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IMPACT OF NUTRIENT MANAGEMENT AND LEGUME ASSOCIATION ON AGRO-QUALITATIVE TRAITS OF MAIZE FORAGE

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Abstract

A two years study pertaining to different agro-qualitative parameters of forage maize grown alone and in association with legumes and different fertilization regimes viz., control (F_0), 150 kg N ha^{-1} (F_1), 150-100 kg NP ha^{-1} (F_2) and 150-100-100 kg NPK ha^{-1} (F_3) was conducted at the research area of the Department of Agronomy, University of Agriculture, Faisalabad. The results revealed that maize crop grown in association with cowpea and given fertilizer @ 150-100-100 kg NPK ha^{-1} produced significantly the highest mixed forage yield of 58.62 t ha^{-1} on the average. This treatment combination resulted in the increased leaf area index of 7.95 and 10.75 in the two consecutive years of study leading not only to enhanced crop growth rate but also mixed fodder of higher nutritive value as evidenced by its protein contents, compared to other legume intercrop combinations as well as maize alone

Introduction

Maize is a summer season dual purpose crop and is grown extensively for the production of grain and fodder for human food and animal feed, respectively. It provides heavy tonnage of fodder throughout the summer season and is commonly grown as late spring, mid-summer and late summer fodder crop in Pakistan. Its fodder is succulent, palatable and highly relished by the buffaloes and cattle. Its green fodder contains 7.2-8.5% protein, 32.52-33.49% fibre and 1.00-2.2% fat (Awan, 1999). The average fodder yield of maize in Pakistan is 20t ha^{-1}, which is very low, compared to advanced countries of the world. This is primarily due to substandard methods of cultivation, poor crop stand, malnutrition and lack of high yielding varieties.

Forage yield and its nutritive value can be improved by balanced use of fertilizers like NPK (Chela *et al.*, 1993) and intercropping with forage legumes (Chittapur *et al.*, 1994). Legume and non-legume mixed cropping not only increases the total productivity per unit area but may also improve the quality of the resulting mixed forage (Patel & Rajagopal, 2001). Ahmad *et al.*, (2001) concluded that soybean can successfully be intercropped with maize for an efficient use of land. Rashid & Himayatullah (2003) found that mungbean (*Vigna radiate* L.) or clusterbean (*Cyamopsis tetragonoloba* L.) when intercropped in between the rows of sorghum (*Sorghum bicolor* L.) reduced the plant height and LAI of sorghum compared to sorghum alone.

Rana *et al.*, (2001) intercropped various legumes viz. soybean cv. Bragg, cowpea cv. HPC-1, frenchbean var. Contender and urdbean var. A-1 with maize var L-1P at varying levels of NPK. The results revealed that intercropping systems were superior to sole crop. The maize as well as legumes yields in intercropping systems were higher where 100% of NPK dose was applied compared to 50% NPK dose. William & Cherney (2001) studied the effect of 6 nitrogen rates on dry matter yield of forage corn and reported that dry

matter had quadratic plus plateau responses to N-rates with maximum yield at N rate of 150 kg ha^{-1}.

The present study describes the impact of NPK fertilizer application and different legumes intercropping on the agro-physiological traits of forage maize.

