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RESEARCH ARTICLE

Forage Yield and Quality Response of Pearl Millet Sown Alone and in Mixtures with Legumes to Different Levels of NPK

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ABSTRACT
The two years' field experiments were conducted to compare the forage production potential of millet-legume mixtures under different fertilizer applications. The treatments included were four NPK levels i.e. 00-00-00, 60-60-00, 60-60-30, 90-90-45 Kg ha^{-1} and four legume mixtures, millet alone, millet + clusterbean, millet + cowpea and millet + mungbean. The treatments were arranged according Randomized Complete Block Design with factorial arrangement and replicated three times. Results revealed that maximum forage yield, total dry matter yield and forage quality values were obtained with 90-90-45 kg NPKha^{-1}. The presence of all legumes reduced the forage yield but improved the forage quality. Millet sown alone produced significantly higher forage yield than sowing of millet in mixtures with legumes and the yield was decreased in the order of millet + clusterbean, millet + cowpea and millet + mungbean. Similarly, maximum crude protein contents were recorded from millet + clusterbean. The interactive effect was significant both the years only for fresh and dry matter yield and crude protein. The legumes intercropping improved the forage quality even without fertilizer. Therefore, it was concluded that millet should be fertilized with 90-90-45 kg NPK ha^{-1} and millet + clusterbean should be combined to harvest better forage yield with improved quality.

INTRODUCTION

Livestock is an important subsector of agriculture in Pakistan which contributes approximately 58.33% of value addition in agriculture and nearly 11.39% in Gross Domestic Product (GOP, 2018). The demand for livestock products in developing countries like Pakistan is continuously increasing due to increasing population trend. It is source of employment for about 1.3 billion people across the world and 600 million poor farmers rely on livestock in developing countries (Thornton et al., 2006). Green forages are an important and the cheapest sources of the animal nutrition and improved forage quality help out to reduce the complete reliance on synthetic animal feeds (Ayub et al., 2012; Ijaz et al., 2016). Millet (*Pennisetum americanum* L.) is a tall, warm season and an annual grass belongs to family Poaceae. It locally known as Bajra is a very important dual-purpose summer crop grown for both fodder and grain. It can grow up to height of 6 to 10 feet as conditions of high temperatures and favorable moisture prevails. Forage yield and quality of cereal forages can be improved by growing them in mixtures with other crops capable of increasing the protein contents. Blending of cereals and legumes seed together is an easy approach to achieve better forage quality. Legumes contain more protein contents than cereals as well as they fix N, so by growing cereal forages with legumes, both quality and yield can be ensured. Mixed cropping or intercropping of forage cereals improves the nutritive value of fodder and mixed cropping especially with legumes can improve both the forage quality and yield (Ahmad et al., 2007; Akhtar et al., 2013).

For the success of an intercropping system, selection of suitable companion crop is very important. Cow pea performs well when grown in mixture with maize, sorghum and millet (Cook et al., 2005). Mungbean is another important legume crop that can be sown alone or intercropped with other crops such as sugar cane, maize, sorghum fodder grasses or tress. Cluster bean is highly appreciated in mixed stands with millet because of its industrial importance and fodder quality (Yadav and Yadav, 2000). Intercropping of guar in millet proved more compatible as witnessed by its more millet equivalent yield and benefit: cost ratio (Kumar et al., 2005). Sole mungbean and pigeon pea or pigeon pea and mungbean intercropping had higher CGR, LDW, SDW, S/H/PDW than millet and sorghum intercropping (Khalid et al., 2021)

Mostly soils in Pakistan are deficient in nitrogen, available phosphorus and potassium. The deficiency these major nutrients remained a major limiting factor for forage production. Inappropriate use of fertilizers is one of the reasons for low production in forage crops, therefore the proper use of fertilizer sources is required to boost crop production and improved soil fertility (Shehzad et al., 2020). Soil applied fertilizers i.e. nitrogen, phosphorus and potassium increased yield and quality of forage crops (Iqbal et al., 2006; Tariq et al., 2011). Fertilizer application may alleviate weather related issues and correct nutrient deficiencies. Therefore, fodder yield and quality can be improved by balanced use of fertilizers. Fertilizers not only increased the fodder yield but also improve the nutritive value of fodder by increasing the crude protein content (Ahmad, 1999; Iqbal et al., 2006).

