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YIELD AND QUALITY OF FORAGE MAIZE GROWN IN ASSOCIATION WITH MUNGBEAN INOCULATED WITH *AZOSPIRILLUM*

Haseeb Arshad • Shahid Ibni Zamir* • Muhammad Sajjad • Suneela Yaseen • Faiza Rafiq • Farhana Bibi • Ansa Tabinda Khatoon

AUTHO'S AFFILIATION

Department of Agronomy, University of Agriculture, Faisalabad, Pakistan
Department of Biology, University of Agriculture, Faisalabad, Pakistan
Department of Agronomy, College of Agriculture, University of Sargodha, Sargodha, Pakistan
*Corresponding author's e-mail: zamir757@gmail.com

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ABSTRACT

Background Maize fodder often have good dry matter yield but poor nutritional status. Intercropping of fodder crop with nitrogen fixing protein enriched legumes might be an important approach for improving nutritional quality of fodder.

Methodology Field experiment was planned to evaluate the effect of inoculation and seed ratios of maize and mungbean on the yield and quality of forage. The experiment was comprised of two factors namely inoculation *Viz*. with or without, and seed ratios of maize and mungbean intercropping i.e. sole maize, sole mungbean, 60-40%, 70-30% and 80-20%. The design used was randomized complete block with factorial arrangement having three replications. Data regarding maize, legume, maize + legume and quality parameters were recorded first at 21 days after sowing, then after every 10 days and finally 75 days after sowing.

Results Treatment having 60% maize and 40% mungbean with inoculation produced maximum yield of green fresh fodder with better crude protein, crude fiber and total ash percentage. While the lowest fodder yield and quality was obtained from sole maize without inoculation.

Conclusion The yield and quality of maize fodder can be improved by intercropping with the mungbean and *Azospirillum brasilense* inoculation.

INTRODUCTION

In Pakistan, major animal feed is low quality roughage which cannot fulfill the nitrogen (N), energy, vitamins and minerals needs of livestock. Cereal crops have less cost of production and high dry matter yield potential due to which they are usually used as livestock feed. Cereal forage quality is low because they commonly contain less nutrition (Ross et al. 2004) due to which protein supplements are necessary to feed the animals. Higher prices of protein supplements increases the cost of animal rearing. For this reason, intercropping of cereals with legumes might be best option for getting good quality fodder (Crew and Peoples 2004). Maize is an important Kharif fodder crop which gives highly succulent fodder. Therefore, it is an important part of the dairy animals feed. The high livestock population reared to fulfill livestock product needs of ever increasing population demands increased forage production. However, it is difficult to increase fodder production by allocating more area to fodder crops but intercropping of non-legumes and legumes might have potential to significantly increase yield and crude protein of forage (Iqbal et al. 2006).

Intercropping may become most productive and economical when both the crops differ in genetic makeup, photosynthesis pathway, growth habit, growth duration and demand of different growth resources. Mungbean can fix 50-100 kg ha^{-1} of N in a year. It can be grown as green manure, cover and a fodder crop. Mungbean grown as green forage can improve the quality of the available forage because it is rich in proteins. Legumes have positive effect not only on all plant nutrients but also improve soil physical properties (Bronick and Lal 2005). Legumes are very good in absorbing phosphorus (P) and potassium (K). The best benefit of intercropping is the efficient soil and water management in all the season and increase in water use efficiency. By the utilization

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of proper genetic and biological potential of plant and microbial species, mungbean yield can be increased. In recent years, free living soil bacteria are commonly used as inoculants in different regions of the world for increasing yield of agricultural crops. Rhizobia fix atmospheric N and improve growth and yield of legumes significantly.

Few studies have shown that the inoculation of seed with mixed cultures has remarkable positive effects on plant growth as compared to the single strain (Xavier and Germida 2002). Application of plant growth promoting rhizobacteria (PGRP) in crops as inoculants on a very large scale has the potential to reduce the usage of chemical fertilizers and pesticides substantially and hence environmental pollution. Shaharoona et al. (2006) reported that for the improvement of the maize growth and yield, the Pseudomonas sp. are applied and to save this crop from pathogens like *Fusarium* and *Rhizoctonia* the application of *Bacillus subtilis* is very effective.

