

Influence of Intercropping Maize with Cowpea on Forage Yield and Quality

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In this study, maize (*Zea mays* L.) and cowpea (*Vigna unguiculata* L.) were intercropped in different sowing densities and their monocropping equivalents and tested to determine the best intercropping system on forage yield and quality. Maize was cultivated alone 75 000 plants ha⁻¹ (SM) and intercropped with cowpea as follows: 75 000 plants ha⁻¹ of maize and 37 500 plants ha⁻¹ of cowpea (MC₁), 75 000 plants ha⁻¹ of maize and 50 000 plants ha⁻¹ of cowpea (MC₂) and 75 000 plants ha⁻¹ of maize and 75 000 plants ha⁻¹ of cowpea (MC₃), in rows alternating with maize. The highest dry matter yield was produced by MC₃ (20.6 t ha⁻¹), and the lowest by SM (19.3 t ha⁻¹). All intercropped systems

had higher crude protein content MC₁ (96 g kg⁻¹ DM), MC₂ (107 g kg⁻¹ DM) and MC₃ (120 g kg⁻¹ DM) than the monocrop maize (76 g kg⁻¹ DM). Intercropping of maize with cowpea reduced neutral detergent and acid detergent fiber content of harvested forage, resulting in increased forage digestibility. Intercropping maize with cowpea could substantially increase forage quantity and quality, and decrease requirements for protein supplements as compared with monocrop maize.

Keywords: intercropping, monocrop maize, cowpea, yield, quality

INTRODUCTION

In many regions of Europe, whole-plant maize silage is the basic feed used in feeding cows and fattening cattle. Despite its high energy content, the protein content is low (88 g kg⁻¹) compared with legumes silage (Anil *et al.*, 2000) and needs to be supplemented with proteins for better feed quality (Stoltz *et al.*, 2013). As a cultivation system, intercropping involves planting two or more crops species in the same field (Costa *et al.*, 2012). Intercropping maize with legumes for silage is a feasible strategy to improving the level of crude protein (Prasad *et al.*, 2005; Contreras-Govea *et al.*, 2009; Zhu *et al.*, 2011). Javanmard *et al.* (2009), worked on intercropping of maize with different legumes, and showed that dry matter yield and crude protein yield of forage were increased by all intercropping compositions compared with the maize monocrop. Dahmardeh *et al.* (2009) concluded that intercropping of maize and cowpea resulted in more digestible dry matter and also crude protein content than maize mono-cropping. Physiological and morphological

differences between intercrop constituents influenced their ability to use resources; especially cereals with legumes, have several advantages such as higher overall yields, better soil utilization (Dhima *et al.*, 2007), yield stability of the cropping system (Lithourgidis *et al.*, 2006), better use of light, water and nutrients (Javanmard *et al.*, 2009), improved soil conservation (Anil *et al.*, 1998), soil fertility through biological nitrogen fixation, increased soil conservation through greater soil coverage as compared to sole cropping, and ensured better soil-susceptible crop in monoculture (Lithourgidis *et al.* 2006) and better control of pests and weeds (Banik *et al.*, 2006; Vasilakoglou *et al.*, 2008). Atmospheric nitrogen fixation using legumes plants can be reduced nitrogen competition in the reciprocal intercropping system of legumes and cereals enabling the cereals to use more nitrogen in the soil (Eskandari *et al.*, 2009). This can be affected the quality of the fodder intercrop components because the protein content is directly related to the

content of nitrogen in the forage plants (Putnam *et al.*, 1985). The study was designed to investigate the influence of different patterns of maize-cowpea intercropping on the yield and quality of forage.

