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Effects of Different Planting Pattern of Maize (*Zea mays* L.) and Soybean (*Glycine max* (L.) Merrill) Intercropping in Resource Consumption on Fodder Yield, and Silage Quality

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Abstract

An experiment was carried out at the field units of the north campus experimental areas in Northwest Agriculture and Forestry University, Yangling, Shaanxi Province, P. R. China. The experiment was conducted on summer season (June to September) to determine the effects of different planting patterns of maize and soybean intercropping in resource consumption on fodder yield and silage quality. The main treatments were one sole crop of maize (SM) and four maize-soybean intercropping patterns (1 row maize to 1 row soybean (1M1S), 1 row maize to 2 rows soybean (1M2S), 1 rows maize to 3 rows soybean (1M3S) and 2 rows maize to 1 row soybean (2M1S), respectively. The experiment was a randomized complete block design with three replications, and plot size of 12 m by 5 m. The crops were harvested when the maize reached at milk stage and soybean at R7 stage. The result indicated significant increase in fresh biomass and dry matter production of maize fodder alone as compared to maize intercropped with soybean fodder. It was correlated with a higher consumption of environmental resources, such as photosynthetically active radiation (PAR) and soil moisture by intercropping. After 45 days of ensiling period, silage samples were analyzed for pH, organic acids (Lactic, acetic, and butyric), dry matter (DM), crude protein (CP), ether extract (EE), neutral detergent fibre (NDF), acid detergent fibre (ADF), calcium (Ca), sodium (Na), phosphorus (P), magnesium (Mg), and potassium (K). It was concluded that in all intercropped silages, crude protein (CP) values were higher (1M1S, 12.1%; 1M2S, 12.2%; 1M3S, 12.4%; 2M1S, 12.1%) than the monocrop maize (SM, 8.7%) silage. Higher organic acids ($p < 0.05$) were produced in the 1M3S silages as compared to others silages. The study indicated that among all intercropped silages, the 1M3S (1 row maize to 3 rows soybean) was preferable according to nutrient composition than other intercropped silages.

Keywords

Intercropping Patterns, Maize-Soybean, Resource Consumption, Fodder, Silage Quality

1. Introduction

Maize (*Zea mays.* L) played an important role in China's food system since it was introduced from the American continent in the 1500s. The introduction of maize contributed to a surge of Chinese population growth as its cultivation expanded on hillsides and other marginal land [1]. Maize has the potential to supply large amounts of energy-rich forage for animal diets, 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 [2]. It can be grown in warm temperate, continental and tropical climatic zones. It is major forage specie and can be used as primarily in the production of whole plant maize silage [3]. The importance of maize was magnified when its use as an animal feed became common in the late 20th century. Feed became the dominant use as the commercial livestock sector grew. In the 21st century, China also began increasing industrial uses of maize for production of starches, alcohol, sweeteners, feed additives, and chemicals while feed use continued growing [4].

As a cultivation system, intercropping involves the planting of two or more crop species on the same field [5] [6]. Intercropping maize with legumes for silage is a feasible strategy to improve crude protein level (CP) [7] [8] [9]. Proper spatial arrangements, planting proportions and the maturity dates of components in maize-grain legume intercropping improve biodiversity and have many advantages over pure maize cropping. Although maize provides high yield in terms of dry matter, it produces forage with low protein content. However, protein is needed by livestock for growth and milk production. Protein is also needed by rumen bacteria which digest much of the feed for ruminant animals [10]. Because of low protein content, maize hay is usually lower than that of required to meet satisfactory production levels for many categories of livestock [11]. Toniolo *et al.* [12] observed significantly higher CP content of maize-soybean intercropping than that of monocropped maize. Javanmard *et al.* [13] worked on intercropping of maize with different legumes, pointed out that dry matter yield and crude protein yield of forage were increased by all intercropping compositions as compared with the maize monoculture. The use of maize grown for ensilaging and the seeding of soybean with maize in alternate-rows as

1 maize + 1 soybean or 1 maize + 2 soybeans highly increased the silage quality and CP content [14].