Materials and Methods

Effect of NPK application and forage legumes intercropping on the forage yield and various agro-physiological traits of forage maize were studied at the research area of the Department of Agronomy, University of Agriculture, Faisalabad, Pakistan during 2003 and 2004. The study comprised of 4 fertilization regimes viz., control (F_0), application of 150 kg N ha^{-1} (F_1), 150-100 kg NP ha^{-1} (F_2) and 150-100-100 kg NPK ha^{-1} (F_3) as main plot treatment; whereas 4 intercropping systems viz., maize alone (I_0), maize + clusterbean (I_1), maize + ricebean (I_2) and maize + cowpea (I_3) were superimposed on each of the main plot as sub plot treatment. The experiment was quadruplicated in a split-plot design with a net plot size of 3.6m x 9 m. The component crops were sown in a fine prepared seedbed on 12th of July and harvested on 15th of September each year. The NPK were applied in the form of urea, single super phosphate and sulphate of potash, respectively. The whole of phosphorus and potash and half of nitrogen were applied at sowing while the remaining half of nitrogen was applied with the first irrigation by side placement along maize rows. A promising forage maize variety "Afgoi" was used as the base crop and was sown in 30 cm apart rows using the standard seed rate while the legume intercrops viz., clusterbean (*Cyamopsis tetragonoloba*), ricebean (*Vigna umbellate*) and cowpea (*Vigna unguiculata*) were sown in the space between rows with a single row hand drill, using their recommended seed rates. The crop was given four irrigations each of 7.5 cm in both the years. All other cultural practices were kept uniform and normal for all the plots. The crop was harvested after 8 weeks manually with a sickle. Data on LAI, forage yield, dry matter yield, crop growth rate and crude protein content were collected by using the standard procedures. The data were analyzed using Fisher's analysis of variance technique to differentiate the effects of treatment means and their interaction using MSTAT-C statistical computer package. Treatment means were compared using LSD test at P =0.05 level (Steel & Torrie, 1984).

Results and Discussion

Leaf area index (LAI) of mixed forage: The year effect of LAI of mixed forage (maize + legume) was significant which on an average was greater (7.96) during the 2nd year than the previous year (6.36). Both the interactive and main effects of fertilizer and intercropping on LAI of mixed forage were significant during each year (Table 1). During the Ist year, the maximum LAI (7.95) was recorded for maize + cowpea fertilized @ 150-100-100 kg NPK ha^{-1} (F_3I_3) which was at par with F_2I_3 and F_1I_3 showing LAI of 7.78 and 7.84, respectively and followed by maize + clusterbean (7.35) fertilized @ 150-100-100 kg NPK ha^{-1} (F_3I_1). Contrarily, the minimum LAI (4.25) was recorded for maize + ricebean with no fertilizer (F_0I_2) which was at par with F_0I_0 (4.09), preceded by F_0I_3 (5.42) and F_1I_2 (6.11). The rest of the treatment combinations, however, intermediated. By contrast, during the 2nd year, significantly the maximum LAI (10.75) was exhibited by maize + cowpea at 150-100-100 kg NPK ha^{-1} (F_3I_3) followed by F_2I_3 (10.55). However,

the minimum LAI (4.52) was recorded for maize + ricebean at zero fertilizer (F_0I_2) preceded by F_0I_0 (4.79), F_0I_1 (4.99) and F_0I_3 (5.26) while rest of the treatment combinations intermediated. Variable LAI recorded for different intercropping combinations was probably attributed to different growth habits of the component crops and responsiveness to fertilizers. These results are in confirmatory with the findings of Rana *et al*., (2001) who reported that LAI of maize was higher in maize + legume intercropping.

Table 1. Leaf area index (LAI), Total mixed forage yield and total dry matter yield of maize and maize + legumes mixed forage crops as affected by fertilizer application and maize-legumes intercropping.

