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Effect of Intercropping Maize (Zea mays L.) with Soybean (Glycine max L.) on Green Forage yield, and Quality Evaluation

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Abstract: *In this study effect of different planting patterns and harvest time of intercropping maize and soybean on green forage yield and nutritive quality of maize forage (Zea mays L.) was evaluated in the Department of Agronomy, Northwest Agriculture and Forestry University of Shaanxi, Yangling, China, during 2016.Maize was cultivated alone (SM) and intercropped with soybean as follows;1 row maize to1 row soybean (1M1S),1 row maize to 2 rows soybean (1M2S), 1 row maize to 3 rows soybean (1M3S) and 2 rows maize to 1 row soybean (2M1S).The intercropped of maize and soybean in different planting pattern significantly affected the quantitative and qualitative characters of the forage. The highest green fodder yields of SM were 46.2% in milk stage and 42.7% in dough stage .The highest crude protein yield (2.8 t/ha) was produced by 1M3S forage at the harvest time of milk stage. However, no difference (p>0.05) was observed in ether extract (EE) and Ash of nutrient composition of fodder among the five treatments. The NDF and ADF levels were higher for maize forage as compared to intercropped forages. The highest water soluble carbohydrate (WSC) concentration was obtained by sole maize compared with intercropped forages. The study showed that among all intercropped forages the 1M3S was preferable according to nutrient composition than other intercropped forages.*
Keywords: *Intercropping, Planting pattern, Maize, Soybean, forage*

I. Introduction

Maize (*Zea mays* L.) is the third most important cereal crop of the world. It is used as food, feed and forage. Maize fodder can safely be fed at all stages of growth without any danger of oxalic acid, prussic acid as in case of sorghum or fodders. Maize is the most suitable fodder crop for making silage. Therefore, it is called the king of crops suitable for silage [1].Intercropping of legumes and cereals are an old practice in tropical agriculture that dates back to ancient civilization. The main objectives of intercropping have been to maximize use of resources such as space, light and nutrients [2], as well as to increase crop quality and quantity [3] [4]. The current trend in global agriculture is to search for highly productive, sustainable and with more soil, increased microbial activity and can act as a deterrent to pests and weeds of the other crop. There is also evidence that suggests intercropping may benefit a non-legume which needs nitrogen if the other crop is a legume, since legumes will fix nitrogen in the soil [5].

Production of good quality fodder is of a great importance for the economical ruminant production. Both quality and quantity of fodder are influenced due to plant species [6], stage of growth [7] and agronomic practices [7] [8].The growing of fodder crops in mixture with legumes improved fodder palatability and digestibility [9]. Intercropping of cereals and legumes produce higher grain yields than either sole crop [3].In such intercropping, the yield increases were not only due to improved nitrogen nutrition of the cereal component, but also to other unknown causes [10]. Mixing of legumes in cereals is a better choice to enhance the quality of cereal fodders. It has been reported that dry matter yields of maize sown alone were greater than soybean intercropping. However, intercropping gave higher crude protein yields than maize alone [11]. Therefore, it is on considerable value to carry out an experiment on green fodder yield and fodder quality of maize in relation to different planting pattern and harvest time. For obtaining a good fodder of improved quality, an accurate balance of legumes and non- legumes in a mixture is very essential. The present experiment was carried out to study the potential of fodder yield and quality of maize and soybean sown alone and mixture with each other in different planting patterns.

II. Materials And Methods

2.1 Plant cultivation and fodder production

The field experiment was carried out during the crop growing season in summer 2016 at the North campus experimental area (34˚18' 00"N, 108˚ 5' 42" E) in Northwest Agriculture and Forestry University, Shaanxi, Yangling, China. The treatments were compared in 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), 1 row maize to 3 rows soybean (1M3S) and 2 rows maize to 1 row soybean (2M1S).The treatments used for this experiment is shown in Table 2. 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 14 June 2016 in a field which had previously been cropped with winter wheat. The maize and soybean were spaced at 70 cm x 25 cm and 30 cm x 15 cm 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. Initially 2-3 seeds were sown per hill. Twenty five days after sowing, the seedlings were thinned to retain one healthy seedling per hill. Three hand weeding procedures were applied 20, 30 and 40 days after sowing. Maize and soybean fodders were manually harvested simultaneously in three sampling areas in a total area of a 1 m^2 of each plot at two levels of maturity stages (milk stage and dough stage) in 19 September and 30 September 2016.The maximum and minimum daily air temperatures were 31 ˚C and 20˚C respectively, and precipitation was 600 mm during the crop production.

