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Effect of intercropping on forage yield and quality of *Zea mays* L. in Saiha district of Mizoram, India

U.K. Sahoo[1*], K. Vanlalhriatpuia[1], S. L. Singh[1], K. Upadhyaya[1], Lalnilawma[2] and Tawnenga[3]
[1]Department of Forestry, Mizoram University, Aizawl-796004, India
[2]Department of Extension Edn. and Rural Development, Mizoram University, Aizawl-796004, India
[3]Pachhunga University College, Mizoram University, Aizawl-796001, India
*Corresponding author e-mail: uksahoo_2003@rediffmail.com
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Abstract
Local maize (*Zea mays* L.) was intercropped with common bean (*Phaseolus vulgaris* L.), turmeric (*Curcuma longa* L.) and roselle (*Hibiscus sabdariffa* L.) as field experiments to evaluate the effects of intercropping on forage yield and quality of maize in East Kawlchaw, Saiha, Mizoram. The dry matter (DM) yield in maize increased by 26.51 to 43.18% in 2008 and 3.80 to 16.44% in 2009 in intercrops than the sole crop. On the contrary, the average acid detergent fibre (ADF) and neutral detergent fibre (NDF) contents in maize significantly ($P<0.05$) decreased in intercrops than the sole maize crop in both years increasing digestibility of forage. The crude protein (CP) in maize was highest (88 g/kg) when intercropped with bean and lowest (64 g/kg) with turmeric. Cropping also resulted in higher soil organic carbon (by 7.77 to 28.64%), microbial biomass by 6.23% (maize) to 22.9% (turmeric) than the initial value. Soil microbial nitrogen also got enhanced due to intercropping to a maximum of 87.66% in bean. Land equivalent ratios (LER) were higher in intercropping by 7-26% than sole cropping. Further, intercropping brought stability to the soil health by improving the chemical and biological properties of soil compared to the sole crop.

Keywords: Dry matter, Intercropping, Land equivalent ratio, Maize, Quality forage

Introduction

Maize (*Zea mays* L.) is the third most important cereal crop of world, and in Mizoram it is the second most cereal next to paddy. It has the potential to supply large amounts of energy-rich forage for animal di-ets, and its fodder can safely be fed at all stages of growth without any danger of oxalic acid, prussic acid as in case of sorghum (Dahmardeh *et al.*, 2009, 2010). The production of good quality fodder nevertheless has great importance for livestock. The quality aspects of forage are evaluated in terms of voluntary intake, palatability, digestibility and nutrient utilization. The poor digestibility and lower voluntary intake are always associated with a relatively high lignin content which increase with the age and cause a corresponding decrease in the nutritive value. The crop is grown widely under shifting cultivation and agroforestry system along with different tree species.

Maize can be grown under diversity of environment and is recognized as a common component in most intercropping systems and is often combined with different legumes (Maluleke *et al.*, 2005, Prasad and Brook, 2005). Many researchers have explored the use of intercropping for forage production. Toniolo *et al.* (1987) reported significantly higher crude protein (CP) content of maize-soybean intercropping than that of mono-cropped maize. Javanmard *et al.* (2009), worked on intercropping of maize with different legumes, indicated that dry matter yield and crude protein yield of forage were increased by all intercropping compositions as compared with the maize monoculture. Dahmardeh *et al.* (2009) concluded that intercropping of maize and cowpea resulted in more digestible dry matter and also crude pro-tein content than maize sole cropping.

Maize possesses most of the characteristics of an ideal type of forage plant. It also provides high yield in terms of dry mat-ter but results in forage with low protein content. However, protein is needed by livestock for growth and milk produc-tion. Very little information is known on how the forage yield and maize quality gets affected when grown along with other crops. The present paper analyses the effect of intercropping on forage yield and quality of maize when intercropped with common bean (*Phaseolus vulgaris* L.), turmeric (*Curcuma longa* L.) and roselle (*Hibiscus sabdariffa* L.).