The potash application must not be skipped from the fertilization programme as phosphorus alone is not sufficient to improve the dry matter production and forage quality (Ayub et al., 2012). Iqbal et al. (2006) reported that application of NPK fertilizer to maize intercropped with cowpea increased mixed forage yield. Abusuwar and Alsolimani (2013) found that NPK fertilizer had significantly improved the quality of sorghum and lablab forage by improving crude protein and leaf nutrients. To meet future demands for meat and milk, livestock producers require continuous supply of fodder, having good qualities to feed their animals. The present study was designed to determine the effect of various levels of NPK on millet sown alone and in combination with summer legumes.

MATERIALS AND METHODS

The two years (2008 and 2009) field trials were conducted at Agronomic Research Area of University of Agriculture Faisalabad, Pakistan. The experimental site was located at an altitude of 184 m with 30.35-31.47º N latitude and 72.08-73.40ºE longitude. The soil samples were collected from the experimental field up to a depth of 30 cm prior to sowing and were analyzed for physico-chemical properties to assess fertility status of the soil (Table 1). The data on weekly average maximum and minimum temperatures during the growing season was obtained from nearest meteorological observatory which is presented in table 2. Relative humidity ranged between 44-55% in both the year. The total rainfall received was lower in 2009 than 2008 during the growth span of the crops. The seasonal mean maximum & minimum temperature and relative humidity was higher for the year 2008 than 2009. The treatments included four fertilizers levels i.e. 00-00-00 NPK (F_1), 90-90-45 NPK (F_2), 90-90-45 NPK (F_3) and 90-90-45 NPK (F_4) and four intercropping systems including millet alone (I_1), millet and clusterbean (I_2), millet and cowpea (I_3) and millet and mungbean (I_4). The experiments were laid out according to randomized complete block design (RCBD) with factorial arrangement and treatments were replicated thrice. The net plot size measured an area of 2.4 m x 6.0 m. The sole millet, sole legumes and the blended seed mixtures of millet and legumes were sown in 30 cm apart rows with the help of a single row hand drill. The crop was sown on 19th July and 21st July during first and second year, respectively. The millet, clusterbean, cowpea and mungbean were seeded at the rate of 20, 50, 30 and 50 kg ha^{-1}, respectively. Three irrigations each of 7.5 cm were given to the plots during the entire growth period in both years. The NPK fertilizers were applied in the form of Urea, DAP and SOP. The whole of phosphorus, potassium and half of the nitrogen were applied at the time of sowing whereas the remaining half of nitrogen was applied with 1st irrigation. Both the millet and associated legumes were harvested manually at ground level with a sickle on 21th September and 23th September, in 2008 and 2009, respectively. An area of 1m-2 was harvested at the maturity and weighted to determine fresh forage yield. The sub-sample was oven dried to work out the dry matter yield through dry matter %age. The fresh mass was chopped, dried and grinded for quality profile testing. The data on crude protein, crude fiber and total ash was determined using procedure set by AOAC (1984). The collected data were statistically analyzed by using Analysis of Variance technique to differentiate the effects of treatments and their interactions using MSTAT-C statistical computer package. Treatment's

Table 1: Soil analysis prior to sowing during both the years of experimentation

Characteristics	Unit	Value 2008	Value 2009
A. Particle size distribution			
Sand	%	60	62
Silt	%	19.2	17
Clay	%	22.8	23
Textural Class	-	Sand clay loam	Sand clay loam
Saturation	%	33	32
B. Chemical analysis			
Electrical conductivity	dS/m	1.42	1.54
pH	-	7.9	8.0
Organic matter	%	0.79	0.69
Organic Carbon	%	0.42	0.40
Total N	%	0.04	0.03
Available P	ppm	6.1	6.8
Available K	ppm	120	115

