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Effect of Different Planting Structure of Maize and Soybean Intercropping on Fodder Production and Silage Quality

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ABSTRACT

A study was conducted to examine the effects of different planting structure of maize (*Zea* mays L.) and soybean (*Glycine max* L.) intercropping on fodder production and silage quality. Maize was cultivated alone and intercropped with soybean as follows;1 row maize to 1 row soybean (1M1S),1 row maize to 2 rows soybean (1M2S) and 1 row maize to 3 rows soybean (1M3S).The experiment was laid out in randomized complete block design with four treatments and three replications.The crops were harvested when the maize reached at heading stage (at about 35% dry matter).The results indicated significant increase in fresh biomass and dry matter production of maize fodder alone as compared to maize intercropped with soybean fodder.However,no difference ($p>0.05$) was observed in ether extract (EE), ash (%) and acid detergent fibre (ADF) of nutrient composition of fodder among the four treatments.After 60 days of ensiling period,silage samples were analysed for pH,dry matter (DM),crude protein (CP),ether extract (EE),neutral detergent fibre (NDF), acid detergent fibre (ADF) and water soluble carbohydrate (WSC).All intercropped silages had higher CP values (1M1S,12.1%;1M2S,12.1%;1M3S,12.7%) than the monocrop maize (SM,8.4%) silage.The NDF and ADF levels were higher for maize silage as compared to intercropped silages. The study showed that among all intercropped silages the IM3S (1 row maize to 3 rows soybean) was preferable according to nutrient composition than other intercropped silages.

Keywords: Intercropping, Planting pattern, Maize, Soybean, Fodder, Silage quality.

INTRODUCTION

The use of maize (*Zea mays* L.) silage is a strategic tool for the intensification of livestock systems not only due to its high production potential and quality, but also its versatility[1]. Comparing with legume silage[2], it is poor in protein content 8.8%[3]. On the other hand, legume material is highly difficult to ensile because of its high buffering capacity and low level of water soluble carbohydrate[4].Therefore, protein-rich legume and high-energy corn silage can be ensiled to form better nutrient composition[2]. The intercropping of maize with climbing bean (*Phaseolus vulgaris* L.) may serve as a way to increase crude protein CP and improve the overall nutritive value of silage[5].

As a cultivation system, intercropping involves the planting of two or more crop species on the same field[6,7].Intercropping corn with legumes for silage is a feasible strategy to improve CP level[7,8,9,10].The use of corn grown for ensilaging and the seeding of soybean with corn in alternate-rows as 1 corn + 1 soybean or 1 corn + 2 soybeans highly increased the silage quality and CP content[11]. Proper spatial arrangements, planting rates and the maturity dates of components in maize-grain legume intercropping enhance biodiversity and have many advantages over pure maize cropping. The intercropping advantage, its improved stability on environmental resources, recycling nutrients and enhance nitrogen fixation[12,13].It's also better for weed, pest and diseases control as well as increased CP of silage[2,14].

The hypothesis of present study it would provide valuable information about the contribution of intercropping maize with soybean for better silage; (1) the making of silage under China territory climate condition with both crops simultaneously sown and harvested; (2) improves the silage quality by increasing protein contents. Therefore it was examined that the effect of different planting structure of maize and soybean intercropping on the fodder production and silage quality.

MATERIALS AND METHODS

Plant cultivation and Fodder Production

The crops were produced during the crop growing season in summer 2015 at the North campus experimental area (34º 18' 00" N,108º 5' 42" E) in Northwest Agriculture and Forestry Univ ersity,Shaanxi,Yangling,China.The crop production was carried out with a randomized complete block design with three replicates.The experiment was established on a sandy clay loam soil with 8.3 pH (Table 1). Summer maize (*Zea mays* L.Zheng Dan 958) was seeded as monocrop (SM) and intercropped with soybean (*Glycine max* L.Zao Huang) as follows: 1 row maize to 1 row soybean (1M1S),1 row maize to 2 rows soybean (1M2S),and 1 row maize to 3 rows soybean (1M3S).The site of experiment was ploughed to 0.2 to 0.3 m depth after the removal of winter wheat straw,followed by harrowing prior to trial.All plots were fertilized with the same amount of fertilizer before sowing,containing 70 kg N ha^{-1},70 kg P_2O_5 ha^{-1} and 70 kg of K_2O ha^{-1}. Maize and soybean were simultaneously seeded in 30 June 2015 in a field which had previously been cropped with winter wheat.The maize and soybean were spaced at 70cm x 25cm and 30cm x 15cm with population of about 114,285 and 666,667 plants per hectare, respectively. None of the soybean seeds were inoculated with *Rhizobium*. Neither herbicides nor insecticides were used. Hand weeding by hoe was done once when the corn was approximately 30cm in height.During the experimental period, the field was irrigated 3 times with 30 days interval.

