Pak. J. Agri. Sci., Vol. 43(3-4), 2006

GROWTH AND FORAGE YIELD RESPONSE OF MAIZE-LEGUME MIXED CROPPING TO DIFFERENT SOWING TECHNIQUES

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A two years study pertaining to raising mixed forage of maize + legume was conducted at agronomic research area of the department of Agronomy, University of Agriculture, Faisalabad during 2003 and 2004. A promising forage maize variety "Afgoi" was grown in association with various forage legumes namely clusterbean, ricebean and cowpea in different sowing techniques viz. broadcast with blended seed of the component crop species, line sowing with this blended seed by a drill or sowing the component crops in alternate 1:1 row. Maximum mixed forage yield 55.75 and 65.10 t ha^{-1} during the first and second year of experimentation was obtained from maize +cowpea association when cowpea was intercropped in alternate lines with maize. Cowpea appeared to be more compatible with forage maize as it yielded significantly higher than clusterbean and ricebean, irrespective to sowing technique. The results further revealed that sowing of maize and intercrop legume in alternate row facilitated better circulation of air and light penetration, providing conducive conditions for crop growth and development than broadcasting or line sowing with blended seed.
Key words: Maize fodder, legume, mixed cropping and sowing techniques

INTRODUCTION

The production of abundant quantity of good quality forage is pre-requisite for an efficient and productive livestock industry. At present 2.35 million hectares of land is under fodder crops which accounts for 12% of the total cropped area of Pakistan (Agricultural Statistics of Pakistan, 2005). The area under fodder crops can not be increased at the expense of food crops. The fodder production in the country is primarily through primitive and traditional ways which does not meet fully the fodder requirement both in terms of quantity and quality with the result that the animals are undernourished. There are many avenues for increasing the fodder supply, amongst these mixed sowing of cereals with legumes is a reasonable option. Generally cereals give high tonnage of yield but their protein contents are low as compared to legumes. It is a well established fact that livestock feed should contain enough protein to maintain their health and according to an estimate the minimum protein content of 5-6% is essential in the maintenance ration and 10-14% for productive purposes. The mixed sowing of legumes with cereals not only improves the quality of fodder but also enhance the soil fertility by fixing atmospheric nitrogen (Abdullah and Chaudhry, 1996). Another advantage of this practice is that usually such mixtures yield more than either of the sole crop. The possible compatible mixtures for maize crop, which provides quite succulent and palatable fodder; can be maize+ cowpea, maize+ cluster bean, and maize+ rice bean etc.

Chittapur *et al.* (1994) reported that maize was intercropped with cowpea, soybean or sunhemp in 1:1, 2:1 or 3:1 ratio. The highest fodder yield was obtained by intercropping soybean or cowpeas in 1:1 ratio. Similar results were reported by Jayanthi *et al.* (1994). Abdullah and Chaudhry (1996), they stated that intercropping of cowpea with soybean was beneficial in the areas of water scarcity as the cowpea provided thick cover over the soil surface to reduce moisture loss of soil through evaporation. Macelli *et al.* (1996) reported that maize was grown alone or with 10 or 20 pigeon pea plants m^{-1}within or between the maize rows. Results revealed that pigeon pea at 10 plants m^{-1} within or between the maize rows increased maize plant height but did not affect maize yield. Tripathy *et al.* (1997) conducted a study in which forage maize and cowpea were grown alone or intercropped in 1:1 or 2:1 row ratio. The data revealed that mean forage yield was highest (50.8 t ha^{-1}) from growing maize and cowpea in 2:2 ratios and this mixed fodder also resulted in highest crude protein yield. Azim *et al.* (2000) found significant increase in crude protein production of fodder in which maize and cowpea were intercropped at seed ratio of 70:30 followed by a seed ratio of 85:15. Razende and Ramalho (2000) reported that seven maize cultivars and seven soybean cultivars were grown in monoculture and in all possible mixtures in the same rows. On average the mixtures produced 6% more DM and 17.5% more protein than the monocultures of maize. Patel and Rajagopal (2001) reported that increase in forage yield with maize + cowpea in 5:2 row ratio intercropping was 9.69 and 17.31 percent over the yield of sole maize forage during the two consecutive years, respectively.