2.2 Determination of Nutrient Composition

Fodder was manually harvested and chopped into 3 to 4 cm in length with chaff cutter (JB 400, Power chaff cutter, Gujarat, India). The pH of fodder was determined on the aqueous extract of silage by pH meter. Samples were dried at 80 ˚C for 48 hrs and ground to pass through a 2 mm screen.The ground samples were ashed at 550 ˚C [12] [13] 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 [12].Neutral Detergent Fiber (NDF) and Acid Detergent Fiber (ADF) were determined with Van Soest *et al* [14] procedures. The water soluble carbohydrate (WSC) was determined by the anthrone method, using freeze dried samples, where the WSC was extracted with water [15]. Ca, Na and K were analysed by using Flame Photometer (FP 6431, Nanjing Everich Medicare Import and Export Co., Ltd, China).Magnesium and Phosphorus were analysed by colorimetry [12].All analyses were done in triplicate.

2.3 Statistical analysis

The data on yield and quality parameters were analyzed by One –way-ANOVA using SPSS (version -19) and Duncan test (α=0.05) was used to compare the treatments means.

III. Results And Discussion

3.1 Green fodder, dry matter and crude protein yields

Data regarding green fodder yield, dry matter and crude protein yield of monocrop and intercropped fodder as influenced by different planting patterns and harvest time are presented in table 3.Sole maize had a higher green fodder yield 46.2 t/ha and 42.7 t/ha at milk and dough stage than other intercropped forages, respectively. Various experiments have reported the best time to harvest maize for silage to improve yield and quality [16] [17]. Total biomass yield of intercropped maize per unit area tended to increase with increasing maize population [18]. Green fodder yield (GFY) and dry matter yield (DMY) were higher in SM fodder, followed by others fodder. DM yield characteristic is a very dependable parameter in agronomical studies [19] [20].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 than SM [21].On the other hand, maize in row intercropping had a marked depression effect on legume growth because of tall and leafy structure [22].Competition and unequal use of environmental or underground resource, 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 crude protein yield then the SM.The production of crude protein was also affected significantly by planting patterns and harvest time of maize and soybean. The maximum crude protein yield (2.8 t/ha) was obtained by 1M3S in milk stage and minimum crude protein (1.6 t/ha) was obtained by SM in dough stage. Crude protein has previously been shown to decline with increasing maturities [25]. Armstrong [26] reported that intercropping climbing beans with corn increased CP in the mixture, but also increased neutral detergent fiber concentration and decreased digestibility compared to monoculture corn. Dawo *et al* [27] reported that CP concentration increased 22 % in the mixture when corn proportion in the mixture decreased by 50 %. The results are in agreement with other studies where legumes also increased CP concentration when in mixture with corn [27] [28].Primitive effect of legume intercrops on protein concentration of main crop also been reported by Mpairwe *et al* [3] and Azraf-ul-Haq *et al* [29]. Maximum crude protein percentage (15.2%) was obtained in milk stage and minimum crude protein (12.3 %) was obtained in dough stage, the decrease of CP content with maturity reported by Ghanbri and lee [7].

3.2 Nutrient composition of fodder

Results of nutrient composition of maize and intercropped maize and soybean fodder are shown in table 4.The intercropped fodder were highly effective on pH compared to sole crop maize.There were significant differences between monocrop maize (SM) and intercrop fodder in pH ($p<0.05$), SM having the lowest pH 3.8 and 3.7 at harvest time of MS and DS, respectively.The DM contents of the fodder was shown in table 4.The 1M3S fodder had the highest DM value 41.2% and 29.1% at harvest time of MS and DS than the others fodder. In the present study it was determined that the crude protein value of intercropped fodder 1M1S, 1M2S, 1M3S and 2M1S 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 [28]. Dawo *et al* [23], reported that CP concentration increased 22 % in the mixture when corn proportion in the mixture decreased by 50 %.Present results are in agreement with other studies where legumes also increased CP concentration when in mixture with corn [27] [28] .No difference ($P> 0.05$) was found in ether extract (EE) and Ash of nutrient composition of fodder among the treatments.

Harvest time was also affected significantly on ADF; Maximum ADF (25.2%) was recorded by sowing maize alone at milk stage.The NDF contents was decreased ($p<0.05$) with the intercropping of maize with soybean at different planting patterns compared to maize fodder alone. A decline in fiber concentration with increasing maturity can be attributed to the dilution effect created by the increasing content of grain as corn matures [30].The presence of leguminous plants in the fodder 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 [31].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 [32].However, such as effect had not been observed in other experiments as no effect of intercropping was found on the NDF and ADF levels [31].When compared to SM, the maize intercropped fodder increased pH, and CP contents ($P<0.05$,) whereas decreased NDF and ADF ($p<0.05$) contents.Maximum WSC (10.3%) was recorded maize sown alone in dough stage. In maize WSC in milk stage lowest content and dough stage was highest content. An increase in WSC with increasing maturity can be attributed to the dilution effect created by the increasing content planting pattern of fodder as corn matures. Johnson and McClure [33] reported increased soluble carbohydrate in stalks from tasseling to the milk stage and a decline thereafter plots were established at University of Wisconsin Ag- with advancing maturity. The value of WSC of fodder tended to be sufficient for good fermentation required for the preservation of fodder in the form of silage [34]. Decrease in ash concentration with maturity could results from dilution of minerals as crop mature and agree with Ghanbari and Lee [7].No difference ($p>0.05$) was observed in Na ,K, P and Mg contents of nutrient composition of forages among the five treatments.Also Ca contents in the intercrop forages were higher ($p<0.05$) than SM.

