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FULL-LENGTH RESEARCH ARTICLE

Periodic Assessment of Dry Matter Production and Nutritional Value of Millet Legumes Mix Fodder

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Abstract The intercropping of millet with legumes rich in protein was tested at 50, 60 and 70th day of sowing for the dry matter and its nutritional value. The seeds of cluster bean, cowpea and sesbania were inter-seeded on the same day in millet. The preliminary analysis for forage quality of mixture indicated that the practice of intercropping appeared to be more successful for achieving the required nutritional value. Apparently, the successive delay in harvesting produced more dry matter and organic matter yield with the completion of biologic cycle of both the component crops. The significant loss of feeding value with respect to crude protein and ash of mixture was achieved with delayed harvesting. However, its negative impact was much low in millet–cluster bean and millet–cowpea mixture which sustained their protein contents over the sampling period. It is, therefore, suggested that mix cultivation of millet–legume, preferably sesbania, should be popularized among the dairy farmers for getting palatable and proteinaceous fodder.

Keywords Fodder · Dry matter · Feeding value · Millet · Legumes

Introduction

The livestock and crop mixed agriculture farming is commonly practiced by farmers, where livestock consume crops to fulfill their energy and nutritional requirements. The cereal crops are important forage source [10]. Due to low protein contents in cereal dry matter, the animals which rely on cereals for feeding requirement on long-term basis, develop protein deficiency and thus require a variety of protein rich supplements. In Pakistan, the principal and cheapest source of animal feed is green forage, but its production and nutritional value is not satisfactory. There are several evidences in literature that had depicted considerable improvement in animal performance by ensuring the forages supply rich in protein and energy [1, 4]. The protein rich supplements could be used as an additional source [9], but their high cost is a major concern in profitable livestock industry.

The millets are promising fodder in arid areas due to their drought tolerance capacity. Though their dry matter represents a small proportion of protein, the protein value can be boosted on sustainable basis through agronomic and crop improvement approaches. Although, dry matter production of legume is poor but it is superior for forage quality [19]. The mixing of legumes in cereals may improve the protein proportion through their significant biomass contribution. The legumes being rich in protein, their inclusion in cereal stand is applicable option to compensate the protein deficiency [12] and hence, this strategy is helpful to reduce the livestock feed expenditure. The presence of legumes in cereals stand during joint growth period facilitates the cereals growth through improved nitrogen supply [22] and

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thus, increases nutritional value [3, 15]. This strategy is widely practiced over tropics, sub humid and rain-fed areas of the globe [2, 8, 13, 14].

The crops growth is series of events and transition within growth stages is accompanied by changes in physiologic and morphological traits to reach its destiny which has direct or indirect influence over forage nutritional value [16, 24]. For the grains, crop is mostly allowed to attain maturity, but for forage early harvesting of crop at vegetative growth is practiced. Certain quality constituents are built up and others are dropped with the advancement of growth. The present investigation was aimed to recognize the optimum harvesting time and legume association effect on forage production and quality of millet.