MATERIALS AND METHODS

A study pertaining to raising mixed forage of maize + legume was carried out at the agronomic research area, University of Agriculture, Faisalabad during autumn season of 2003 and 2004. The study comprised of sowing of a promising forage maize cultivar "Afgoi"in association with various forage legumes namely cluster bean (*Cyamopsis*

tetragonoloba), rice bean (*Vigna umbellate*), and cowpea (*Vigna unguiculata*). The sowing of mixed forage crop was accomplished with three different techniques to find out the most appropriate one. Thus the experimental treatment combinations consisted of blending the seed of maize and cluster bean and sowing by broadcast (I_1S_1), drill sowing in lines 30 cm apart with the blended seed (I_1S_2), drill sowing of maize in 30 cm apart rows and sowing of cluster bean in between maize rows (I_1S_3); blending the seed of maize + rice bean and sowing this blend by broadcast (I_2S_1), drill sowing in lines 30 cm apart with this blend (I_2S_2), drill sowing of maize in rows 30 cm apart and sowing of rice bean in between maize rows (I_2S_3); blending the seed of maize + cowpea and sowing by broadcast (I_3S_1), drill sowing in lines with this blend (I_3S_2) and drill sowing of maize in rows 30 cm apart and sowing of cowpea in between maize rows (I_3S_3). The experiment was quadruplicated, using randomized complete block design with net plot size of 3.6 m 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. NPK @ 150-100-100 kg ha^{-1} 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. 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, LAD crop growth rate, forage yield and dry matter yield were collected by using the standard procedures and the formulae are given below:

For recording leaf area index (LAI) plants of both the maize and legume intercrop from a unit area of 0.9 x1 m were harvested, their leaves were separated and leaf areas were measured with leaf area meter. LAI was calculated as the ratio of crop leaf area to land area (Watson, 1947).

$$LAI = \frac{\text{Crop leaf area } (m^2)}{\text{Land area } (m^2)}$$

The leaf area duration was estimated according to Hunt (1978).

$$LAD = \frac{LAI_1 + LAI_2}{2} \times t_2 - t_1$$

Where LAI_1 and LAI_2 are the leaf area indices at times t_1 and t_2, respectively.

Mean crop growth rate was measured by dividing the increase in total dry matter of maize+ legume mixed crop to the time interval between two sampling.

$$\text{Mean CGR } (g\ m^{-2}\ day^{-1}) = \frac{W_2 - W_1}{t_2 - t_1} \text{ (Hunt, 1978)}$$

Where

W_1 = Plant dry biomass g m^{-2} at Ist sampling (15 DAS)

W_2 = Plant dry biomass g m^{-2} at harvest (60 DAS)

t_1 = Time corresponding to W_1 (days)

t_2 = Time corresponding to W_2 (days)

For recording the forage yield (t ha^{-1}) all the crop plants in each plot were harvested and weighed separately with the help of a spring balance and then plot yield was converted to t.ha^{-1}. Total green forage yield was calculated as:

Total green forage yield = Maize forage yield + intercrop legume forage yield

Total dry matter yield (t ha^{-1}) was calculated by taking the random samples of maize as well as legumes, chopped and sub samples of 100 g were put in an oven at 80°C for 72 hours to estimate dry matter percentage and it was multiplied with respective crop yields to work out total dry matter yield (t ha^{-1}).

$$\text{Dry matter percentage} = \frac{\text{Dry weight}}{\text{Fresh weight}} \times 100$$

Dry matter yield = Forage yield x Dry matter percentage

The data were analyzed using 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 and Torrie, 1984).

RESULTS AND DISCUSSION

Leaf area index (LAI)

The effect of treatment combinations on composite LAI of mixed forage crops was significant in both years (Table 1). During the Ist year, the maximum LAI (8.75) was recorded for cowpea grown in alternate rows of maize (I_3S_3) followed by cluster bean (8.14) grown in alternate rows with maize (I_1S_3) which was significantly greater than rice bean seeded in alternate rows with forage maize (I_2S_3) showing LAI of 7.49. Contrarily, the minimum LAI (6.59) was recorded for rice bean grown in lines with blended seed of maize + rice bean (I_2S_2) preceded by I_1S_2 (6.83). The same trend prevailed during the 2nd year with the maximum LAI (11.27) of cowpea grown in alternate rows of forage maize (I_3S_3) and the minimum (7.82) in case of rice bean seeded in lines with blended seed of maize + rice bean (I_2S_2). This variation in LAI values due to seeding techniques is attributed to the interference of neighboring members of same or different plant species upon one another. When the component plant species are sown in the same row by blended seed there might be shading effect of taller species (maize) upon legumes.