MATERIALS AND METHODS

A field experiment was carried out during the 2017 growing season at experimental fields in Daruvar (45°35'34"N, 17°13'25"E), Croatia. Meteorological data of the experimental site are presented in (Table 1) (Statistical Yearbook of the Republic of Croatia, 2018). The experiment was set up as a randomized complete block design with three replicates. Maize hybrid seed (KWS Kolumbaris) was obtained from Seed Company "KWS" from Germany. Seed of the cowpea cultivar "Dolga vigna" was obtained from Company "Sjemenarna" from Slovenia. The treatment comprising the individual plot size was (50×2.8) m. The maize population 75 000 plants ha⁻¹ (SM) were spaced at 70 cm × 19 cm and cowpea population 37 500 (MC₁), 50 000 (MC₂) and 75 000 plants ha⁻¹ (MC₃) were spaced at 70 cm × 38.1 cm, 70 cm × 28.6 cm and 70 × 19 cm, respectively, in rows alternating with maize. Basic tillage was carried out by ploughing to 30 cm depth. Pre-sowing preparation was done using a tractor-mounted rototiller. All plots were fertilized with the same amount of fertilizer before sowing, containing 200 kg of N ha⁻¹, 100 kg P₂O₅ ha⁻¹ and 200 kg of K₂O ha⁻¹. Maize and cowpea were sown to a depth of approximately 5 cm by maize drill in May 3, 2017. Herbicide Wing P (active substance 212.5 g/l dimethenamide-p and 250 g/l pendimethalin) was applied pre-emergence in intercropping maize with cowpea at a dose of 4 l ha⁻¹. The soil of the study area has an acid pH 5.7 reaction (M-KCl), humus (2.1%), poorly supplied with physiologically active phosphorous (14.9 mg P₂O₅/100 g soil), medium supplied with physiologically active potassium (21.5 mg K₂O/100 g soil) and richly supplied with total nitrogen amounting to 0.15%. The fresh fodders were manually harvested when the maize reached soft dough stage and cowpea at R8 stage (full maturity, 95% of the pods are mature in color) and then chopped into 20 mm size pieces with a chaff cutter. Method of analyses: The dry matter content was determined by drying in an oven at a temperature of 65°C to a constant mass. Crude protein was measured according to Kjeldahl (AOAC, 2000), neutral and acid detergent fibres according to Van Soest *et al.* (1991), calcium, potassium were analysed by atomic absorption spectrophotometry by analyzer Spectrophotometer 2010 Model M530 Infrared Spectrophotometer (USA) and phosphorus was analysed by colorimetry (AOAC, 2000). The water soluble carbohydrate (WSC) was determined by the anthrone method, using freeze dried samples, where the WSC was extracted with water (Thomas, 1977). Statistical analyses: Analyses of variance were made for fresh

forage and dry matter yield and forage quality parameters (P<0.05), and the Tukey test was used for comparing means (P<0.05). Data were analyzed using SAS statistical software (SAS Inst. 2002).

RESULTS AND DISCUSSION

Table 2 showed the yield of forage and dry matter of maize intercropped with cowpea. The differences in the yield of forage are significant and yield of dry matter are significant (P<0.05). The yield of forage and dry matter yield ranged from 65.8 t ha⁻¹ (MC₃) to 51.3 t ha⁻¹ monocrop maize (SM) and 20.6 t ha⁻¹ (MC₃) and 19.3 t ha⁻¹ monocrop maize in 2017. The average yield of forage over the one year showed that MC₃ was the best intercropping production system with significantly higher yield of fresh forage compared to monocrop maize (Table 2).

According to the results, when cowpea seed number is increased in intercrop, fresh forage and dry matter yields on parcels increased. One of the possible explanations for higher yields of intercrops is the ability of the crops to exploit different soil layers without competing with each other. Besides, higher consumption of environmental resources, agronomic practices, crop genotypes, photosynthetic active radiation and soil moisture during the rainy season may affect yield and potential use of the intercropping system (Ofori *et al.*, 1987; Anil *et al.*, 1998; Lithourgidis *et al.*, 2006). Cowpea can be intercropped with maize (Dahmardeh *et al.*, 2009) and sorghum (Azraf *et al.*, 2007) for a higher yield and quality compared with sole cropping. Geren *et al.* (2008) and Htet *et al.* (2016) showed that legume contribution to maize in mixtures was significant and increased the total biomass yield of mixtures. One of the main reasons of intercropping maize and cowpea is the increase crude protein level in silage. Since crude proteins are very important in cattle fodder, silage containing more crude proteins is desirable. In this study it was found that the content of crude proteins of intercropped fodder MC₁, MC₂ and MC₃ was significantly (P<0.05) higher than monocrop maize during a one year study (Table 2). According to the results, when cowpea seed number is increased in intercrop, the content of crude protein in the mixture increased. Cowpea fodder is a rich source of crude protein, giving up to 184 g kg⁻¹ (Khan *et al.*, 2010). Furthermore, protein content of cowpea forage (220 g kg⁻¹) was higher compared to some legumes such as lablab (*Lablab purpureus* L.), mucuna (*Mucuna pruriens* L.) and grass species (*Sorghum sudanense* (Piper) Stapf), though it was the species least consumed by goats (Gwanzura *et al.* 2011). Dahmardeh *et al.* (2009) concluded that maximum crude protein percentage of forage was obtained at the milky stage and minimum crude protein was achieved at the dough stage of maize growth in maize-cowpea intercropping. Results in the present study were in

Table 1. Air temperature and rainfall by month during the 2017 growing season.

Meteorological data	Month					
	April	May	June	July	August	September
Air temperature (°C)	10.9	16.5	21.8	22.9	22.4	14.7
Rainfall (mm)	62.8	45.0	70.3	71.9	29.0	121.7

Table 2. Fresh forage, dry matter and crude protein yield of maize and maize-cowpea intercropped.

Items	Treatments			
	SM	MC ₁	MC ₂	MC ₃
Fresh forage yield (t ha ⁻¹)	51.3 ^c	55.1 ^{bc}	60.4 ^{ab}	65.8 ^a
Content of dry matter (g kg ⁻¹)	376 ^a	356 ^b	331 ^c	313 ^d
Dry matter yield (t ha ⁻¹)	19.3 ^a	19.6 ^a	20.0 ^a	20.6 ^a
Crude protein yield (t ha ⁻¹)	1.47 ^d	1.88 ^c	2.14 ^b	2.47 ^a

Means within a row marked with different letters are significantly different at (P<0.05).