Materials and Methods

The present investigation was carried out at the Agronomic Research Area, University of Agriculture, Faisalabad (31°40″ N, 73°11″ E) during kharif season on 26th July 2010. The seed bed was prepared with normal soil preparation tools and millet seeds were sown with hand drill method in 70 cm spaced rows. The soil was irrigated before sowing and its preparation started on 8th day of irrigation. The seeds of legumes were sown at recommended seeding density on the same day by replacing the single rows of millet at 30 cm away using a seed rate of 5 kg ha^{-1}. Thus, each experimental plot was equally covered by millet and legumes. The performance of millet for forage yield and quality was evaluated with legumes (cluster bean, cowpea, and sesbania) and harvesting variables (H1 = 50, H2 = 60 and H3 = 70 DAS) in randomized complete block design (factorial arrangement). The experiment was replicated thrice measuring a net plot size of 3.60 × 6 m. Thus, individual plot has 6 rows, each of legumes and millet. The crop was supplied with NP fertilizer at 60 kg ha^{-1} each in the form of urea and single superphosphate, respectively at sowing. Both the fertilizers were incorporated in soil during seed bed preparation. The experimental plots were flood irrigated to keep the soil moisture to optimum level. The emerging weeds were removed manually at 15th day of sowing (DAS). The plant agronomic traits, dry matter yield and its composition were measured separately at each harvest. The average plant height and stem diameter were recorded from ten randomly selected plants. The plant height was taken from tape measured method from ground surface to the highest leaf tip and stem diameter was measured at bottom, middle and top of the plants. The area of one meter square was harvested at prescribed schedule to have dry matter yield of millet and legumes. The dry matter yield was derived from the proportion of dry matter in fresh plants. A part of sample was preserved in grind form in polythene bags for its chemical composition. The proximate analysis of forage sample was carried for crude protein and ash [6], and crude fiber [25]. The organic matter was determined by subtracting the ash contents from dry matter. The collected data were statistically analyzed by using Fisher's analysis of variance technique and the significance of mean values was evaluated by least significance test (LSD) at 5 % probability level [23].

Results and Discussion

Dry Matter Yield of Millet and Legumes Mixture

The dry matter yield and its related agronomic traits increased by extending the harvesting and thus minimum and maximum values for these attributes were recorded at 50th and 70th days of sowing, respectively. This happens because plots harvested at the end got more time for utilization of growth factors and it gave higher values over earlier harvesting. It can be concluded from these results that the growth continued up to 70 days after sowing, and the maturation was not till completed. Similar effect of harvesting was observed on the dry matter yield of legumes. The increase in forage yield with delayed harvesting has also been reported by other workers [5, 7, 17].

Likewise, the effect of harvesting time was also studied on the dry matter yield and agronomic traits of millet by the type of legume intercropped. Among the three legumes studied, sesbania seems to be most suitable legume for millet intercropping for maximum plant length, stem thickness, leaf area development and finally dry matter yield. It showed the additive and complementary effects of millet–sesbania intercropping due to which it produced superior figures for dry matter over rest of the treatments. The interseeding of cluster bean in millet had poor performance over the tested intercropping systems. The millet–sesbania combination out crossed the other combinations for dry matter yield at all sampling period. Therefore, forage growers strictly follow this intercropping system for ensuring better yield irrespective of time of harvesting. The interface of legumes for dry matter yield improvement of millet is not much important at earlier harvesting and became prominent at final harvesting for the reason of time period of joint growth. The sesbania intercropping and late harvesting of millet resulted in maximum dry matter yield through supportive yield parameters. The dry matter from millet–cluster bean was not statistically different from millet–cowpea at 50th days of growth but the differences were more prominent at 60th day. The improved yield may be explained in term of efficient resource utilization like light, moisture, nutrients and soil nitrogen enrichment through nitrogen fixation. The erect and fast growth of sesbania received sufficient light with millet and both the components almost equally contributed to be

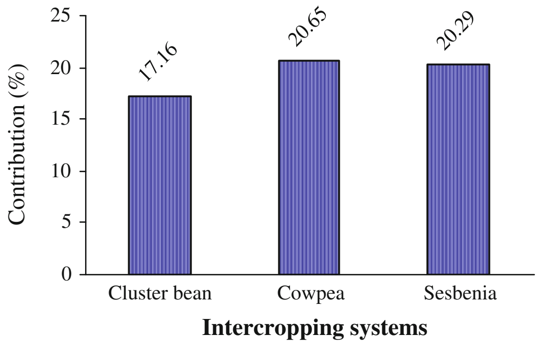

Fig. 1 Percent contribution of legumes to total dry matter yield

superior over other plots. The tall canopy of millet which shaded the underlying cowpea during their overlapping growth period resulted in yield reduction of mix forage. The behavior of legume crops did not change and hence the legume proved superior throughout the sampling period. The significant differences reported [20, 21] in dry matter yield from sorghum-legume intercropping, confirm our findings. In dry matter yield, the share of cluster bean was the lowest (17.16 %) whereas cowpea and sesbania constituted 20.65 and 20.29 %, respectively, in mixed millet–legume cropping (Fig. 1).