Application (kg ha^{-1})	LAI of mixed forage		Total mixed forage yield (t.ha^{-1})		Total dry matter yield (t. ha^{-1})		Protein content of mixed forage	
	2003	2004	2003	2004	2003	2004	2003	2004
A. Fertilizer								
F_0= Control (Zero)	4.63 D	4.89 D	32.47 D	35.84 D	5.34 B	5.94 C	8.59 D	9.46 D
F_1= N alone (150)	6.34 C	7.67 C	42.93 C	48.93 C	7.07 A	8.03 B	11.01C	11.78 C
F_2= NP (150 + 100)	6.96 B	9.53 B	47.97 B	55.34 B	7.06 A	10.07 A	11.58B	12.55 B
F_3= NPK (150+100+100)	7.11 A	9.74 A	51.07 A	56.09 A	7.01 A	10.17 A	11.87A	13.09 A
B. Intercrops								
I_0=Control (Maize alone)	5.81 *D*	7.47 *D*	38.97 *C*	44.49 *C*	6.07 *D*	8.10 *D*	9.75*D*	10.75 *D*
I_1=Maize + Clusterbean	6.48 *B*	8.01 *B*	43.14 *B*	48.68 *B*	6.65 *B*	8.62 *B*	11.16*B*	12.29 *B*
I_2 = Maize + Ricebean	5.91 *C*	7.60 *C*	38.78 *C*	43.67 *D*	6.21 *C*	8.18 *C*	10.22*C*	10.98 *C*
I_3= Maize + Cowpea	7.25 *A*	8.76 *A*	47.02 *A*	52.58 *A*	7.56 *A*	9.30 *A*	11.92*A*	12.87 *A*
C. Fertilizer x intercrops								
F_0I_0 (Control)	4.07 j	4.79 m	29.80 m	34.84 j	4.92 g	5.88 i	7.51 L	8.12 l
F_0I_1	7.69 I	4.99 l	32.20 l	35.69 j	5.38 f	6.02 h	8.90 j	10.27 j
F_0I_2	4.25 j	4.52 n	28.03 n	30.92 k	4.97 g	5.62 j	8.19 k	8.63 k
F_0I_3	5.42 h	5.26 k	35.53 k	37.17 i	6.09 e	6.26 g	9.75 I	10.82 h
F_1I_0	6.27 fg	7.23 j	38.67 I	44.56 g	6.55 d	7.70 f	9.74 I	10.51 i
F_1I_1	6.74 d	7.51 i	42.87gh	48.16 f	7.00 c	7.81 f	11.55d	12.27 e
F_1I_2	6.11 g	7.49 i	37.90 j	43.07 h	6.49 d	7.83 f	10.29h	11.27 g
F_1I_3	7.84 a	8.47 h	45.94 e	53.28 c	8.25 a	8.79 e	12.47b	13.09 c
F_2I_0	6.46 ef	8.75 g	42.69 h	49.06 ef	6.59 d	9.26 d	10.76g	11.73 f
F_2I_1	7.06 c	8.69 d	46.91 d	55.14 b	7.05 c	10.29 b	12.02c	13.23 bc
F_2I_2	6.54de	9.14 ef	43.10 g	50.07de	6.67 d	9.68 c	11.08 f	11.84 f
F_2I_3	7.78 a	10.55b	52.80 b	59.44 a	7.94 b	11.86 a	12.47b	13.38 b
F_3I_0	6.42 ef	9.09 f	44.71 f	49.51de	6.21 e	9.55 c	11.02 f	12.61 d
F_3I_1	7.35 b	9.87 c	50.55 c	55.73 b	7.17 c	10.39 b	12.15c	13.40 b
F_3I_2	7.74 d	9.24 e	46.06 e	50.63 d	6.68 d	9.61 c	11.32e	12.19 e
F_3I_3	7.95 a	10.75a	54.80 a	60.44 a	7.96 b	11.13 a	12.98a	14.18 a
LSD	0.197	0.143	0.390	1.128	0.192	0.136	0.175	0.212
Year mean	6.364b	7.963a	41.97b	47.36a	6.62b	8.55a	10.76b	11.72a

* Any two means not sharing a letter differ significantly at $p \leq 0.05$

Total mixed green forage yield (t ha^{-1}): There was a significant year effect on total green forage yield of maize + legumes which was higher by 5.39 t ha^{-1} during the 2nd year than the previous year. It may be attributed to more conducive and favourable weather conditions for growth and development of the components crops during the 2nd year than the Ist year of experiment. Both the interactive and main effects of fertilization and intercropping on total mixed forage yield of maize + legumes ha^{-1} were significant in both years (Table 1).