The intercropping yields are often higher than in sole cropping systems [15]. The reasons are mainly that resources such as water, light and nutrients can be utilized more efficiently than in the respective sole cropping systems [16]. The underlying principle of better resource use in intercropping is that, if crops differ in the way they utilize environmental resources when grown together, they can complement each other and make better combined use of resources than when they are grown separately [10]. It was reported [17] on intercropping considered resource use as the biological basis for obtaining yield advantages. Yield advantages occur when intercrop components compete only partly for the same plant growth resources, and inter specific competition is less than intra-specific competition [18]. Ideally, cultivars suitable for intercropping should enhance the complementary effects between species [19]. Light, water and nutrients are more completely absorbed and converted to crop biomass by intercropping. This is a result of differences in competitive ability for growth factors between intercrop components [20]. Efficient utilization of available growth resources is fundamental in achieving sustainable systems of agricultural production. Intercropping can conserve soil water by providing shade, reducing wind speed and increasing infiltration with mulch layers and improved soil structure [21]. Surface soil temperatures, in a similar environment, fluctuated from near 20˚C at night to over 50˚C at midday in unmulched soil, whereas surface temperature of mulched soil ranged from near 20˚C at night to 38˚C during the day [22]. At a depth of 10 cm, midday temperatures were 30˚C in the mulched soil and 36˚C in the unmulched soil. Wet soils buffered soil temperature fluctuation more than dry soils.

The present study was designed to determine the effect of different patterns of maize-soybean intercropping in resource consumption on fodder yield and silage quality. The hypotheses we tested were: intercropping is better in a) light capture, b) soil water conservation, c) fodder yield and d) silage quality by increasing protein content, compared to sole maize.

2. Materials and Methods

2.1. Plant Cultivation and Fodder Production

A field experiment was carried out during the growing season in summer June, 2016 at the North campus experimental areas (34˚18'00"N, 108˚5'42"E) in Northwest Agriculture and Forestry University, Shaanxi, Yangling, China. The experiment was established on a sandy clay loam soil with 8.3 pH (**Table 1**). The previous crop was winter wheat which was harvested in May 20, 2016. After that, wheat straw was removed from field. The meteorological data of experimental site are given in **Table 2**.

The crop production was carried out with a randomized complete block design with three replicates. Summer maize (*Zea mays* L. Zheng Dan 958) was seeded as monocrop (SM) and intercropped with soybean (*Glycine max* L. Zao

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

Parameter	Value
Depth (cm)	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. Meteorological data for maize-soybean intercropping area in 2016.

Month	Minimum temp (˚C)	Maximum temp (˚C)	Relative humidity (%)	Rainfall (mm)
June	29.8	39.3	26	NR
July	27.2	38.2	20	NR
August	24.3	37.3	24	NR
September	19.6	29.4	34	1.5

NR = no rainfall.

Huang) as provided in **Table 3**. Summer maize (*Zea mays L.*) local variety known as "Zheng Dan 958", it has red grain color, and takes 90 to 110 days to mature. Its seed was obtained from Seed Company Agricultural Technology Extension Station .The soybean (*Glycine max* L. Zao Huang) crop variety known as local and annual varieties, which matures at 60 to 75 days. These soybeans were obtained from farmer at seed company township station. The treatment comprising the individual plot size was 12 m × 5 m. The maize and soybean were spaced at 70 cm × 25 cm and 30 cm × 15 cm with population of about 114,200 and 666,677 plants per hectare, respectively. The site of experiment was ploughed to 0.2 - 0.3 m depth after the removal of winter wheat straw, followed by harrowing prior to drilling the trial. All plots were fertilized with the same amount of fertilizer before sowing, containing 70 kg of N ha^{-1}, 70 kg P_2O_5 ha^{-1} and 70 kg of K_2O ha^{-1}. Maize and soybean were sown to a depth of approximately 7 and 5 cm respectively by hand in June 26, 2016. Seed rates of 10 and 38 seeds of maize and soybean, respectively, per m^2 were sown to allow for thinning down to an approximate plant population of 6.7 and 20 plants per m^2. None of the soybean seeds were inoculated with *Rhizobium*. Neither herbicides nor were pesticides used. Hand weeding by hoe was done once when the maize was approximately 30 cm in height. During the experimental period, the field was irrigated 3 times with 30 days interval.

