guinea grass (GG) sole cropping	2.27	2.32	2.30	6.74	6.93	6.84
T_3	PN hybrid in paired rows + Ricebean - Egyption clover	4.60	4.65	4.63	9.35	9.56	9.46
T_4	PN hybrid in paired rows + *Desmanthus*	4.75	4.84	4.8	10.43	10.59	10.51
T_5	PN hybrid in paired rows + *Sesbania grandiflora*	4.08	4.11	4.10	7.52	7.68	7.60
T_6	GG in paired rows + Ricebean - Egyption clover	3.76	3.80	3.78	7.24	7.40	7.32
T_7	GG in paired rows + *Desmanthus*	3.77	3.82	3.79	8.38	8.51	8.45
T_8	GG in paired rows + *Sesbania grandiflora*	3.32	3.41	3.37	5.79	6.00	5.90
SEm ±		0.067	0.071	0.069	0.131	0.146	0.139
CD (*p=0.05*)		0.203	0.214	0.209	0.366	0.444	0.405

energy also provides vitamins, minerals with better dry matter digestibility (Surve *et al.,* 2012 and Singh *et al.* (2018). Intercropping is a possible way of increasing the productivity on small farms, as it provides security against potential losses of monoculture. Intercropping increases diversity in the cropping system and results in higher yield on a certain piece of land by making more effective usage of the existing growth resources such as light, heat and water with a combination of crops of diverse rooting ability, canopy arrangement, height and nutrient requirements based on the corresponding exploitation of growth resources by the component sole crops. (Pandey and Singh, 2018).

Correlation matrix of dry fodder yield (t/ha) with different crude protein yield and crude fibre yield under different grass based cropping systems

Table 5 described about the zero order correlation matrix of dry fodder yield (t/ha) with different crude protein yield and crude fibre yield under different grass based cropping systems on the basis of mean data over the both years (Fig. 1). The crude protein yield (r =0.946) and crude fibre yield (r =0.929) had highly significant positive association with dry fodder yield at 1 % level of significance (Fig. 2), while the crude protein yield (r =0.824) had significant positive correlations with crude fibre yield potential at 1 % level of significance (Fig. 3).

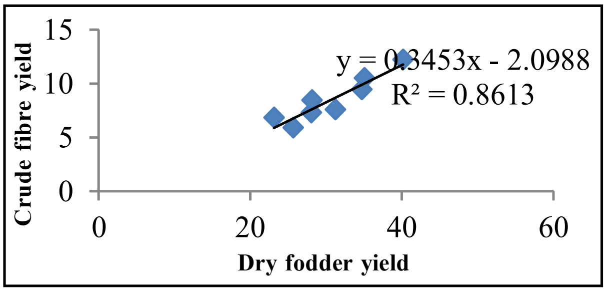

Fig. 1. Relationship between dry fodder yield and crude fibre yield.

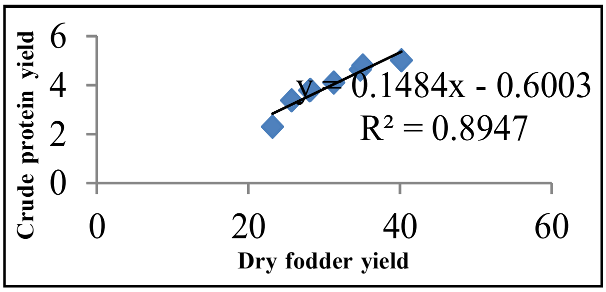

Fig. 2. Relationship between dry fodder yield and crude protein yield.

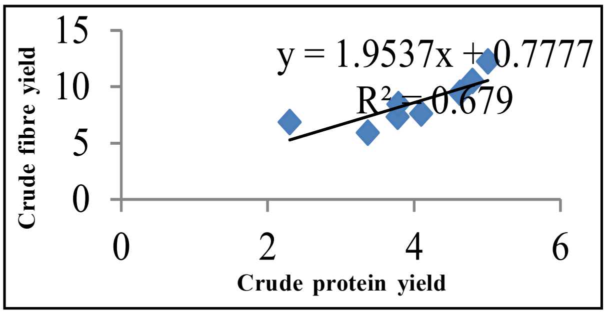

Fig. 3. Relationship between crude protein yield and crude protein yield.

CONCLUSION

Maximum crude protein content (15.60 and 15.65 %) and crude protein yield (4.93 and 5.08 t/ha) were recorded under PN hybrid in paired rows + Sesbania grandiflora. Crude fibre content (30.38 and 30.43 %) and crude fibre yield (12.05 and 12.41 t/ha)

TABLE 5
Correlation matrix of dry fodder yield (t/ha) with different crude protein yield and crude fibre yield under different grass based cropping systems

	Dry fodder yield	Crude protein yield	Crude fibre yield
Dry fodder yield	1		
Crude protein yield	0.946	1	
Crude fibre yield	0.929	0.824	1

were recorded under pearlmillet napier hybrid sole crop over GG in paired rows + Sesbania grandiflora.

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