Original Scientific paper
10.7251/AGRENG1903060U
UDC 633.15

INFLUENCE OF INTERCROPPING MAIZE WITH CLIMBING BEAN ON FORAGE YIELD AND QUALITY

Darko UHER[1], Zlatko SVEČNJAK[1], Dubravka DUJMOVIĆ-PURGAR[1], Dario JAREŠ[1], Ivan HORVATIĆ[2*]

[1]Faculty of Agriculture, University of Zagreb, Zagreb, Croatia
[2]Božjakovina d.d., Božjakovina, Croatia
*Corresponding author: ihorvatic@hotmail.com

ABSTRACT

Maize forage is poor in protein content which shows its low quality and nutritive value. Regarding to high feed costs of protein supplementations, legumes can be used in livestock nutrition for their high protein content and, thus, providing cost savings. Since legumes have low dry matter yield, acceptable forage yield and quality can obtained from intercropping cereals and legumes compared with their sole crops. In this study, maize (*Zea mays* L.) and climbing bean (*Phaseolus vulgaris* L.) were intercropped in different sowing densities and their monocropping equivalents were tested to determine the best intercropping system on forage yield and quality. Maize was cultivated alone (75 000 plants ha^{-1}) and intercropped with bean as follows: 75 000 plants ha^{-1} of maize and 37 500 plants ha^{-1} of bean (MB_1), 75 000 plants ha^{-1} of maize and 50 000 plants ha^{-1} of bean (MB_2) and 75 000 plants ha^{-1} of maize and 75 000 plants ha^{-1} of bean (MB_3), in rows alternating with maize. The highest dry matter yield was produced by MB_3 (20.9 t ha^{-1}), and the lowest by maize (16.9 t ha^{-1}). All intercropped systems had higher crude protein contents, MB_1 (92 g kg^{-1} DM), MB_2 (99 g kg^{-1} DM) and MB_3 (110 g kg^{-1} DM), than the maize (77 g kg^{-1} DM). Intercropping of maize with bean reduced neutral and acid detergent fiber, resulting in increased forage digestibility. Therefore, maize intercropping with bean could substantially increase forage quantity and quality, and decrease requirements for protein supplements as compared with maize.

Keywords: *Intercropping, Maize, Climbing Bean, 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). Intercropping maize with legumes for silage is a feasible strategy to improving the level of crude protein (Contreras-Govea et al., 2009; Zhu et al., 2011). Although

maize provides high yield in terms of dry matter, it produces low protein content in fodder. The bean (*Phaseolus vulgaris* L.) is a common legume cultivated for its edible seeds all over the world. It is slightly hairy with a well-developed root system and the stems are many branched. The bean is a fast growing, warm season legume, and, it can grow in a diverse range of environmental conditions worldwide because of its adaptability. There are many varieties of beans grown in all the regions. However, selecting high yielding (seed and herbage), disease resistant variety is most important factor for successful cultivation. In addition, the bean serves as an adequate source of protein. Furthermore, it can be planted alone or intercropped with other crops such as corn and sorghums. 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. Physiological and morphological differences between intercrop constituents influence 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, increases soil conservation through greater soil coverage as compared to sole cropping, and ensures 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 reduce 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 affect 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).

This study was designed to determine the influence of different patterns of maize-climbing bean intercropping on the yield and quality of forage.

MATERIAL 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).