2.2. Measurement

Photosynthetically active radiation (PAR) was measured two times during the

Table 3. 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

crops growing season (30 and 60 days after sowing) between 12 - 14 hours on occasions. A Sun fleck ceptometer (model SF-80T) was used to measure above the plant canopy and the soil surface at 5 randomly selected locations within each plot. Mean values for each plot were then used to calculate the percentage of PAR intercept by plant canopy. Percentage of PAR intercept was calculated according to the formula as follows:

$$\%\text{PAR intercepted} = \frac{\left(\text{PAR}_a - \text{PAR}_b\right)}{\text{PAR}_a} \times 100$$

where PAR_a is PAR above the canopy and PAR_b is PAR below the canopy. The soil water balance was estimated to be influenced by different cropping systems. Soil water content at 0 - 0.25 m depth was determined on two occasions (30 and 60-days after sowing) during the growing season. Soil samples were taken from three locations within each plot and a well mixed sample was used to determine soil moisture content by gravimetric measurement. Soil temperature was also recorded at a depth of 0 - 10 cm below the surface on two occasions in all plots, using a soil thermometer.

2.3. Silage Preparation

The fresh fodders were manually harvested when the maize reached at milk stage and soybean at R7 stage and chopped into 2 to 4 cm in length with chaff cutter (TZ9Z-0.4, Power chaff cutter, Henan, China) 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 air-tight and kept at room temperatures to permit for anaerobic fermentation for 45 days. Before fermentation, samples of 300 to 500 g 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 further nutritive values. The fodder and silage samples were air-dried and ground by grinder and then flour samples were stored into a refrigerator for further chemical analysis.

2.4. Determination of Nutrient Composition

A 10 g sample was taken, mixed with 100 ml of distilled water and stored in a refrigerator at 5˚C for 24 hrs. Then, the material was filtered and pH was determined on the filtrate with a glass electrode pH meter (PHS-3C, CSDIHO Co., Ltd, Shanghai, China). Dry matter (DM) content was determined by oven drying at 80˚C for 24 hrs and ground to pass through a 2 mm screen. The ground samples were ashed at 550˚C [23] [24] 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 methods (AOAC, 2000). Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were determined with Van Soest *et al.* [25] procedures. Ca, Na, and K were analysed using Flame Photometer (FP 6431, Nanjing Everich Medicare Import and Export Co., Ltd, China). Organic acids [26] (Lactic, acetic, and butyric) were analysed by high pressure liquid chromatography (SPD-20A, Shimadzu Co., Ltd, Kyoto, Japan).

2.5. Statistical Analysis

Data of maize and soybean fodder yields, and chemical analysis of different silages was analyzed by One-way analysis of variance (ANOVA) using SPSS (version 21.0) and Duncan test ($\alpha = 0.05$) was used to compare the treatments means.

3. Results

3.1. PAR Interception

The percentage of PAR interception was significantly ($P < 0.05$) affected by cropping system (Table 4). The mean of PAR interception averaged over sampling dates by intercrop treatments was significantly ($P < 0.05$) higher than that of sole cropped maize at 30 DAS and 60 DAS (Table 4).

3.2. Soil Temperature

Soil temperature was significantly ($P < 0.05$) affected by cropping systems. At 30 DAS and 60 DAS, the soil temperatures for intercrop treatments were significantly lower than that of sole cropped maize (Table 5).

3.3. Soil Moisture Content

The moisture content of soil, determined by gravimetric method, was significantly ($P < 0.05$) influenced by cropping system (Table 6). Moisture content of soil in sole cropped maize at 30 DAS and 60 DAS sampling dates were lower than for intercrop treatments.