Materials and Methods

The present study was carried out at east Kawlchaw village (Lat 22°24'05.0"N, Long. 92°57'23.0"E, 177 m asl) in Saiha district, Mizoram, India during 2008 and 2009 growing seasons. Common bean (*Phaseolus vulgaris* L.), turmeric (*Curcuma longa* L.) and roselle (*Hibiscus sabdariffa* L.) were selected to be intercropped with maize (*Zea mays* L.). Experimental plots of varying sizes *viz*., nine plots (3m x 4m) and twelve plots (1.5m x 4m) were prepared well by removing the residual crops and debris, in both the years of study. The soil is sandy loam with pH varying from 6.3-6.6, soil organic carbon 4.12 g/kg soil, total Kjeldahl nitrogen (TKN) 3.0 g/kg soil, available N 245 kg/ha, available P 16.5 kg/ha and exchangeable K 150 kg/ha. Prior to sowing of maize seeds, the seeds were treated with 0.2% benomyl (w/w) in order to prevent soil-borne pathogens. The row to row crop distance was 40 cm and a buffer zone of 2 m was allowed between the treatments. The seeds were planted at a density of 125000 seeds/ha on 12th May 2008 and 18th May 2009 and the experiment was laid using simple RBD with three replications. Intercropping of maize with common bean, turmeric and roselle were carried out in the bigger plots (3m x 4m) and the sole crops are grown in the smaller plots (1.5m x 4m). All plots were given similar agronomic treatment and farmyard manure was applied @ 20 tonnes/ha. The crop was raised under rain-fed condition.

The soil samples (0-15 cm) were collected twice, once prior to maize sowing and after the crop harvest/end of study period. The soil organic carbon (SOC), TKN, available N, available P, exchangeable K, soil microbial biomass C (MBC) and N (MBN) were determined by standard methods.

At dough stage, six maize plants from each treatment were considered for analyzing different forage quality parameters. Each plant was measured for its height, number of leaves, and stem diameter at one node below the cob attachment. The cobs were shelled and grain weights were recorded to determine harvest index (HI) as the ratio between cob dry matter and fodder dry matter. A compound sample of leaves and stem was collected from each variety. The grounded samples were analyzed for dry matter (DM) and crude protein (CP) as per AOAC (1984). Total N was determined by the Kjeldahl procedure and CP was calculated by multiplying total N with 6.25 and all data were calculated on DM basis. The cell wall constituents like Neutral Detergent Fiber (NDF) and Acid Detergent Fiber (ADF) were estimated from the whole plant samples (Goering and Van Soest, 1970).

The land equivalent ratio (LER) was calculated following the formula:

$$LER = (Yij/Yii) + (Yji / Yjj),$$

Where Y is the yield per unit area, Yii and Yjj are sole crop yields of the component crops i and j, respectively and Yij and Yji are intercrop yields.

Results and Discussion

The plant height, number of leaves, stem diameter of maize were all influenced by the component crops in the intercropping (Table 1). Among the intercropping, maize performed growth in term of plant height (312 cm) and number of leaves (14.0) with bean as component crop followed by roselle and turmeric. The vegetation growth was better during 2009 than 2008 growing season. Similar trend was also observed for the stem diameter. The harvest index, however, was better during 2008 than 2009 for maize irrespective of the treatment and the intercropping treatment had significantly ($P<0.05$) higher harvest index than the maize monoculture. The maize plant height and number of leaves did not show significant variation when compared between different component crops (Table 1) unlike stem diameter which showed a significant variation ($P<0.05$) between component crops but did not show significant variation when compared with the sole crop. Harvest index was maximum in maize when grown in associated with bean (39.6%) followed by turmeric (36.2%) and roselle (35.8%) and these values were significantly ($P<0.05$) higher than the monoculture maize HI (30.6%) in 2008 and similar trend was also observed in 2009. Compared to monoculture of maize, maize-soybean had significant advantage in yield, economy and land utilization ratio (Zhang *et al*. 2015). Nutritional composition in forage is nevertheless influenced by growth stage of a plant (Kharage *et al*., 2014) and nutritional value and palatability of forage are also influenced by the climatic conditions (Ismail *et al*., 2014).