Nitrogen is a very important nutrient for the normal crop plants and yield. Nitrogen is made available to plants by the help of industrial and biological processes. Industrial process involves the consumption of fossil fuels and it certainly degrades the soil and environmental health by the enrichment of CO_2 and NO_2 but the biological process is carried out by the prokaryotic microorganisms, which is a natural and eco-friendly process. Half of the N applied to crop plants is lost in various processes. It is clear that we cannot minus the inorganic fertilizers from the modern agriculture without compromising crop yield but its application can be reduced by the integration of bio-fertilizers.

Microorganisms which are beneficial for soil, plant health and agricultural productivity can help to improve plant quality in a sustainable manner. Plant growth can be promoted by the PGRP through various processes directly or indirectly to the plant, biological control of soil pathogens and by the production of plant growth promoting hormones. Rhizosphere is rich with the microbial biomass that plays a crucial role in the development and growth of the crops by the secretions of growth promoting metabolites and nutrient supply. It indicates that the research on the rhizosphere can be a great agricultural value for improving crop nutrition.

The objective of present study was to find out the effect of *Azospirillum* inoculation on yield and quality of forage maize intercropped with mungbean in different ratios.

MATERIALS AND METHODS

The experiment was carried out during 2018 at Agronomic Research Area (located at 31° North latitude to 73° East longitude with altitude of about 184.4 m), University of Agriculture Faisalabad, Pakistan. The soil of experimental area was sandy loam. Experiment consisted of two factors namely inoculation and intercropping. Treatments were 1) without *Azospirillum brasilense* inoculants + 100% Maize; 2) without *Azospirillum brasilense* inoculants + 100% Mungbean; 3) without *Azospirillum brasilense* inoculants + 60% Maize and 40% Mungbean; 4) without *Azospirillum brasilense* inoculants + 70% Maize and 30% Mungbean; 5) without *Azospirillum brasilense* inoculants + 80% Maize and 20% Mungbean; 6) with *Azospirillum brasilense* inoculants + 100% Maize; 7) with *Azospirillum brasilense* inoculants + 100% Mungbean; 8) with *Azospirillum brasilense* inoculants + 60% Maize and 40% Mungbean; 9) with *Azospirillum brasilense* inoculants + 70% Maize and 30% Mungbean; 10) with *Azospirillum brasilense* inoculants + 80% maize and 20% mungbean.

The experiment was laid out in a randomized complete block design with factorial arrangement and replicated thrice. Plot size was 5 m x 3.6 m. The crop was sown by Kharif drill using seed rate of 10 kg ha^{-1} for maize and 12 kg ha^{-1} for mungbean. Row to row distance for maize and mungbean was 60 and 30cm, respectively. Data on maize emergence count, plant height, fresh weight per plant, number of leaves per plant, dry weight per plant, fresh forage yield and dry matter yield, mungbean fresh forage and dry forage yield at harvest, total mixed forage as cereal + legume parameters (maize + mungbean fresh forage yield and maize + mungbean dry matter yield) and quality parameters (crude protein, crude fiber and total ash) were collected using standard procedures. The collected data were analyzed by using Fisher's analysis of variance technique and least significance difference test at 5% probability was used to compare the differences among treatments means (Steel et al. 1997).

RESULTS AND DISCUSSION

Emergence count

Emergence count is a very important factor in case of forage crops because more number plants per unit area guarantee more fodder yield. The emergence counts with inoculation (14.34 m^{-2}) and without inoculation (14.54 m^{-2}) were statistically same. The analyzed data (Table 1) regarding emergence count showed that the treatment with 100% maize had the highest emergence count (21.67 m^{-2}) because there were more seeds in unit area followed by 80% maize and 20% mungbean, 70% maize and 30% mungbean while the minimum maize emergence count were recorded in 60% maize and 40% mungbean. Obviously maize emergence was

zero in 100% mungbean treatment. The results matched with the findings of Ayub et al. (2004) and Ibrahim et al. (2006) who noted more seedling count m^{-2} when crops (cereals) were sown alone with 100% seed rate.