3.4. Fodder Yield

Green fodder yield and nutrients composition of maize and maize intercropped with soybean at different planting structure are shown in Table 7. The fresh fodder and DM yields were ranged from 31.9 to 46.2 t/ha and 12.1 to 14.5 t/ha (Table 7). Monocrop maize (SM) had a higher fresh biomass yield (46.2 t/ha) than other intercropped fodder. Fresh forage and DM yields were higher in SM fodder, followed by four intercropped fodder. Maize mixed with soybean possessed better fodder CP yields (2.2 - 2.6 t/ha) than the SM.

Table 4. Effect of different cropping system on percentage of PAR interception by crop canopies.

Cropping system	PAR %	
	30 DAS	60 DAS
SM	31.8b	60.1b
1M1S	37.3a	66.8a
1M2S	37.6a	67.1a
1M3S	36.9a	66.4a
2M1S	37.1a	66.6a

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; DAS, day after sowing.

Table 5. Effect of different cropping system on soil temperature at 0 to 10 cm depth (˚C).

Cropping system	Soil temperature (˚C)	
	30 DAS	60 DAS
SM	29.0a	29.0a
1M1S	27.9b	28.0b
1M2S	28.0b	28.2b
1M3S	27.9b	28.2b
2M1S	27.8b	28.2b

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; DAS, day after sowing.

Table 6. Effect of different cropping system on percentage of soil moisture content at 0 to 20 cm depth.

Cropping system	Soil moisture content (%)	
	30 DAS	60 DAS
SM	12.3b	60.0b
1M1S	15.7a	73.1a
1M2S	15.6a	73.5a
1M3S	15.8a	72.1a
2M1S	15.6a	72.6a

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; DAS, day after sowing.

Table 7. Fresh biomass, dry matter and crude protein yield of maize and maize-soybean intercropped fodder.

Fodder	Yields (ton/ha)		
	Fresh biomass	Dry matter	Crude protein*
SM	46.2a	14.5a	1.9d
1M1S	31.9e	12.1d	2.3b
1M2S	34.5d	12.1d	2.4b
1M3S	36.4c	12.3c	2.6a
2M1S	40.3b	13.2b	2.2c

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. *On dry matter basis.

3.5. Fermentation Quality of Silages

Results of fermentation quality of different silages are shown in Table 8. Desirable pH values were found in all the silages. There were significant differences between monocrop silages (SM) and intercrop silages in pH ($P < 0.05$), SM having the lowest pH (3.8). Higher organic acids (lactic, acetic, and butyric) ($P < 0.05$) were produced in the 1M3S silages as compared to others silages.

3.6. Nutrient Composition of Silages

Results of nutrient composition of different silages are depicted in Table 9. The DM contents of the silages were between 29.2% to 32.1%. The 1M3S silage had the highest DM value (32.1%) than the other silages. When compared to SM, the maize intercropped silages increased CP contents ($P < 0.05$), whereas decreased NDF, ADF, and ash ($P < 0.05$) contents. No difference ($P > 0.05$) was found in Na, K, P and Mg contents of nutrient composition of silage among the five treatments. Also Ca contents in the intercrop silages were higher ($P < 0.05$) than SM.

Table 8. Fermentation quality of maize and maize-soybean intercropped silage (%DM).

Parameter	Silage				
	SM	1M1S	1M2S	1M3S	2M1S
pH	3.8d	4.1c	4.2b	4.4a	4.1c
Lactic acid	9.0c	11.1b	11.2b	12.1a	11.2b
Acetic acid	9.2e	10.2d	10.5b	13.1a	10.3c
Butyric acid	2.1c	2.1c	2.9b	3.1a	2.1c

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.

Table 9. Nutrient composition of maize and maize-soybean intercropped silage (% DM).