Table 2: Climatic conditions during the growing season in 2008 and 2009

Dates	Max. Temp.		Min. Temp.		Relative Humidity (%)		Rainfall (mm)	
	2008	2009	2008	2009	2008	2009	2008	2009
19th July-2nd Aug	41.10	39.30	30.77	30.23	55.53	47.00	14.40	04.00
3rd Aug-17th Aug	39.87	39.03	28.93	27.83	54.20	51.13	15.20	63.20
18th Aug- 1st Sep	40.31	38.40	28.90	28.63	51.80	45.40	26.40	65.40
2nd Sep- 16 Sep	39.25	37.57	28.29	27.76	51.72	44.59	73.00	71.80
17th Sep-23 Sep	39.60	38.40	28.70	27.90	50.70	49.40	0	07.00
Seasonal Mean	40.02	38.54	29.11	28.47	52.79	47.50	129	211.4

Table 3: Effect of NPK fertilizer and legume mixture on growth and yield of pearl millet forage

Treatments	Tillers (m^{-2})		Plant height (cm)		Stem diameter (cm)		Fresh weight per plant (g)		Dry weight per plant (g)		Millet forage yield (t ha^{-1})		Millet dry matter yield (t ha^{-1})	
NPK Levels (kg ha^{-1})	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
00-00-00 (F_1)	40.91	39.91	126.30c	117.52	0.848 d	0.738c	95.60 c	92.79c	19.35c	18.32d	39.11d	44.87d	7.92d	7.31d
60-60-00 (F_2)	41.16	40.32	170.18b	162.10	0.876 c	0.768b	120.38	118.57b	28.8b	26.62c	49.55c	45.86c	11.5c	10.73c
60-60-30 (F_3)	41.25	40.66	174.17b	165.31	0.890 b	0.770b	121.28	119.69b	28.80b	28.09b	50.55b	47.36b	12.01b	11.42b
90-90-45 (F_4)	41.66	40.25	198.69a	189.00	0.901 a	0.791a	137.61	135.01a	33.89a	34.90a	56.75a	49.75a	13.90a	14.04a
LSD (5%)	NS	NS	8.13	8.59	0.006	0.020	2.55	2.49	0.81	0.59	0.61	0.64	0.14	0.15
Millet alone (I_1)	42.33a	41.50a	191.19a	182.29	0.895 a	0.783a	124.00	119.92a	29.32a	27.93a	52.47a	49.75a	12.24a	11.58a
Millet + clusterbean (I_2)	41.08b	40.08b	163.88b	156.90	0.878 b	0.766b	117.63	114.32b	27.49b	26.44b	48.37b	47.36b	11.22b	10.61c
Millet + cow pea (I_3)	40.83b	39.83b	158.67bc	148.28	0.872 c	0.760c	117.24	119.21a	27.15b	27.56a	47.75c	45.86c	10.97c	10.95b
Millet + mungbean (I_4)	40.75b	39.75b	155.61c	146.46	0.870 c	0.758c	115.95	112.61b	26.93b	26.01b	47.38c	44.87d	10.91c	10.36d
LSD (5%)	0.60	0.61	8.13	8.59	0.00	0.02	2.55	2.49	0.81	0.59	0.61	0.64	0.14	0.15
Interaction	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	**	**	**	**

Means not sharing same letter in column differed significantly at 5% probability level.

Table 4: Effect of NPK fertilizer and legume mixture on forage quality of pearl millet

Treatments	Crude protein %		Crude fibre %		Total Ash%	
NPK Levels kg ha^{-1})	2008	2009	2008	2009	2008	2009
00-00-00 (F_1)	7.59 d	7.05 d	37.58 a	34.36 a	5.43 c	5.15 c
60-60-00 (F_2)	8.36 d	7.82 c	35.24 b	32.00 b	7.34 b	7.33 b
60-60-30 (F_3)	8.59 b	8.04 b	34.67 b	31.42 c	8.01 a `	7.62 b
90-90-45 (F_4)	8.70 a	8.16 a	30.40 c	25.73 d	8.05 a	8.08 a
LSD (5%)	0.21	0.20	1.92	0.44	0.51	0.44
Millet alone (I_1)	8.15 d	7.61 d	37.54 a	32.90 a	7.40	7.19
Millet + clusterbean (I_2)	8.44 a	7.89 a	34.01 b	30.76 b	7.22	7.02
Millet + cow pea (I_3)	8.37 b	7.83 b	33.33 b	30.09 c	7.07	7.02
Millet + mungbean (I_4)	8.27 c	7.73 c	33.00 b	29.75 c	7.14	6.95
LSD (5%)	0.21	0.20	1.92	0.44	Ns	Ns
Interaction	**	**	Ns	Ns	Ns	Ns

Means not sharing same letter in column differed significantly at 5% probability level

means were compared using least significant difference (LSD) test and differences were considered significant at 5% probability level (Steel et al., 1997).