Among the treatment combinations, the maize crop intercropped with cowpea and given fertilizer @ 150-100-100 kg NPK ha^{-1} (F_3I_3) produced significantly the highest mixed forage yield (56.80) t ha^{-1} followed by F_2I_3 and the crop intercropped with cowpea at @ 150-100-0 kg NPK ha^{-1} (52.80 t ha^{-1}) during the Ist year. Contrarily, the lowest mixed forage yield of 28.03 t ha^{-1} was recorded for the crop intercropped with ricebean at zero fertilizer (F_0I_2) preceded by F_0I_0 (29.80 t ha^{-1}) and F_0I_1 (32.20 t ha^{-1}). The rest of the treatment combinations, however, intermediated and produced mixed forage yield

ranging between 37.90 and 50.55 t ha^{-1} showing significant differences among themselves. During the 2nd year although the trend was the same but the crops fertilized @ 150-100-100 and @ 150-100-0 kg NPK ha^{-1} produced statistically similar forage yield of 60.44 and 59.44 t ha^{-1} followed by F_3I_1 (55.73 t ha^{-1}) which was at par with F_2I_1 (55.14 t ha^{-1}) against the lowest forage yield of 30.92t ha^{-1} for the crop intercropped with ricebean and given no fertilizer (F_0I_2). The difference between F_0I_0 and F_0I_1 was also non-significant. The rest of the treatment combinations, however, intermediated but showed significant differences among themselves. The higher mixed forage yield of maize +legumes than the monocroped maize has also been reported by Chittapur *et al*., (1994), Abdullah & Chaudhry (1996) and Tripathy *et al*., (1997).

Total dry matter yield (t ha^{-1}) of mixed forage: The year effect on total dry matter yield of maize + legumes mixed forage was significant which was higher by 1.93 t ha^{-1} during the 2nd year than the previous year. The interactive and main effects of fertilizer and intercropping on total dry matter yield of maize + legumes mixed forage were significant during each year (Table 1). During the 1st year, the crop fertilized @ 150 kg N ha^{-1} and intercropped with cowpea (F_1I_2) produced significantly the highest dry matter yield of 8.25 t ha^{-1} followed by the crop intercropped with cowpea and given fertilizer @ 150-100-0 kg NPK ha^{-1} (F_2I_3) which was at par with F_3I_3 producing dry matter yield of 7.94 and 7.96 t ha^{-1}, respectively. By contrast, the minimum dry matter yield of 4.92 t ha^{-1} was recorded for the maize crop grown alone and given no fertilizer (F_0I_0) which was at par with F_2I_2 (4.92 tha^{-1}). The differences among F_3I_1, F_2I_1 and F_1I_1were also found to be non-significant. The rest of the treatment combinations, however, intermediated. During the 2nd year, although the crop fertilized @ 150-100-0 kg NPK ha^{-1} and intercropped with cowpea produced the maximum dry matter yield (11.86 t ha^{-1}) but was at par with that intercropped with cowpea and given fertilizer @ 150-100-100 kg NPK ha^{-1} (F_3I_3) which produced dry matter yield of 11.13 t ha^{-1}.Contrarily, the minimum dry matter yield of 5.62 t ha^{-1} was recorded for the crop intercropped with ricebean with no fertilizer (F_0I_2) preceded by F_0I_0 (5.88 t ha^{-1}). The differences among F_1I_2, F_1I_1 and F_1I_0 were also non-significant producing dry matter yield of 7.83, 7.81 and 7.70 t ha^{-1}, respectively. Similarly, the variation between F_2I_1 and F_2I_1 was non-significant giving dry matter yield of 10.39 and 10.29t ha^{-1}, respectively. These results are in line with those of Rezende & Ramalho (2000) who reported promotive effect of NPK application and legume intercropping on dry matter yield of maize + legumes mixed forage.

Crude protein content of mixed forage: The year effect on crude protein content of mixed fodder was significant which was relatively higher in the 2nd year than the previous year. Both the interactive and main effects of fertilizer and intercropping on crude protein content of maize + legume mixed forage was significant in both years (Table 1). During the Ist year, the highest crude protein content (12.98%) was recorded for the crop fertilized @ 150-100-100 kg NPK ha^{-1} and intercropped with cowpea (F_3I_3) closely followed by that fertilized @ 150-100-0 kg NPK ha^{-1} and intercropped with cowpea (F_2I_3) which was at par with F_1I_3 showing crude protein content of 12.47%. By contrast, the lowest crude protein of 7.51% was recorded for the maize crop grown alone with no fertilizer (F_0I_0) while rest of the treatment combinations intermediated. Almost similar trend was exhibited during the 2nd year with the maximum at F_3I_3 (14.18%) and the minimum (8.12%) at F_0I_0. Promotive effect of high fertilization and forage legume intercropping on crude protein content of maize + legume mixed forage has also been reported by Rezende & Ramatto (2000).