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

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". Seed of the climbing bean cultivar "Meraviglia Di Venezia" was obtained from Company "Green Garden". The treatment comprising the individual plot size was 50 m × 2,8 m. The maize population 75 000 plants ha^{-1} (SM) were spaced at 70 cm × 19 cm and climbing bean population 37 500 (MB_1), 50 000 (MB_2) and 75 000 plants ha^{-1} (MB_3) were spaced at 70 cm × 38.1 cm, 70 cm x 28.6 cm and 70 x 19 cm, respectively, in rows alternating with maize. Basic tillage was carried out by ploughing to 30 cm depth. Presowing 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 P_2O_5 ha^{-1} and 200 kg of K_2O ha^{-1}. Maize and climbing bean 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 climbing bean at a dose of 4 l ha^{-1}. The soil of the research area has an acid pH 4.4 reaction (M-KCl), good humus (3.3%), poorly supplied with physiologically active phosphorous (7.6 mg P_2O_5/100 g soil), medium supplied with physiologically active potassium (22.3 mg K_2O/100 g soil) and richly supplied with total nitrogen amounting to 0.15%. The crops were harvested when the maize reached at soft dough stage and climbing bean at R7 stage and then chopped into 20 mm size pieces with a chaff cutter. 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 (Tomas et al., 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 shows the yield of forage and dry matter of maize intercropped wih climbing bean. The diferences in the yield of forage and dry matter are statistically significantly ($P<0.05$). The yield of forage and dry matter yield ranged from 66.3 t ha^{-1} (MB_3) to 46.7 t ha^{-1} (SM) and 20.9 t ha^{-1} (MB_3) to 16.9 t ha^{-1} (SM). According to the results, when climbing bean seed number increased in intercrop, forage and dry matter yields on parcels increased. The intercropped maize with cowpea (*Vigna unguiculata* (L.) Walp.) and bean (*Phaseolus vulgaris* L.) produced higher dry matter yield than monocrop maize (Geren et al., 2008). Dry matter concentration was in the range recommended for ensiling of maize-climbing bean intercropped.

One of the main reasons of intercropping maize and climbing bean is the increase crude protein level in silage.

Table 2. Fresh forage and dry matter yield of maize and maize-climbing bean intercropped

Intems	Treatmens			
	SM	MB_1	MB_2	MB_3
Fresh forage yield in t ha^{-1}	46.7^{c}	53.1^{bc}	59.5^{ab}	66.3^{a}
Content of dry matter in g kg^{-1}	361^{a}	343^{b}	326^{c}	315^{d}
Dry matter yield in t ha^{-1}	16.9^{c}	18.2^{b}	19.4^{b}	20.9^{a}
Crude protein yield in t ha^{-1}	1.30^{d}	1.67^{c}	1.92^{b}	2.30^{a}

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

Since crude proteins are very important in cattle fodder, silage containing more crude proteins is desirable. In this study it was found that the value of crude proteins of intercropped fodder MB_1, MB_2 and MB_3 was statistically significantly ($P<0.05$) higher than SM (Table 3). According to the results, when climbing bean seeds number increased in intercrops, the content of crude protein in the mixture increased. Armstrong et al. (2008) found that climbing bean intercropped with corn had the greatest potential among the climbing beans to increase crude protein concentration compared with monoculture corn. The intercropping of maize (*Zea mays* L.) with climbing bean (*Phaseolus vulgaris* L.) may serve as a way to increase crude protein and improve the overall nutritive value of silage (Grobelnik et al., 2005). Results in the present study were in agreement with other studies where legumes also increased crude protein concentration when in a mixture with maize (Htet et al., 2016; Dawo et al., 2007). In this study it was found that the yield of crude proteins of intercropped fodder MB_1, MB_2 and MB_3 was statistically significantly ($P<0.05$) higher than SM (Table 2).

The results suggested that the contributions provided by legume components in the mixtures increased crude protein yields of fodder. This could be due to higher nitrogen availability for maize in intercropping compared with the monoculture crop (Eskandari et al., 2009). From this point of view fodder produced in maize-climbing bean 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 and acid detergent fibers.

Table 3. Nutrient composition of maize and maize-climbing bean intercropped fresh forage (g kg^{-1} dry matter)

Nutrient composition	Treatmens			
	SM	MB_1	MB_2	MB_3
Crude protein	77^{d}	92^{c}	99^{b}	110^{a}
Neutral detergent fiber	370^{a}	353^{b}	348^{c}	334^{d}
Acid detergent fiber	203^{a}	189^{b}	179^{c}	170^{d}
Potassium	5.6^{b}	6.3^{a}	6.5^{a}	6.9^{a}
Phosphorus	2.4^{c}	2.5^{bc}	2.6^{ab}	2.7^{a}
Calcium	3.4^{d}	3.8^{c}	4.1^{b}	4.5^{a}
Water soluble carbohydrate	136^{a}	118^{b}	113^{bc}	103^{c}