Plant height

The inoculation of *Azospirillum* has a positive effect on the maize plant height (207.20 cm) as compared to without inoculation (197.27 cm). The data related to plant height is presented in Table 1 which indicated that treatment with inoculation and 40% mungbean had a significant impact on the plant height (258.83 cm) followed by 70% maize and 30% mungbean and then 80% maize + 20% mungbean (250.33 cm), however was at par with 100% maize. The results were backed by the Agegnehu et al. (2006) who reported that by increasing the seed rate of faba bean, the plant height of intercropped wheat was also increased. Inoculation and seed ratio had a highly significant effect on the plant height but the interaction between inoculation and seed ratio had a non-significant effect on the plant height.

Number of leaves plant^{-1} of maize

The factor which shows the development and growth of any plant is the number of leaves on that plant because more the number of leaves better will be the photosynthetic activity. Inoculation of *Azospirillum* had a positive effect on number of leaves (13.14) as compared to without inoculants (12.54). Data (Table 1) depicted that treatment with a maximum number of leaves was 60% maize and 40% mungbean (16.84). The minimum number of leaves were recorded in the treatments having sole maize (15.67) and 80% maize + 20% mungbean (15.67) and both of these were at par with 70% maize + 30% mungbean (16.00). The results could be compared with the Ayub et al. (2004) and Ibrahim et al. (2006) who stated that the number of leaves increased significantly by the cereal-legume intercropping. Pongdet (2010) reported that the inoculation of different bacterial species increased the growth and biomass of corn. The inoculant and seed ratio had a highly significant while, their interaction had a non- significant effect on the number of leaves on plant.

Fresh weight plant^{-1}

The growth and development of any plant can be determined by its fresh weight which depends on environment and soil rhizosphere. The experiment showed that the maximum fresh weight plant^{-1} of maize was achieved with inoculation (345.71 g) as compared to without inoculation (325.73g). Table 1 showed that the treatment of 60% maize + 40% mungbean intercropping resulted in maximum fresh weight (429.02 g), however it was at par with 70% maize + 30% mungbean (422.68 g), 80% maize + 20% mungbean (417.57 g). The minimum fresh weight (409.32 g) was recorded in sole maize but zero in sole mungbean case. The same results were also reported by the Patel and Rajagopal (2001) who found that fresh weight plant^{-1} and green forage yield was maximum among intercrop combinations.

Dry weight plant^{-1}

The inoculation treatment showed a significantly higher average dry weight (69.12 g) maize plant^{-1} as compared to without inoculation (64.15 g). The data regarding the dry weight plant^{-1} given in Table 1 showed that maximum dry weight plant^{-1} was in 60% maize + 40% mungbean (85.81 g) intercropping ratio, however it was at par with 70% maize + 30% mungbean (84.45 g), 80% maize + 20% mungbean (83.52 g). The minimum average dry weight plant^{-1} was in sole maize (81.86 g) but it was zero in sole mungbean case. The interactive effect of inoculants and seed ratio was non-significant. The significant effect of intercropping was also reported by Khot and Umrani (1992) who noted higher dry matter yield in mixture or intercropping as compared to sole cereal cropping.

Fresh forage yield

The ultimate objective of the experiment was to identify a treatment which helped to get maximum good quality green forage yield. Data presented in Table 1 showed that more fresh forage yield was recorded in sole maize (52.00 t ha^{-1}) followed by 80% maize + 20% mungbean (50.81 t ha^{-1}) and it was at par with 70% maize + 30% mungbean (50.09 t ha^{-1}). However minimum fresh forage yield was recorded in 60% maize + 40% mungbean (49.52 t ha^{-1}) and obviously it was zero in sole mungbean. The effect of inoculation, seed ratio and the interaction between inoculants and seed ratio all had a highly significant effect on the fresh forage yield. The impact of the inoculants was very much clear as average fresh forage yield with inoculants was maximum (42.43 t ha^{-1}) as compared to the without inoculant (38.54 t ha^{-1}). Our findings of higher yield with intercropping were supported by Jhansi (2004) who found more green forage yield when intercropping of different seed ratios was practiced. Pongdet (2010) stated that the inoculation of different bacterial species increased the growth and biomass of corn.