IV. Conclusion

This study has thus clearly brought out the beneficial effects of maize – soybean intercropping for forage yield and quality. As a conclusion, intercropping is more productive than sole cropping. Maize-soybean intercropping increasing green fodder yield and forage quality of maize. Intercropped maize with legumes increased CP, and decreased NDF and ADF concentrations in forages. However, for high yield, SM fodder is recommended. The highest nutritive values were obtained by harvest time in milk stage. Finally, among all intercropped treatments the 1M3S (1 row maize to 3 rows soybean) was preferable according to nutrient composition than other intercropped fodder.

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Appendices

Table 1: Physical and chemical characteristics of the soil experimental area

Parameter	**Value**
Depth	20-40
Organic matter (%)	1.5
Texture	Sandy clay loam
Nitrogen (%)	0.2
Phosphorus (ppm)	0.3
Potassium (ppm)	400
pH	8.3

Table 2: The description of experimental treatments

Treatment	Description
SM	Sole 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
2M1S	2 rows maize to 1 row soybean

Table 3: Mean values of green fodder yield, dry matter and crude protein yield of monocrop and intercropped fodder as influenced by different planting patterns and harvest time based on Duncan test

Fodder	Yields (ton/ ha)					
	GFY		DMY		CPY*	
	MS	DS	MS	DS	MS	DS
SM	46.2a	42.7a	14.4a	12.3a	1.9d	1.6c
1M1S	36.7d	31.2d	12.1d	10.2d	2.2c	2.1b
1M2S	36.9d	31.3d	12.1d	10.3d	2.2c	2.1b
1M3S	40.4b	37.1b	12.6b	11.5b	2.8a	2.4a
2M1S	37.3c	34.1c	12.4c	11.1c	2.6b	2.1b

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;2M1S,2 rows maize to 1 row soybean ; GFY, green fodder yield; DMY, dry matter yield; CPY, crude protein yield; MS, milk stage; DS, dough stage

*On dry matter basis

Table 4: Mean values of quality parameters as influenced by different planting patterns and harvest time of monocrop and intercropped fodder based on Duncan test

Quality Parameter %	Fodder									
	SM		1M1S		1M2S		1M3S		2M1S	
	MS	DS	MS	DS	MS	DS	MS	DS	MS	DS
pH	3.8c	3.7c	4.1b	3.9b	4.2b	3.9b	4.4a	4.2a	4.2b	4.0b
DM,%	35.1d	20.2d	36.1c	24.4c	40.1b	25.8b	41.2a	29.1a	40.2b	25.8b
CP,%	8.2c	7.9c	11.1b	10.1b	11.2b	10.1b	11.4a	10.3a	11.2b	10.2b
EE,%	1.9	1.8	1.8	1.7	1.9	1.8	1.9	1.8	1.9	1.9
Ash,%	6.2	6.1	6.1	6.1	6.2	6.1	6.2	6.1	6.2	6.1
NDF,%	42.1a	40.2a	32.4d	31.1d	32.5d	31.2d	40.2b	38.3b	34.6c	32.3c
ADF,%	25.2a	24.1a	20.1c	20.1b	21.1c	20.1b	22.3b	20.1b	21.0c	20.0b
WSC,%	9.8a	10.3a	8.6c	8.9c	8.7c	8.9c	8.9b	9.3b	8.7c	8.9c
Ca,%	0.25c	0.20c	0.31b	0.22b	0.32b	0.22b	0.35a	0.24a	0.32b	0.22b
Na,%	0.15	0.14	0.16	0.14	0.16	0.14	0.17	0.15	0.16	0.14
K,%	2.4	2.2	2.4	2.2	2.4	2.2	2.4	2.2	2.4	2.2
Mg,%	0.31	0.22	0.32	0.21	0.31	0.21	0.32	0.22	0.31	0.22
P,%	0.32	0.31	0.31	0.31	0.32	0.32	0.33	0.32	0.32	0.32

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;2M1S,2 rows maize to 1 row soybean ; GFY, green fodder yield; DMY, dry matter yield; CPY, crude protein yield; MS, milk stage; DS, dough stage