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

For this reason, the best option in maize-climbing bean intercropping is the use of climbing bean 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 values of neutral and acid detergent fibers of intercropped MB_1, MB_2 and MB_3 were statistically significantly ($P<0.05$) lower than SM (Table 3). According to the results, when climbing bean seed number increased in intercrop, the values of neutral and acid detergent fibers in the mixture decrase. The content of neutral detergent fiber is important in ration formulation because it reflects the amount of animal forage that animals can consume (Lithourgidis et al., 2006). In general, the concentration of neutral detergent fibers is higher for grass than for legumes (Dahmardeh et al., 2009). Many researchers stated that the nutritional value of cell wall components decreased with plant age was related to increased lignin content (Atis et al. 2012; Zhao et al., 2012). Since smaller amounts of fiber components are used for better digestion, the climbing bean intercropped plots to be superior to monocrop maize in terms of neutral detergent fiber. In this paper, the value of water soluble carbohydrate (WSC) of intercropped forage MB_1, MB_2 and MB_3 was statistically significantly ($P<0.05$) lower than SM (Table 3). According to the results, when the climbing bean seed number increased in intercrop, the values of water-soluble sugar in the mixture decrase. Contreras-Govea et al. (2011) ensiled corn and forage sorghum with different proportions of lablab bean and reported that legume must make up at least 50% of the mixture to affect fermentation and nutritive value. In this paper, the value of potassium, phosphorus and calcium of intercropped forage MB_1, MB_2 and MB_3 was statistically significantly ($P<0.05$) higher than SM (Table 3). According to the results, when the climbing bean seed number increased in intercrop, the values of potassium, phosphorus and calcium in the mixture

indecrase. Contribution of legumes with sweet sorghum in mixtures was significant increased potassium, phosphorus, calcium and magnesium in fresh fodder (Terzić et al., 2004; Basaran et al., 2017).

CONCLUSION

The conclusion of the present study is that intercropping of maize with climbing bean 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 climbing bean increased values of crude protein, potassium, phosphorus and calcium and decreased values of neutral and acid detergent fibre and water-soluble carbohydrate concentrations in forage. Finally, intercropping with 75 000 plants ha^{-1} of maize and 75 000 plants ha^{-1} of climbing bean was most suitable according to the nutrient composition in forage.

REFERENCES

Anil A., Park P., Phipps P., Miller M. (1998). Temperate intercropping of cereals for forage: a review of the potential for growth and utilization with particular reference to the UK. Grass Forage Science, 53: 301-317.

Anil L., Park J., Phipps R.H. (2000). The potential of forage-maize intercrops in ruminant nutrition. Animal Feed Science and Technology, 85: 157-164.

Armstrong K.L., Albrecht K.A., Lauer J.G., Riday H. (2008). Intercropping corn with lablab bean, velvet bean, and scarlet runner bean for forage, Crop Science, 48: 371–379.

Atis I., Konuskan O., Duru M., Gozubenli H., Yilmaz S. (2012). Effect of harvesting time on yield, composition and forage quality of some forage sorghum cultivars. International Journal of Agriculture and Biological, 14: 879-886.

AOAC (Association of Official Analytical Chemists), (2000). Official Methods of Analysis of AOAC International. 17th Edition, Washington DC.

Banik P., Midya A., Sarkar B.K., Ghose S.S. (2006). Wheat and chickpea intercropping systems in an additive series experiment: Advantages and weed smothering. European Journal of Agronomy, 24: 325-332.

Basaran U., Copur Dogrusoz M., Gulumser E., Mut H. (2017). Hay yield and quality of intercropped sorghum-sudan grass hybrid and legumes with different seed ratio. Turkish Journal of Field Crops, 22 (1): 47-53.

Contreras-Govea F.E., Muck R.E., Armstrong K.L., Albrecht K.A. (2009). Nutritive Value of Corn Silage in Mixture with Climbing Beans. Animal Feed Science and Technology, 150: 1-8. DOI: https://doi.org/10.1016/j.anifeedsci.2008.07.001.