Dry matter yield

The data regarding dry matter yield (t ha^{-1}) presented in Table 1 indicated that sole maize had maximum dry matter yield (10.40 t ha^{-1}) followed by 80% maize + 20% mungbean (10.16 t ha^{-1}) seed ratio however, it was

Table 1 Effect of inoculation and seed ratio on maize emergence count, plant height, number of leaves plant^{-1}, fresh weight plant^{-1}, dry weight plant^{-1}, fresh forage yield and dry matter yield

Treatments	EMC (m^{-2})	PH (cm)	Leaves plant^{-1}	FW	DW	FFY	DMY
				(g plant^{-1})		(t ha^{-1})	
Non-inoculated	14.54a	197.27a	12.54b	325.73b	65.15b	38.54b	7.71b
Inoculated	14.34b	207.20b	13.14a	345.71a	69.12a	42.43a	8.48a
Seed ratios							
100% Maize	21.67a	247.67b	15.67b	409.32b	81.86	52.00a	10.40a
100% Mungbean (MB)	0.00d	0.00c	0.00c	0.00c	0.00c	0.00 d	0.00d
60% Maize + 40% MB	15.33c	258.83a	16.84a	429.02a	85.81a	49.52c	9.91c
70% Maize + 30% MB	17.17b	254.33ab	16.00b	422.68ab	84.45ab	50.09bc	10.02bc
80% Maize + 20% MB	18.00b	250.33b	15.67b	417.57ab	83.52ab	50.81b	10. 16b

The means having similar letter are non-significant and mean having different letter are significant, EMC: Emergence count, PH: Plant height, FW: Fresh weight, FFY: Fresh forage yield, DMY: Dry matter yield

Table 2 Effect of inoculation and seed ratio on mungbean fresh forage yield, dry matter yield, mixed fresh forage yield, mixed dry matter yield, crude protein, crude fiber and total ash percentage

Treatments	FFY	DMY	MFFY	MDMY	CP	CF	Total ash
	(t ha^{-1})				(%)		
Non-inoculated	10.253b	2.0507b	33.972b	6.7944b	15.109b	35.121b	12.217b
Inoculated	11.734a	2.3468a	37.713a	7.5427a	15.429a	35.621a	12.460a
Seed ratios							
100% Maize	0.00 e	0.00 e	0.00c	0.00 c	0.00b	0.00b	0.00b
100% Mungbean (MB)	25.907a	5.1813a	0.00 c	0.00 c	0.00b	0.00b	0.00b
60% Maize + 40% MB	11.410b	2.2820b	60.995a	12.199a	25.767a	58.658a	20.915a
70% Maize + 30% MB	10.123c	2.0247c	60.212a	12.042a	25.425a	59.180a	20.517a
80% Maize + 20% MB	7.5283d	1.5057	58.007b	11.601b	25.153a	59.018a	20.262a

The means having similar letter in a column are not significantly from each other. FFY: Fresh forage yield, DMY: Dry matter yield, MFFY: Mixed fresh forage yield, MDMY: Mixed dry matter yield, CP: Crude protein, CF: Crude fiber

at par with seed ratio of 70% maize + 30% mungbean (10.02 t ha^{-1}). The minimum maize fodder dry matter yield was obtained in 60% maize + 40% mungbean (9.91 t ha^{-1}) but it was zero in sole mungbean planting. The treatments with inoculation produced a significantly higher average maize dry matter yield (8.48 t ha^{-1}) than without inoculant (7.71 t ha^{-1}). The inoculant, seed ratio and their interaction all had a positive effect on the maize fodder dry matter yield. Our study was supported by Sarwar (2006) who found that sole sorghum produced more yield than intercrop.

Mungbean (legume)

Fresh forage yield

High fresh forage yield is the ultimate goal of a farmer engaged in growing fodder crops (Table 2). The perusal of data indicated that the inoculants and seed ratio had a highly significant effect on the fresh forage yield of the mungbean. But the interactive effect of inoculation and seed ratio was non-significant. Data showed that the treatment having sole mungbean produced more fresh forage yield (25.91 t ha^{-1}) followed by 60% maize + 40% mungbean (11.41 t ha^{-1}), 70% maize + 30% mungbean (10.13 t ha^{-1}). The lowest mungbean FFY (7.53 t ha^{-1}) was obtained from 80% maize + 20% treatment while, it was zero in case of sole maize cropping. The average yield of inoculation treatments was 11.74 t ha^{-1} while, without inoculant was 10.26 t ha^{-1}. These results were also in conformity with Ayub et al. (2004) who noted that yield of any forage intercropped with pea was more when they were seeded at higher rates than pea.