Table 2. Periodic crop growth rate (g m^{-2} d^{-1}) of maize + legumes as affected by nutrient application and forage legume intercropping in 2003 and 2004

Nutrient application (kg NPK ha^{-1})	Intercropping system	Days after sowing					
		2003			2004		
		15-30	30-45	45-60	15-30	30-45	45-60
F_0 = 0-0-0	I_0 = (Maize alone)	4.7 h*	10.4 i	16.5i	5.2 k	11.4 i	21.2ij
	I_1=(Maize+clusterbean)	5.6 g	10.9 h	17.4h	6.5 i	10.1 j	21.5 i
	I_2=(Maize + Rice bean)	4.9 h	9.7 j	16.7i	5.6 j	9.2 k	20.9 j
	I_3 = (Maize + cowpea)	8.3 c	12.0 g	23.1d	8.1 g	10.3 j	21.6 i
F_1 = 15-0-0	I_0 = (Maize alone)	5.9 g	13.7 e	18.7g	7.9 h	14.0 g	27.7 h
	I_1=(Maize+clusterbean)	8.1 c	12.9 f	22.5e	9.1 e	13.0 h	27.6 h
	I_2=(Maize + Rice bean)	6.9def	12.1 g	23.6d	8.7 f	12.8 h	28.5 g
	I_3 = (Maize + cowpea)	11.9 a	15.2ab	26.0a	12.2b	14.3 g	30.0 f
F_2 = 150-100-0	I_0 = (Maize alone)	6.6 ef	14.4cd	21.4f	9.2 e	17.0cd	33.8 e
	I_1=(Maize+clusterbean)	8.2 c	14.0de	22.5e	11.4c	16.6de	36.3 c
	I_2=(Maize + Rice bean)	7.0 de	13.1 f	18.8g	10.2d	14.9 f	36.9 c
	I_3 = (Maize + cowpea)	11.3 b	14.7bc	25.6a	14.5a	18.6 b	39.2 a
F_3 = 150-100-100	I_0 = (Maize alone)	6.5 f	14.7bc	22.5e	9.3 e	18.7 b	35.2 d
	I_1=(Maize+clusterbean)	8.5 c	13.9 e	23.2c	11.6c	18.5 b	37.8 b
	I_2=(Maize + Rice bean)	7.2 d	13.7 f	22.5e	10.1d	16.3 e	36.3 c
	I_3 = (Maize + cowpea)	11.5ab	15.2 a	25.7a	14.3a	20.7 a	39.8 a
LSD		0.54	0.43	0.50	0.21	0.59	0.62

*Any two means not sharing a letter within a column differ significantly at p = 0.05

Crop growth rate (CGR) of mixed forage: It is evident from the data presented in Table 2 that effects of nutrient application and legume intercropping on CGR of the mixed forage crop were significant. The periodic CGR data collected at 15-days interval revealed a steady increase in CGR as the crop advanced from the early stages to the final crop growth stage, 45-60 DAS. Significant low CGR values were recorded in unfertilized plots (F_0) and successive increase of nutrients viz., F_1, F_2 and F_3 caused a progressive increase in CGR, irrespective of the intercropping system in a similar pattern during both the years of study. Maximum CGR of 25.7 in year 2003 and 39.8 g m^{-2} d^{-1} in the 2nd year was recorded at 45-60 DAS in maize + cowpea mixed forage crop fertilized with 150-100-100 kg NPK ha^{-1} and this treatment combination exhibited its superiority at the early crop sampling stages as well. Maize + cowpea mixed forage crop receiving 150-100-0 kg NPK ha^{-1} (F_2I_3) gave comparable CGR values. The lowest CGR values were obtained in maize alone cropping system, where as the CGR of maize + cluster bean and those of maize + rice bean cropping systems were intermediate in all the nutrient application regimes at all the crop sampling stages.

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