Table 1: Soil characteristics of the experiment area

Soil (20-40cm)			
Sand (%)	36.7	pH	8.3
Clay (%)	30.6	OM (%)	1.5
Silt (%)	30.4	N (%)	0.2
CaCO3 (%)	18.5	P (ppm)	0.3
Salt (%)	0.07	K (ppm)	400

OM - organic matter; N – nitrogen; P (ppm) - phosphorus (parts per million); K (ppm) - Potassium (parts per million).

Maize and soybean fodders were manually harvested simultaneously in three sampling areas in a total area of a 1m^2 of each plot at heading stage (at least 35% dry matter) in 26 September 2015.The maximum and minimum daily air temperatures were 31 ^{0}C and 20 ^{0}C respectively, and precipitation was 640 mm during the crop production.

Silage Preparation

Fodder was manually harvested and chopped into 3 to 4 cm in length with chaff cutter (JB 400, Power chaff cutter, Gujarat, India) and ensiled without additives into the plastic bags. The plastic bags were used for each type of silage and packing was done by manual trampling on the fodder.The plastic bags were sealed airtight and kept at room temperatures to allow for anaerobic fermentation for 60 days.Before fermentation samples were taken for nutrient composition analysis.After the ensiling period,the mature samples were taken from the centre of ensiled mass of each plastic bags for chemical analysis.The fodder and silage samples were air-dried and ground by Blender and then flour samples were stored into a refrigerator for chemical analysis.

Determination of Nutrient Composition

The pH of silages was determined on the aqueous extract of silage by pH meter.Silages samples were dried at 80 C for 48hr and ground to pass through a 2 mm screen.The ground samples were ashed at 550 C[16,17] for 2 hr in a muffle furnace (Nabertherm, Lilienthal, Germany).The Crude Protein (CP) content was determined as N x 6.25 using the Kjeldahl Analyzer (RAY-K9840, Auto Kjeldahl Distiller, Shandong, China). Ether extract (EE) was analysed by a standard ether extraction method[17]. Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were determined with procedures[18]. Ash content was measured by ingestion of the dried material in muffle furnace at 600^0C for 4hrs.The water soluble carbohydrate (WSC) was determined by the anthrone method,using freeze dried samples, where the WSC was extracted with water[19].

Statistical analysis

Data of fodder production and chemical analysis of different silages was analysed by One-way-ANOVA using SPSS (version 19) and Duncan test (α=0.05) was used to compare the treatments means.

RESULTS AND DISCUSSION

Fodder yield

Data regarding green fodder and nutrients production (tons/ha) of fodder cultivated as a maize alone and maize intercropped with soybean at different planting structure are presented in table 2.The fresh fodder and DM yields were ranged from 33.6 to 45.4 t/ha and 12.2 to 14.6 t/ha (Table 2).Monocrop maize had a higher fresh biomass yield (45.4 t/ha) than other intercropped fodder.

Table 2: Fresh biomass, dry matter and crude protein yield of maize and maize-soybean intercropped fodder

	Yields (tons/ha)		
Fodder	**Fresh biomas**	**Dry smatter**	**Crude protein***
SM	45.4^a	14.6^a	1.8^c
1M1S	33.6^d	12.2^d	2.6^b
1M2S	42.1^c	13.1^c	2.6^b
1M3S	44.1^b	14.5^b	2.7^a

Note: Different letters in the column mean significant difference ($p<0.05$). SM,monocrop maize;1M1S,1 row maize to 1 row soybean;1M2S,1 row maize to 2 rows soybean;1M3S,1 row maize to 3 rows soybean. *On dry matter basis

Fresh forage and DM yields were higher in SM fodder, followed by three intercropped fodder. DM yield characteristic is a very dependable parameter in agronomical studies[20,21] Several researchers have reported variable results of intercropping systems.The intercropped maize with cowpea (*Vigna unguiculata* (L.) Walp.) and bean (*Phaseolus vulgaris* L.) produced higher DM yield than SM[22].On the other hand, maize in row intercropping had a marked depressing effect on legume growth because of tall and leafy structure[4].Competition and unequal use of environmental or underground resources,such as light and water, seem to account for problems experienced on intercropped communities.These imbalances may have negative effects (for example reduced leaves or leaf area index) on crop yield[23,24]. Maize mixed with soybean possessed better fodder CP yields (2.6-2.7 t/ha) than the SM. The results suggested that the contributions provided by legume components in the mixtures increased CP yields of fodder.