Table 3. Nutrient composition of maize and maize-cowpea intercropped fresh forage (g kg⁻¹ dry matter).

Nutrient composition	Treatments			
	SM	MC ₁	MC ₂	MC ₃
Crude protein	76d	96c	107b	120a
Neutral detergent fiber	375a	357b	334c	322d
Acid detergent fiber	190a	177b	168c	159d
Ash	34b	39ab	41a	43a
Potassium	5.4b	6.1a	6.3a	6.7a
Phosphorus	2.1c	2.2bc	2.3ab	2.4a
Calcium	3.4 ^d	3.8c	4.0b	4.2a
Water soluble carbohydrate	133 ^a	115b	110bc	100c

Means within a row marked with different letters are significantly different at (P<0.05).

agreement with other studies where legumes also increased crude protein concentration when in a mixture with maize (Dawo *et al.*, 2007; Baghdadi *et al.*, 2016; Erdal *et al.*, 2016; Htet *et al.*, 2016). This could be due to higher nitrogen availability for maize in intercropping compared with the monoculture crop (Eskandari *et al.*, 2009). In this study it was found that the yield of crude proteins of intercropped forage MC₁, MC₂ and MC₃ was statistically significantly (P<0.05) higher than monocrop maize during a one year study (Table 2). Treatment of MC₃ had the highest yield of crude protein 2.47 t ha⁻¹ in 2017 from other forage mixtures (Table 2). From this point of view forage produced in maize-cowpea intercrops is important not only to profit from the increase in the content of crude protein, but also from the reduction of the content of neutral detergent fibers. For this reason, the best option in maize-cowpea intercropping is the use of cowpea genotypes that provide forage with the greatest amount of pods at harvest. In addition, the level of neutral detergent fibers is associated with the stage of maturity of the fodder due to the level of the cell wall components, mainly cellulose,

hemicellulose and lignin (Mugweni *et al.*, 2000). The value of a neutral detergent fiber refers to the total cell wall and consists of an acid detecting fiber fraction plus hemicellulose. In this study it was found that the contents of neutral and acid detergent fibers of intercropped MC₁, MC₂ and MC₃ were significantly (P<0.05) lower than monocrop maize during one year of study (Table 3).

Neutral detergent fiber is the measure of the total content of fibre (hemicellulose, cellulose and lignin) in silage. The content of neutral detergent fiber is important in ration formulation because it reflects the amount of animal forage that animals can be consumed (Lithourgidis *et al.*, 2006). In general, the concentration of neutral detergent fibers is higher for grass than for legumes (Dahmardeh *et al.*, 2009). Acid detergent fibers are a sub fraction of the neutral detergent fiber, which is primarily composed of lignin and cellulose and negatively correlated with total digestibility of forage (Alfalfa Workgroup 1998). Since smaller amounts of fibre components are used for better digestion, the cowpea intercropped plots to be superior to monocrop maize in terms of neutral detergent fiber and acid detergent fibre.

According to the results, when cowpea seed number in increased in intercrop, the values of neutral and acid detergent fibers in the mixture decrease. Similar results have been reported by Dahmardeh *et al.* (2009) and Htet *et al.* (2016). In this study, the potassium, phosphorus and calcium levels of intercropped fodder MC₁, MC₂ and MC₃ were significantly ($P < 0.05$) in relation to monocrop maize during a one year study (Table 3). According to the results, when cowpea seeds number is increased in intercrop, the ash, potassium, phosphorus and calcium content in mixture increased. Terzić *et al.* (2004) and Basaran *et al.* (2017) state that the contribution of legumes with sweet sorghum in mixtures was significant increased ash, potassium, phosphorus and calcium in fresh fodder. In this study, the water soluble carbohydrate values of intercropped fodder MC₁, MC₂ and MC₃ were significantly ($P < 0.05$) in relation to monocrop maize during a one year study (Table 3). According to the results, when cowpea seed number in increased in intercrop, the water soluble carbohydrate content in mixture decreased.

conclusion

The conclusion of the present study is that intercropping of maize with cowpea at various planting densities was shown to be an effective way to influence fresh biomass production, dry matter and crude protein yield to enhance nutrient quality of forage. Intercropping of maize with cowpea increased levels of crude protein, ash, potassium, phosphorus and calcium, and decreased contents of neutral detergent fibre, acid detergent fibre and water soluble carbohydrate concentrations in fresh forage. Finally, intercropping with 75 000 plants ha⁻¹ of maize and 75 000 plants ha⁻¹ of cowpea was most suitable according to the nutrient composition in fresh forage.

Authors` Declaration

We declare that this study is an original research by our research team and we agree to publish it in the journal.

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