RESULTS AND DISCUSSION

Agronomic and yield attributes

The impact of various fertilizer was significant on plant height, stem diameter, fresh and dry weight per plant, forage yield and dry matter yield (Table 3). These traits were improved by increasing fertilizers level. Therefore, the maximum values were obtained from 90-90-45 kg NPK ha^{-1} and minimum were recorded from plots sown without fertilizer application. The plant height, stem diameter, fresh weight & dry weight per plant, fresh forage yield and dry matter yield were increased from 117.52 to 198.69 cm, 0.738 to 0.901 cm, 92.79 to 137.61 g, 18.32 to 34.90 g, 39.11 to 56.75 t ha^{-1} and 7.31 to 14.04 t ha^{-1}, respectively during both the years. In 2008, the increase in plant height over control was 34.74, 37.90 and 57.31 percent for F_2, F_3, and F_4, respectively and trend was similar for second year as well. Whereas, the number of tillers were non-significantly affected by fertilizer treatments.

Table 5: Interactive effects of various treatments on millet forage yield, dry matter yield and crude protein

Treatments	Millet forage yield (t ha^{-1})		Millet dry matter yield (t ha^{-1})		Crude protein %	
	2008	2009	2008	2009	2008	2009
F_1I_1	40.40 g	38.26 h	8.24 h	7.61 j	7.46 j	6.92 i
F_1I_2	38.45 h	36.55 ij	7.80 ij	7.24 kl	7.69 h	7.15 j
F_1I_3	39.68 g	37.54 hi	7.97 hi	7.35 jk	7.66 h	7.12 j
F_1I_4	37.93 h	35.79 j	7.66 j	7.05 i	7.56 i	7.02 k
F_2I_1	53.19 c	51.65 c	12.44 d	11.67 e	8.22 g	7.68 i
F_2I_2	49.26 de	46.51 efg	11.48 f	10.46 hi	8.49 d	7.95 f
F_2I_3	47.81 f	47.56 e	11.04 g	10.61 jh	8.39 e	7.85 g
F_2I_4	47.94 f	45.57g	11.12 g	10.21 i	8.32 f	7.78 h
F_3I_1	54.95 b	51.85 c	13.13 c	12.29 d	8.42 e	7.88 g
F_3I_2	50.01 d	47.01 ef	11.90 e	11.04 f	8.75 b	8.19 c
F_3I_3	48.56 ef	49.72 d	11.46 f	11.58 e	8.64 c	8.10 d
F_3I_4	48.69 ef	46.05 fg	11.54 f	10.77 fg	8.54 d	8.00 e
F_4I_1	61.36 a	57.25 a	15.15 a	14.77 a	8.51 d	7.97 ef
F_4I_2	55.77 b	53.39 b	13.72 b	13.72 c	8.84 a	8.30 a
F_4I_3	54.98 b	54.61 b	13.41 c	14.25 b	8.79 ab	8.25 b
F_4I_4	54.88 b	52.05 c	13.33 c	13.43 c	8.66 c	8.12 d
LSD	1.22	1.28	0.28	0.30	0.42	0.40

Means not sharing same letter in column differed significantly at 5% probability level

The non-significant differences in number of tillers due to fertilizer are the confirmation of the results of Ayub et al. (2002, 2013). The significant differences in fresh forage and dry matter yield were due to significant differences in plant height and stem diameter. The improved forage yield and other agronomic traits due to fertilizers has also been witnessed from previous relevant studies (Gokmen et al. 2001; Abusuwar and Omer 2011; Hussein et al. 2011; Tariq et al., 2011; Ayub et al., 2012; Bilal et al., 2017).