Dry matter yield

Data given in the Table 2 indicated that sole mungbean had more dry matter yield (5.18 t ha^{-1}) followed by 60% maize + 40% mungbean (2.28 t ha^{-1}), 70% maize + 30% mungbean (2.03 t ha^{-1}) and minimum was in 80% maize + 20% mungbean. It was zero in sole maize cropping. The average dry matter yield of mungbean with inoculation was (2.35 t ha^{-1}) and that of without inoculation was 2.05 t ha^{-1}. The interaction of seed ratio and inoculation had a non-significant effect on the dry matter yield of mungbean.

Total mixed forage (cereal + legume)

Maize + mungbean fresh forage yield

The data regarding the mixed fresh forage yield in

Table 2 indicated that the inoculants, seed ratio and their interaction had a highly significant effect on the mixed fresh forage yield. The experiment showed that 60% maize + 40% mungbean had maximum fresh mixed forage yield (60.10 t ha^{-1}), however it was at par with 70% maize + 30% mungbean (60.22 t ha^{-1}) and minimum was recorded in 80% maize + 20% mungbean. Mixed forage yield was significantly affected by different seed ratios of maize and cowpea (Agegnehu et al. 2006). Pongdet (2010) reported that the inoculation of different bacterial species increased the growth and biomass yield of corn.

Maize + mungbean dry matter yield

The data representing the mixed forage dry matter yield reflected that the inoculants, seed ratio and their interaction had a highly significant effect. The seed ratio and inoculant individually increased dry matter yield of the mixed crops. The treatments having seed ratio of 60 % maize + 40% mungbean had maximum yield (12.10 t ha^{-1}), however it was at par with 70% maize + 30% mungbean (12.04 t ha^{-1}) and minimum was recorded in 80% maize + 20% mungbean (11.60 t ha^{-1}). The mixed dry matter yield of maize and cowpea was significantly affected by seed ratio (Ayub et al. 2004) and by inoculation (Pongdet 2010).

Quality parameters of mixed crop

Crude protein

Crude protein percentage is a very important quality parameter of the green and fresh forage crops. The data indicated that the inoculation and the interaction between inoculants and seed ratio had non-significant effect on the crude protein percentage of the mixed crops. But the seed ratio had a highly significant effect on it. The maximum crude protein percentage was obtained from the treatment having 60% maize + 40% mungbean with inoculation, and minimum was recorded from treatment having 70% maize + 30% mungbean. The higher crude protein percentage in mixed cropping of maize and soybean was noted as compared to their sole crops (Rezendo and Ramalho 2000; Patel et al. 2001; Jhansi 2004). Ahmad (2006) also reported higher crude protein of mixed sorghum + legumes forage as compared to their sole crops.

Crude fiber

Crude fiber percentage is a very important quality parameter of forage. The data presented in the Table 2 indicated that the inoculation and interaction between inoculation and seed ratio had a non-significant effect on the crude fiber percentage. The seed ratio had highly significant effect on the crude fiber percentage of the mixed crops. Results showed that the maximum percentage of crude fiber was depicted by the treatment having 70% maize + 30% mungbean with inoculation while, it was minimum in treatment having 60% maize + 40% mungbean without inoculants. These results were related with the findings of Ibrahim et al. (2006) who claimed that when maize and cowpea were intercropped, the crude fiber percentage of maize was less as compared to sole maize.

Total ash (%)

Ash percentage is important quality parameter of any forage crop. The inoculants and interaction between inoculants and seed ratio had a non-significant effect on the total ash percentage of forage. The seed ratios produced a highly significant effect on the total ash percentage of mixed forage. The maximum percentage of total ash was obtained from the treatment having ratio of 60% maize + 40% mungbean with inoculant and minimum ash percentage was obtained from the treatment having 80% maize + 20% mungbean without inoculants. Ayub et al. (2004) also reported a significant increase in the total ash percentage of mixed forage with an increase in seed rate of legume.

CONCLUSION

Azospirillum inoculation and seed ratio of 60% maize + 40% mungbean had a positive effect on mixed forage yield and quality.

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