Forage Quality of Millet–Legumes Mixture

The forage feeding value declined with the subsequent delay in harvesting, mainly from protein and organic matter reduction and crude fiber deposition. Both the millet and legume partners undergo nutritional value loss through an increment in cell wall contents associated with further developmental stage, particularly from leaf loss. The fiber deposition in stems proceeds with advancement of growth with the objective to support flowering head. Toward maturity, the stem elongation is accomplished with stiffness and therefore, contribution of stem for crude fiber is higher at later stages. The forage samples taken at younger growth were leafy and thus proved superior over later stages. By regulating the time of interseeding to synchronize the onset of legumes flowering to best harvesting time may be helpful for further improvement of fodder quality of mixed millet–legume crop [18] Table 1, 2.

The legumes intercropping produce a range of quality fodder mainly from enhanced protein in the total dry matter. The millet–sesbania mixture was significantly higher for crude protein and ash over the other combinations. At the same time, its dry matter is also rich in crude fiber, mainly attributed to its woody growth habit where it has to support a larger stem. At the same time, it had produced the lowest organic matter value over rest of the treatments. The organic matter contents in the dry mass were reduced up to second sampling after which it became

Table 1 Agronomic traits and dry matter yield of millet at various harvesting schedule and legumes intercropping (5 % probability level)

Treatments	Plant height (cm)			Mean LSD = 1.6695	Stem diameter (cm)			Mean LSD = 0.0141
	H1	H2	H3		H1	H2	H3	
Pearl millet + cluster bean	155.83 G	172.20 F	192.50 DE	173.51 C	0.59 H	0.68 G	0.79 E	0.68 C
	LSD = 2.8916				LSD = 0.0244			
Pearl millet + cowpea	169.93 F	190.43 E	209.13 C	189.83 B	0.72 F	0.86 D	0.99 B	0.85 B
Pearl millet + sesbania	194.00 D	212.30 B	232.80 A	213.03 A	0.85 D	0.94 C	1.19 A	0.99 A
Mean LSD = 1.6695	173.25 C	191.64 B	211.47 A		0.72 C	0.83 B	0.99 A	
					LSD = 0.0141			
	Leaf area per plant (cm^2)				Dry matter yield ($t\ ha^{-1}$)			
Pearl millet + Cluster bean	122.21 I	150.74 G	201.41D	158.12 C	9.55 H	15.31 F	25.97 C	16.94 C
				LSD = 2.1594	LSD = 0.7155			LSD = 0.4131
Pearl millet + cowpea	140.53 H	193.54 E	226.59 B	186.90 B	9.91 H	18.77 E	29.87 B	19.51 B
Pearl millet + sesbania	161.14 F	214.16 C	241.53 A	205.61 A	12.34 G	23.62 D	35.07 A	23.67 A
	LSD = 3.7403				LSD = 0.7155			
Mean	141.29 C	186.14 B	223.17 A		10.59 C	19.23 B	30.30 A	
LSD = 2.1594					LSD = 0.4131			

LSD Least significant difference, *H1* 50 days after sowing, *H2* 60 days after sowing, *H3* 70 days after sowing

Table 2 Dry matter yield of legumes (t ha^{-1}) and their mixture with millet (5 % probability level)

Treatments	Dry matter yield of legumes (t ha^{-1})			Mean LSD = 0.3174	Dry matter yield of mixture (t ha^{-1})			Mean LSD = 0.5118
	H1	H2	H3		H1	H2	H3	
Pearl millet + cluster bean	2.29 F	3.71 E	4.55 CD	3.51 C	11.84 H	19.02 E	30.52 C	20.46 C
	LSD = .5497							
Pearl millet + cowpea	4.08 DE	5.08 C	6.12 B	5.08 B	13.99 G	23.85 D	35.99 B	24.60 B
Pearl millet + sesbania	4.63 C	5.78 B	7.79 A	6.06 A	16.70 F	30.10 C	42.84 A	29.87 A
					LSD = 0.8865			
Mean	3.66 C	4.85 B	6.15 A		14.17 C	24.32 B	36.44 A	
LSD = 0.3174					LSD = 0.5118			