Table 1. Leaf area index (LAI) and leaf area duration (LAD) of maize + legume mixed crop as affected by intercropped legume species and sowing technique

Treatment combinations	LAI		LAD (days)	
	2003	2004	2003	2004
I_1S_1	7.53c	8.89e	226.0c	266.9e
I_1S_2	6.83d	8.60f	205.0d	258.0f
I_1S_3	8.14b	10.17b	244.3b	305.1b
I_2S_1	6.86d	8.45f	205.9d	252.8f
I_2S_2	6.59d	7.82g	197.8e	234.8g
I_2S_3	7.49c	9.60c	224.7c	288.1c
I_3S_1	7.68c	9.70c	230.4c	291.2c
I_3S_2	7.60c	9.25d	228.1c	277.7d
I_3S_3	8.75a	11.27a	262.7a	338.1a
LSD	0.221	0.178	6.66	5.38

Any two means not sharing a letter differ significantly at $P \leq 0.05$.

Like wise there may be crowding effect of member plants when sown in the same row, thus imbalancing the metabolic processes. The mixed forage crop grown in alternate rows escapes to such stresses.

Leaf area duration (LAD)

The interactive effect of treatment combinations on LAD of mixed forage crops was significant during each year (Table 1). In the Ist year, significantly the longest LAD (262.7 days) was recorded for cowpea seeded in alternate rows with forage maize (I_3S_3) followed by cluster bean seeded in alternate rows with forage maize (I_1S_3) showing LAD of 244.3 days. However, the differences among I_2S_3, I_3S_2, I_1S_1 and I_3S_1 were non-significant. By contrast, the shortest LAD (197.8 days) was exhibited by rice bean seeded in lines with blended seed of maize + ricebean (I_2S_2) preceded by I_2S_1 (205.9 days). The same trend was noted during the 2nd year of study.

Mean crop growth rate (CGR) of the mixed forage crop

The year effect on CGR of mixed forage crops (maize + legumes) was significant. The mean CGR on an average was higher (15.95 g m^{-2} d^{-1}) during the 2nd year than the preceded year (12.32 g m^{-2} d^{-1}), which is attributed to the more favorable environmental conditions, particularly more rainfall received. It is clear from the data given in Table 2 that during the Ist year, the highest CGR (15.04 g m^{-2} d^{-1}) was noted for cowpea grown in alternate rows with forage maize (I_3S_3) followed by cluster bean seeded in alternate rows with maize (I_1S_3) which exhibited CGR of 13.52 g m^{-2} d^{-1} which was significantly higher than ricebean seeded by broadcast with blended seeds of maize + cowpea (I_3S_1) that was at par with I_2S_3 recording CGR of 12.74 and 12.54 g m^{-2} d^{-1}, respectively. Contrarily, the lowest CGR (10.78 g m^{-2} d^{-1}) was recorded for ricebean seeded in lines with blended seed of maize + ricebean (I_1S_2) and I_2S_1 showing CGR of 11.06 and 11.16 g m^{-2} d^{-1}, respectively. Similarly I_2S_3, I_3S_2 and I_3S_1 were at par with one another. Similar trend existed during the 2nd year of study with the highest CGR for I_3S_3 (19.12 g m^{-2} d^{-1}) and the minimum (13.51 g m^{-2} d^{-1}) for I_2S_2.

Table 2. Mean crop growth rate of maize + legume mixed crop as affected by intercropped legume species and sowing technique

Treatment combinations	CGR ($gm^{-2}d^{-1}$)	
	2003	2004
I_1S_1	12.05d	15.33d
I_1S_2	11.06e	14.59e
I_1S_3	13.52b	17.79b
I_2S_1	11.16e	14.41e
I_2S_2	10.78e	13.51f
I_2S_3	12.54c	16.50c
I_3S_1	12.74c	16.58c
I_3S_2	12.53c	15.65d
I_3S_3	15.04a	19.12a
LSD	0.466	0.367

Any two means not sharing a letter differ significantly at $P \leq 0.05$.