As regards the millet-legume mixtures, maximum stand density was produced both the years when millet was grown alone and minimum was observed when it was grown in mixture with mungbean (Table 3). However, the millet grown with clusterbean, cow pea and mungbean did not produce significant differences for plant stand. Taller plants with thicker stems were produced during both the years when millet was grown alone. The millet sown in association with mungbean produced the shortest plants in both years. However, both the years, plant height and stem diameter for millet was statistically similar either it was grown with mungbean or cowpea (Table 3). Exactly similar trend was found during 2009 (Table 3). These results are quite in line with those of Ayub and Shoaib (2009). They reported that the sorghum produced thinner plants, when it was sown in association with cluster bean compared with sole sorghum. The effect of year on fresh weight per plant of millet was significant. The millet plants grown during 2008 were 1.87% heavier than in 2009. Probably, the millet crop produced heavier plants in 2008 due to the more favourable growth conditions than in the year 2009 (Table 3). Among millet-legume mixtures, heavier plants were produced when millet was grown alone. Therefore, the significant differences among intercropping treatments is mainly due to differences in single plant weight. Likewise, millet fresh and dry matter yield was significantly reduced by the presence of various legumes. The maximum reduction was observed for mungbean and cow pea. Whereas, millet cultivation in association with clusterbean is better option for intercropping. Variable competitive behaviour of the component crops in mixtures might have been the cause of variation in forage yield of millet. The yield reduction of main crop due to presence of other crop have been documented in literature (Ahmad et al., 2007; Sultana et al., 2013).

The interaction between NPK levels and millet-legume mixtures were not significant both the years for observed traits except fresh and dry matter yield and crude protein (Table 3 and 5). The millet sown alone produced the maximum fresh and dry matter yield when grown with fertilizers application at the rate of 90-90-45 NPK kg ha^{-1}. It was followed by F_4I_2 during first year and F_4I_3 during second year (Table 5). The minimum fresh and dry matter yield was obtained with treatment (F_1I_4) when no fertilizer was applied to millet + mungbean mixture.

Quality attributes

The forage quality was evaluated with respect to crude protein, crude fiber and ash contents. These parameters were significantly affected by fertilizer treatments (Table 4). The result revealed that increasing fertilizer application significantly improved the crude protein and ash contents. The maximum values for crude protein and fibre were achieved with 90-90-45 followed by 60-60-30 kg NPK ha^{-1}. However, the crude fibre contents were negatively affected by fertilizer application rate which decreased by decreased up to 2.34, 2.91, and 7.18 percent for 60-

60-00, 60-60-30 and 90-90-45 kg NPK ha^{-1}. The declining crude fibre contents is desireable because of its negative role in forage quality. The quality improvement due to fertilizer treatments have already been described in literature (Ayub et al., 2002; Iqbal et al., 2006).

The intercropping system significantly affected the forage quality except ash contents. The maximum crude protein was recorded from millet + clusterbean followed by millet + cow pea and millet + mungbean. The crude fibre contents were significantly low in millet and legume mixture in comparison with millet grown alone. No significant differences existed in crude fibre of various legumes during first year. However, during second year, the millet + cow pea and millet + mungbean produced significantly low fibre contents than millet + clusterbean. Probably the improvements of forage quality particularly crude protein contents was due to the transfer of nitrogen from component legumes to the companion maize The variation in forage quality due to various intercropping treatments are the confirmation of the previous studies (Mpairwe et al., 2002; Ibrahim et al., 2006; Ayub et al., 2013; Hassan et al., 2014). While, the increase in crude protein from legume intercropping is contradictory to those of Ahmad et al. (2006) which might be due to variations in soil fertility and species differences.

The maximum crude protein contents were recorded for from millet + clusterbean mixture when fertilized with 90-90-45 NPK ha^{-1}. While, the millet sown alone and without fertilizer resulted lowest crude protein contents. Growing legumes at 00-00-00, 60-60-00, 60-60-30 and 90-90-45 kg NPK ha^{-1} resulted an improvement in crude protein contents in comparison with millet sown alone.

It was concluded that increase in fertilizer significantly improved the various attributes of forage yield and quality. The application of 90-90-45 Kg NPK resulted maximum values for observed traits. Various legumes intercropping treatments although suppressed the millet forage yield but also improved the forage quality profile. Furthermore, it was also concluded that millet + clusterbean is better combination for high quality forage production than rest of legumes.

Authors' contribution

MA conceived the idea, IQ performed the experimentation, AT provided the technical input and MY helped out for manuscript write up.

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