LSD Least significant difference, *H1* 50 days after sowing, *H2* 60 days after sowing, *H3* 70 days after sowing

Table 3 Proximate analysis of dry matter of legumes and millet mixture (5 % probability level)

Treatments	Crude protein contents (%)			Mean LSD = 0.2712
	H1	H2	H3	
Pearl millet + cluster bean	6.20 FG	6.05 FG	5.84 G	6.03 C
	LSD = 0.4696			
Pearl millet + cowpea	7.14 CD	6.83 DE	6.49 EF	6.81 B
Pearl millet + sesbania	9.06 A	8.07 B	7.33 C	8.14 A
Mean LSD = 0.2712	7.46 A	6.98 B	6.55 C	
	Ash contents (%)			Mean LSD = 0.5496
Pearl millet + cluster bean	7.18 CD	6.56 DE	6.09 E	6.61 C
	LSD = 0.9520			
Pearl millet + cowpea	8.76 B	7.67 C	7.56 C	8.00 B
Pearl millet + sesbania	9.78 A	8.79 B	8.07 BC	8.88 A
Means LSD = 0.5496	8.57 A	7.68 B	7.24 B	
	Crude fiber (%)			Mean LSD = 0.5207
Pearl millet + cluster bean	34.29 G	35.54 EF	36.27 DE	35.36 C
	LSD = 0.9018			
Pearl millet + cowpea	35.26 F	36.54 D	37.67 C	36.49 B
Pearl millet + sesbania	36.65 D	38.66 B	40.70 A	38.66 A
Mean LSD = 0.5207	35.40 C	36.91 B	38.21 A	
	Organic matter (%)			Mean LSD = 0.5496
Pearl millet + cluster bean	92.88 BC	93.44 AB	93.91 A	93.39 A
	LSD = 0.9520			
Pearl millet + cowpea	91.24 D	92.33 C	92.44 C	92.00 B
Pearl millet + sesbania	90.22 E	91.21 D	91.93 CD	91.12 C
Mean LSD = 0.5496	91.43 B	92.33 A	92.76 A	

LSD Least significant difference, *H1* 50 days after sowing, *H2* 60 days after sowing, *H3* 70 days after sowing

stable. The nutritional quality of forage from millet–legume mixtures deteriorated at subsequent delay in harvesting time. However, the intensity and severity of deterioration was based on the type of legume intercropped. The protein contents in dry matter from millet–sesbania were significantly reduced at every delay in harvesting, whereas mixture from cluster bean and cowpea sustained their protein value over the harvesting period (Table 3). The variation in forage quality deterioration of the mixed fodder at successive delay would make an important implication. If the grower is intended to harvest the crop at full maturity, then millet–cowpea and millet–cluster bean should be preferred. The combination will reduce the risk of forage quality loss associated with delayed harvesting. The mixture from legumes and millet would provide inexpensive protein and energy source, and thus animals consuming mix forage would have better performance. The superior nutritional profile of legumes over cereals suggested that animal would get more forage at similar maturity stage. The positive correlation of forage quality to leaf area suggested that the crop should be harvested before the commencement of significant leaf loss. Significant forage improvement was reported when maize was grown in association with legumes [11].

Conclusions

The yield and quality of mix forage were based on time of harvesting and legume used for intercropping. Simultaneously planted sesbania in millet stand and early harvesting ensure the maximum feeding value especially from higher ash and crude protein followed by millet–cowpea mixture. Thus, it provides inexpensive home grown quality protein source for animals. However, the earlier harvesting reduced the dry matter and organic matter yield but it is up to the grower whether to choose quality or quantity or a compromise between two.

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