Total forage yield of mixed forage crop (t ha^{-1})

Total fodder yield of maize + legume mixture is a true indicator of the real output in response to the treatments combinations under study. There was a significant year effect on total mixed forage yield of maize + legumes. The mixed forage yield was higher by 17.20% during the 2nd year than the preceding year due to more favourable environmental conditions like

Table 3. Fresh forage and dry matter yield (t ha^{-1}) of maize + legume mixed crop as affected by intercropped legume species and sowing technique

Treatment combinations	Fresh forage yield (t ha^{-1})		Dry matter yield (t ha^{-1})	
	2003	2004	2003	2004
I_1S_1	48.22c	56.33d	7.23d	9.20d
I_1S_2	45.63d	54.33e	6.63e	8.76e
I_1S_3	51.44b	60.02b	8.11b	10.67b
I_2S_1	44.11e	52.38f	6.69e	8.64e
I_2S_2	42.39f	48.83g	6.47e	8.11f
I_2S_3	47.65c	55.03e	7.52c	9.90c
I_3S_1	52.01b	60.00b	7.64c	9.95c
I_3S_2	47.59c	57.56c	7.51c	9.39d
I_3S_3	55.75a	65.10a	9.02a	11.47a
LSD	0.900	0.909	0.280	0.226

Any two means not sharing a letter differ significantly at $P \leq 0.05$.

rainfall and temperature during the 2nd year than the preceding year. The data presented in Table 3 indicate that during the Ist year, the highest mixed forage yield (55.75 t ha^{-1}) was obtained from cowpea seeded in alternate rows with maize (I_3S_3) followed by that grown by broadcast with blended seed of maize + cowpea (I_3S_1) and I_1S_3 which yielded 52.01 and 51.44 t ha^{-1}, respectively, both being at par with each other. Contrarily, the lowest mixed fodder yield (42.39 t ha^{-1}) was recorded for ricebean seeded in lines with blended seed of maize + ricebean (I_2S_2) preceded by I_2S_1 (41.11 t ha^{-1}) and I_1S_2 (45.63 t ha^{-1}). Almost similar trend was exhibited in the 2nd year with the maximum mixed forage yield of 65.10 t ha^{-1} in case of cowpea seeded in alternate rows with maize against the minimum of 48.83 t ha^{-1} for ricebean seeded in lines with blended seed of maize + ricebean (I_2S_2). On the whole, cowpea yielded significantly higher than cluster bean, which was followed by ricebean irrespective to sowing techniques. These results are in line with those of Mahapatra and Pradhan (1992) who reported that cowpea was a better intercrop, out of various legumes under study, as it resulted in the highest fodder yield of good quality. These results are also in conformity with the findings of Bhatti (1996) who concluded that maize + cowpea are an appropriate combination for raising mixed fodder, but are partially different with reference to sowing technique as the researcher referred above has advocated the sowing of component crops by the mixed seed rather than in alternate rows. However, Tripathy *et al.* (1997) stated that mean forage yield was highest from growing maize in 2:2 intercrop rows with cowpea.

Total dry matter yield (t ha^{-1})

There was a significant year effect on total dry matter yield of mixed forage (maize + legumes), which was higher by 2.14 t ha^{-1} during the 2nd year than the preceding year. The data in Table 3 showed that in the Ist year, the maximum dry matter yield (9.02 t ha^{-1}) was recorded in cowpea sown in alternate rows with maize (I_3S_3) followed by cluster bean grown in alternate rows with maize (I_1S_3) and I_2S_3 (7.52 t ha^{-1}). By contrast, the lowest dry matter yield (6.47 t ha^{-1}) was recorded for ricebean grown in lines with blended seed of maize + ricebean which was at par with I_1S_2 (6.63 t ha^{-1}) and I_2S_1 (6.69 t ha^{-1}). Similarly, the difference between I_3S_1 and I_3S_2 was found to be non-significant. Almost similar results were obtained during the 2nd year with highest dry matter yield (11.47 t ha^{-1}) for cowpea grown in alternate rows with maize (I_3S_3) and minimum (8.11 t ha^{-1}) in case of ricebean grown in lines with blended seed of maize + ricebean. These results are in line with those of Jayanthi *et al.* (1994) who stated that maize/cowpea 1:1 intercrop gave the highest dry matter yield, highest crude protein and resulted in the highest net returns.

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