The dry matter (DM) yield of maize in all intercropping treatments was also significantly ($P<0.05$) higher than maize monoculture (Table 2). The highest DM yield (18.9 t/ha) was obtained from maize when intercropped with common bean and the lowest DM (16.7 t/ha) was obtained with roselle, amongst the component crops. The higher DM yield in case of former may be due to their better compatibility in utilizing the resources; the other probable reason could be that the bean might have enriched the soil by adding nitrogen to the soil (Bremer *et al*., 1988, Mapfumo *et al*., 2001). Except for the sole maize crop, the DM yield was lower during 2009 than

2008 growing season. DM content similarly was significantly (P< 0.05) greater for maize in maize - bean mixture than the sole maize and it was in the order of maize + bean > maize + turmeric > maize + roselle > sole maize crop. The mineral absorption might have increased in the maize due to complementary intercropping in maize-bean intercropping as was advocated by Mason and Pritchard (1987). The intercropped plots produced relatively greater DM yield and DM content (Table 2), obviously by making use of resources that would otherwise not be utilized by a single crop. DM content for the whole plant at harvest is considered important because of ensiling and animal DM intake (Vattikonda and Hunter, 1983). Highest CP (88 g/kg) was obtained from maize when intercropped with bean and lowest (64 g/kg) with turmeric, among the component crop in intercropping. The LSD value, however, shows a significant variation in CP of maize intercropped with bean when compared with maize as sole crop (Table 2). A higher CP resulted in better forage quality and the maize-bean intercropping must have supplied more N, induced by complementary interaction between the crops. The CP of maize increased by 3-20% (in turmeric) to 26-35% (in bean) when compared with the sole maize crop. The higher CP yield in crop mixture than the sole crop obviously was related to higher forage yield in the former than the later. Results of cell wall constituents showed that NDF values (Table 2) varied considerably among the sole maize (532 g/kg) and when it was grown along with other crop mixture (ranged from 434 g/kg to 512 g/kg). NDF value was significantly (P<0.05) low in maize grown in bean crop mixture than other crops and control. The values of ADF also showed similar trends and were highest 283 g/kg in maize (control) during 2009 (Table 2). It is largely accepted that the total NDF content of the forage is an important factor in determining the overall forage quality. The higher NDF content in maize associated with other crops and sole maize could be due to greater lignifications compared to maize grown along with bean. These results indicate the positive role played by bean in reducing NDF in maize and making it better forage. It is advocated that the crops which mature at different times thereby separating their periods of maximum demand to nutrient and moisture, aerial space and light could suitably be intercropped as also argued by Enyi (1977). Plant competition is generally minimized by spatial arrangement of intercrops, but also by choosing those crops best able to exploit soil nutrients (Fisher, 1977). The maize had high canopy while the bean is a low canopy crop and this mixture probably improved better light interception and hence resulted in better yield when they were spaced widely. The choice of compatible

Table 1. Effect of intercropping on plant height, leaf number, stem diameter and harvest index of maize (2008-2009) in Saiha, Mizoram

Treatment	Plant height (cm)		Leaf number (per plant)		Stem diameter (mm)		Harvest Index (HI) %	
	2008	2009	2008	2009	2008	2009	2008	2009
Maize	252	265	10.8	11.6	25.7	24.6	30.6	30.2
Maize + bean	280	312	12.3	14.0	26.0	25.2	39.6	36.8
Maize + turmeric	266	282	11.2	11.6	23.8	22.4	36.2	30.5
Maize + roselle	268	284	11.4	11.8	27.3	26.3	35.8	27.3
LSD (P<0.05)	16.3	18.2	0.7	0.6	2.2	1.6	2.4	2.6

Table 2. Yield and quality parameters of maize in monoculture and mixture with other component crop