Nutrient composition	Silage				
	SM	1M1S	1M2S	1M3S	2M1S
DM, %	29.2d	30.2bc	31.7b	32.1a	30.1c
CP, %	8.7c	12.1b	12.2b	12.4a	12.1b
Ash, %	7.7a	7.2dc	7.3c	7.3b	7.2c
NDF, %	40.1a	29.9d	36.1c	38.1b	30.2d
ADF, %	22.1a	18.2d	20.4c	20.7b	18.2d
Ca, %	0.25c	0.31b	0.32b	0.35a	0.31b
Na, %	0.15bc	0.16b	0.16b	0.18a	0.16b
K, %	2.2a	2.3ab	2.3ab	2.3ab	2.3ab
Mg, %	0.19b	0.21ab	0.21ab	0.22a	0.21ab
P, %	0.30c	0.31b	0.32ab	0.33a	0.31b

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.

4. Discussion

Planting pattern is the systematic evaluation of the farm area or any growing surface for crop production. Different systems of planting patterns within the row are practiced in both single and multiple rows planting, depending on the characteristics and requirement of the crop, particularly its extent of canopy expansion. In the present study, maize fodder alone was significantly increased fresh biomass and dry matter production than the other intercropped fodder (**Table 7**). Maize and soybean PAR interception at 30 DAS and 60 DAS was showed in (**Table 4**), respectively. Therefore, solar radiation which would be otherwise wasted due to poor growth of maize early in the season, and soybean leaf senescence at the end of the season can be utilized more efficiently by maize-soybean intercropping. Thus, intercrop canopies can intercept PAR more effectively than sole crop. So, as concluded by Eskandari and Kazemi [27], intercropping are leading to increase the total amount of PAR captured and PAR seem to play a fairly important role in determining total intercrop production. Tsubo *et al.* [28] also reported that intercrops intercept more PAR than sole crops in maize-bean intercrops.

The differences in vertical display of plants and canopy design of intercrop components, may lead to more PAR interception by intercropping compared with sole crops [29]. Moreover, there are PAR interception by various intercropping systems has been reported [10]. The PAR interception is essential to play a very important role in determining total intercrop production. The interception highlighted the cause of higher shedding, therefore soil temperature become lower these findings are agree with Harris and Natarajan [30], further it's reported that the micro climate within the cover of cropping systems were changed, so that shading reduced soil temperature. Thus, it seems that percent of light interception is major factor affecting on soil temperature. The soil temperature was altered by the cropping system which agrees with the other researchers finding of Eskandari *et al.* [31], so that soil temperatures under intercrops and bean sole crops were lower than under wheat sole crops. This could be due to higher light interception (**Table 5**), and it's causing a higher shading and decreases temperature, which are agreement with the finding of Harris and Natarajan [30]. Moreover it's reported by Eskandari *et al.* [31], that the light interception by canopies would be a major factor affecting soil temperature. Intercropping is a more efficient at exploiting a larger total soil volume if component crops have various rooting habits, especially depth of rooting [32]. The soil water content at 30 DAS and 60 DAS in maize-soybean intercropping were higher than sole crop (**Table 6**). One explanation for with intercrops could be as a result of more soil exploration by root system of intercrop, resulting in a drier soil profile compared to that for sole crop.

The chemical (DM, yield) and physiological (growth and development) differences among intercrop components result in their ability to occupy different function. Thus, environmental resources could be more efficiently utilized then intercropping converted to biomass by mixed stands of crops than by pure stands. Therefore, in the present experiment, more PAR interception and also a greater water extract (**Table 4**) by intercrops could be the major reason for the greater dry weight observed for intercropping over sole cropping. Greater resource use by intercrops was considered as the biological basis for obtaining yield advantages [29]. Dry matter for all intercrop treatments was greater than those of sole crops. More PAR interception, nutrient uptake and also greater water extract by intercrops could be the major reason for greater dry weight observed for intercropping over sole cropping. Greater resource use by intercrops was measured as the biological basis for obtaining yield advantage [10]. Hauggaard-Nielsen *et al.* [33] reported that the pea-barley intercrop used light, soil water and nutrients more efficiently than sole crops due to differences in the competitive ability for environmental sources for plant growth.