Nutrient composition of fodder

Results of nutrient composition of maize and intercropped maize and soybean fodder are given in table 3. Crude protein contents of maize intercropped with soybean at different planting structure was ($p<0.05$) higher as compared to maize fodder alone.The DM content increased ($p<0.05$) with the intercropping of maize with soybean at different planting structure compared to maize fodder alone. No difference ($p>0.05$) was observed in ether extract, ash and ADF contents among fodders. The NDF contents was decreased ($p<0.05$) with the intercropping of maize with soybean at different planting structure compared to maize fodder alone. The values of water soluble carbohydrate were 10.3, 8.9, 9.0 and 9.3% for SM, 1M1S, 1M2S and 1M3S, respectively.The value of WSC of fodder tended to be sufficient for good fermentation required for the preservation of fodder in the form of silage[25].

Nutrient composition of silages

Results of nutrient composition of different silages are depicted in table 4. The intercropped silages were highly effective on pH compared to monocropped maize.There were significant differences between monocrop silages (SM) and intercrop silages in pH ($p<0.05$),SM having the lowest pH (4.1).The DM contents of the silages were between 30.1%to 34.3%.The 1M3S silage had the highest DM value (34.3%) than the other silages.The optimum DM range of ideal corn silage is between 28% and 32%[26].The DM level was related to the fermentation conditions of the material[7].

One of the main objectives of intercropped silage is to obtain a complementary effect of the desirable nutrient of two or more crops.In the present study it was determined that the crude protein value of intercropped silages 1M1S, 1M2S and 1M3S were ($p<0.05$) higher as compared to SM. Legumes are rich in protein.The intercropping of maize with a variety of protein rich forages could increase silage CP level by 3% - 5% and improve N digestibility, indicating a potential to reduce the requirement for purchased protein supplements[2].

The NDF contents of the silages varied from 36.4% to 40.1%. The presence of leguminous plants in the ensiled mass affected NDF and ADF levels in the present study. There is usually lower concentration of fibres in the DM of legumes in relation to grasses[7]. In addition, NDF level is related to the maturity stage of the forage sources, because of levels of cell wall components, chiefly the cellulose, hemicellulose, and lignin[27].However, such an effect had not been observed in other experiments as no effect of intercropping was found on the NDF and ADF levels[7]. When compared to SM, the maize intercropped silages increased pH, and CP contents ($p<0.05$), whereas decreased NDF, ADF, and ash ($p<0.05$) contents. No difference ($p>0.05$) was found in ether extract (EE) of nutrient composition of silage among the four treatments. The intercropped silage 1M3S had higher nutrient composition than the others intercropped silages.

The findings of this study, it may be concluded that intercropping of maize with soybean at different planting structure proved to be an effective way to increase fresh fodder production and to enhancing quality of silage ensuring the supply of nutritionally rich silage for livestock feeding. Intercropped maize with legumes increased CP, and decreased NDF and ADF concentrations in silages.However, for high yield of fresh biomass and DM yields, SM silage is recommended. Finally,among all intercropped silages the 1M3S (1 row maize to 3 rows soybean) was preferable according to nutrient composition than other intercropped silages.

Table 3: Nutrient composition of maize and maize soybean intercropped fodder (% DM).

	Fodder			
Nutrient composition	SM	1M1S	1M2S	1M3S
DM, %	35.1^{d}	36.1^{c}	40.1^{b}	41.2^{a}
CP, %	8.2^{c}	11.1^{b}	11.1^{b}	11.4^{a}
EE, %	2.1	2.1	2.2	2.3
Ash, %	6.4	6.3	6.3	6.4
NDF, %	43.1^{a}	40.6^{d}	40.8^{c}	40.9^{b}
ADF, %	24.3	24.1	24.1	24.2
WSC, %	10.3^{a}	8.9^{d}	9.0^{c}	9.3^{b}

Note: Different letters in the column mean significant difference ($p<0.05$). SM,monocrop maize;1M1S,1 row maize to 1 row soybean;1M2S,1 row maize to 2 rows soybean;1M3S,1 row maize to 3 rows soybean.

Table 4: Nutrient composition of maize and maize- soybean intercropped silage (%DM)

	Silage			
Nutrient composition	SM	1M1S	1M2S	1M3S
pH	4.1^{c}	4.4^{b}	4.4^{b}	4.7^{a}
DM, %	30.1^{d}	32.1^{c}	32.3^{b}	34.3^{a}
CP, %	8.4^{c}	12.1^{b}	12.1^{b}	12.7^{a}
EE, %	2.0	2.2	2.2	2.3
Ash, %	6.7^{a}	6.1^{d}	6.3^{c}	6.5^{b}
NDF, %	40.1^{a}	36.4^{d}	36.7^{c}	39.7^{b}
ADF, %	22.2^{a}	20.6^{c}	20.7^{c}	21.6^{b}

Note: Different letters in the column mean significant difference ($p<0.05$).
SM,monocrop maize;1M1S,1 row maize to 1 row soybean;1M2S,1 row maize to 2 rows soybean;1M3S,1 row maize to 3 rows soybean.

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