Treatment	DM yield(t/ha)		DM content (g/kg)		CP yield (g/kg)		NDF(g/kg)		ADF(g/kg)	
	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Maize	13.2	15.8	275	205	65	74	532	518	265	283
Maize + bean	18.9	16.6	337	252	88	82	434	462	212	234
Maize + turmeric	18.6	18.4	335	248	67	78	435	474	216	256
Maize + roselle	16.7	16.4	314	230	72	84	450	512	224	258
LSD (P<0.05)	2.6	1.4	18	13	3.2	4.1	24.4	28.6	18.6	26.2

Table 3. Land equivalent ratio (LER) of different intercropping

Treatment	2008			2009			Average of two years		
	M	C	T	M	C	T	M	C	T
Maize + bean	0.98	0.28	1.26	0.94	0.24	1.18	0.96	0.26	1.22
Maize + turmeric	0.79	0.32	1.11	0.85	0.28	1.13	0.82	0.30	1.12
Maize + roselle	0.82	0.25	1.07	0.88	0.25	1.13	0.85	0.25	1.10

M-maize, C- component crop, T-total

crops for an intercropping system nevertheless depends on plant growth, habit, land, light, water and fertilizer utilization (Brintha and Seran, 2009).

Land equivalent ratio was higher in all intercrops than the sole crop indicating the advantage of intercrop on higher yield compared to the mono crops. Our results indicates that about 7 to 26% more land is required to have the same yield when maize is grown as monoculture than the mixed culture (Table 3). A higher LER of the intercrops could be due to better crop compatibility in resource use thereby minimizing competition which is reflected in higher dry matter forage yield. Other studies similarly have shown an increase LER to as high as 48% (Mohta and De, 1980) and by 8% (Putnam *et al*., 1985) when intercropping of maize with soybean was done compared with sole maize crop.

The chemical and biological properties of soil improved upon intercropping. The soil organic carbon (SOC) increased by 15.53% (in turmeric) to 28.64% (in bean). The total Kjeldahl nitrogen similarly got significantly ($P<0.05$) increased due to intercropping after a 2-years period (Table 4). The increase in TKN under intercropping than sole cropping might be due to higher biomass mediated N from the intercrop *vis-à-vis* root turnover. Soil microbial biomass carbon was the highest under turmeric followed by roselle and the lowest under bean among the intercrops. Similarly, MBN was significantly higher ($P<0.05$) in the intercrops than the sole crop, being the highest in bean and the lowest in turmeric. Many authors have found intercropping providing better chemical and biological properties in soil (Suman *et al*., 2006, Verma *et al.,* 2014). In *Geranium* based intercropping an increase of 7.8-69.2% SOC and 10.7-92.8% TKN compared to sole geranium has been reported (Verma *et al.,* 2014). In the present study, bean and roselle as intercrop exhibited higher build up of SOC and TKN. The increase in MBC under turmeric could be due to addition of more organic residue. Crop residues of bean also supported more microbial growth although the intercrop have less residue input to the soil than the other intercrops, is in agreement with Balota *et al.* (2003). The use of cover crop has been suggested as an effective method to maintain and/or increase the organic matter content while increasing the soil physical, chemical and biological properties (Saiza *et al*., 2013), so also intercropping in maintaining soil fertility on a long term basis (Wang *et al*., 2015).

Conclusion

The intercropping of maize with common bean showed better DM, high CP, reduced Neutral Detergent Fiber and Acid Detergent Fiber content and better harvest index (HI), thereby indicating a better cereal-crop mixture in improving forage quality and maize yield and superiority in term of utilization of land resources. Besides, the build up of SOC and enhancement of MBC in intercropping than sole cropping may promote long term stability to the soil health.

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Table 4. Effect of intercropping on some soil chemical and biological properties at the start of experiment and after crop harvest

Treatment	SOC (g/kg soil)	TKN (g/kg soil)	Soil MBC (mg/kg soil)	Soil MBN (mg/kg soil)
Initial (before crop sowing)	4.12	3.0	185.56	8.67
Maize	4.44	3.0	197.12	9.98
Maize + bean	5.30	4.9	224.67	16.27
Maize + turmeric	4.76	4.3	228.06	13.97
Maize + roselle	5.15	4.7	226.67	14.64
LSD (P<0.05)	0.22	0.10	6.76	1.16

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