The optimum Dry Matter (DM) range of ideal maize silage is between 28% and 32% [34]. The DM level was related to the fermentation conditions of the material [6]. DM yield characteristic is a very reliable parameter in agronomical studies [35]. 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 sole maize [36]. On the other hand, maize in row intercropping had a marked depressing effect on legume growth because of canopy structure [37]. The various use of environmental or underground resources, such as light and water, look like to account for problems experienced on intercropped communities. These imbalances appear as factors may have negative effects on crop yield [38]. Maize mixed with climbing bean possessed better fodder CP yields (2.2 - 2.6 t/ha) than the SM. The results suggested that the contributions provided by legume components in the mixtures increased CP yields of fodder.

The effects of the soybean mixtures on silage fermentation were in the directions expected. Legumes have larger organic acid concentrations than grasses; therefore, in general legume silages have higher pH because of the higher buffering capacity caused by the organic acids [39] [40]. Anil *et al.* [41] found pH values of 3.8 to 4.7 and average of 3.8, respectively, in silages of intercropping of maize and soybean. Silage made from the maize-soybean mixtures in our study contained greater lactic and acetic acid concentrations than that of sole maize. Anil *et al.* [41] also reported an increase in lactic acid concentration when maize was ensiled in mixture with other legumes. According to them, a more intense fermentation resulted from the lower DM content of the mixture compared with sole maize. The values are close to and sometimes within the parameters considered ideal for a silage of quality. Costa *et al.* [6] found values of 7.0% to 11.8% lactic acid in the DM of the maize silage. Anil *et al.* [41] evaluated maize silages with the addition of 30, 40 and 50% of soybean, and reported lactic acid values of 4.8; 5.0; and 5.1% in the DM, respectively. The butyric acid content in the silages is also as indicator of its quality [34] and, silages of leguminous plants which present adequate fermentative process posses butyric acid contents inferior to 0.5%, and silages of perennial grasses contents of 0.5% to 1.0%.

The main objectives of intercropped silage are to attain 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, 1M3S, and 2M1S were ($P < 0.05$) higher as compared to SM. Legumes are good sources of protein. The intercropping of maize with a variety of protein rich forages could enhance silage CP level by 3% - 5% and improve N digestibility, indicating a potential to reduce the requirement for purchased protein supplements [41]. The NDF contents of the silages varied from 29.8% to 40.2%. The presence of legume crops 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 [6]. In addition, NDF level is associated to the maturity stage of the forage sources, because of levels of cell wall components, mainly the cellulose, hemicellulose, and lignin [42]. However, such an effect had not been observed in other experiments as no effect of intercropping was found on the NDF and ADF levels [6]. 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 K contents of nutrient composition of silage among the four treatments. Also Ca contents in the intercrop silages were higher ($P < 0.05$) than the SM silage. The intercropped silage 1M3S had higher nutrient composition than the others intercropped silages [42].

5. Conclusion

The conclusion of present study demonstrated that intercropping of maize with soybean at various planting structure showed to be an effective way to influence fresh biomass production, dry matter and crude protein to maintain or enhance nutrient quality of silage ensuring the supply of nutritionally rich silage for livestock feeding. Finally, it can be concluded that environmental resource consumption, especially PAR interception in intercropping system was better than sole crop. The results of this experiment could provide some quantitative evidence for the hypothesis that greater environmental resources consumption (such as PAR and soil moisture) by intercrops is a primary advantage on fodder performance. After concluding results, it's showed that intercropping of maize with soybean influenced CP, and decreased NDF and ADF concentrations in silages. Therefore, for high yield of fresh fodder and DM yields, SM silage is recommended on huge levels. Finally, among all intercropped silages the 1M3S (1 row maize to 3 rows soybean) was preferable according to nutrient composition and nutritive values in silage.

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