Contreras-Govea F., Marsalis M., Angadi S., Smith G., Lauriault L.M., Van Leeuwen D. (2011). Fermentability and nutritive value of corn and forage sorghum silage when in mixture with lablab bean, Crop Science, 51: 1307-1313.

Dahmardeh M.A., Ghanbari B., Syasar B., Ramroudi M. (2009). Effect of Intercropping Maize (*Zea mays* L.) with Cow Pea (*Vigna unguiculata* L.) on Green Forage Yield and Quality Evaluation. Asian Journal of Plant Science, 83: 235-239. https://doi.org/10.3923/ajps.2009.235.239.

Dawo M.I., Wilkinson J.M., Sanders F. E., Pilbeam D.J. (2007). The yield and quality of fresh and ensiled plant material from intercropped maize (*Zea mays* L.) and beans (*Phaseolus vulgaris*). Journal Science of Food and Agriculture, 87 (7): 1391-1399.

Dhima K., Lithourgidis A., Vasilakoglou I., Dordas C. (2007). Competition indices of common vetch and cereal intercrops in two seeding ratio. Field Crops Research, 100: 249-256. DOI: https://doi.org/10.1016/j.fcr.2006.07.008.

Eskandari H., Ghanbari A., Galavi M., Salari M. (2009). Forage Quality of Cowpea (*Vigna sinensis*) Intercropped with Corn (*Zea mays*) as Affected by Nutrient Uptake and Light Interception. Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 37: 171-174.

Geren H., Avcioglu R., Soya H., Kir, B. (2008). Intercropping of Corn with Cowpea and Bean Biomass Yield and Silage Quality. African Journal of Biotechnology, 22: 4100-4104.

Grobelnik M, Zdravko K, Martin B. (2005). Silage quality of maize-climbing bean intercropping. 46th Croatian and 6th International Symposium on Agriculture, Opatija. Croatia, Proceedings: 741-744.

Htet M.N., Soomro N.S., Jiang Bo H. (2016). Intercropping of maize and climbing bean: fodder yield, quality and nutrition composition of silages. International Journal of Agronomy and Agricultural Research, 9 (1): 25-31. DOI: https://www.innspub.net.

Javamard M.N., Javanshir A., Moghaddam M., Janmohammadi H. (2009). Forage Yield and Quality in Intercropping of Maize with Different Legumes as Double-Cropped. Journal of Food Agriculture and Environment, 7: 163-166.

Lithourgidis A.S., Vasilakoglou I.B., Dhima K.V., Dordas C.A., Yiakoulaki M.D. (2006). Forage yield and quality of common vetch mixtures with oat and triticale in two seeding ratios. Field Crops Research, 99 (2): 106-113.

Mugweni B.Z., Titterton M., Maasdorp B.V., Gandiya A.F. (2000). Effect of Mixed Cereal Legume Silages on Milk Production from Lactating Holstein Dairy cows (R7010). 3rd Workshop Livest. Prod. Prog. Projects, Matobo, Zimbabwe, 82-89.

Putnam D.H., Herbert S., Vargas J. (1985). Intercropping Maize-soybean studies, yield composition and protein. Journal of Experimental Agriculture, 22: 375-381.

Statistical Analysis System SAS. 2002. User's Guide: Statistics, Version 8.02. SAS Institute Inc. - Cary, USA.

Stoltz E., Nadeau E., Wallenhammar A.C. (2013). Intercropping maize and fababean for silage under Swedish climate conditions. Agricultural Research, 2 (1): 90-97.

Vasilakoglou I., Dhima K., Lithourgidis A., Eleftherohorinos I. (2008). Competitive ability of winter cereal-common vetch intercrops against sterile oat. Experimental Agriculture, 44: 509-520.

Van Soest P.J., Robertson J.B., Lewis B.A. (1991). Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. Journal of Dairy Science, 74: 3583-3597.

Terzić D., Stošić M., Dinić B., Lazarević D., Radović J. (2004). Productivity of sorghum and soybean as mixed crops in after crop seeding. Biotechnology in Animal Husbandry, 20 (3-4): 169-177.

Tomas T.A. (1977). An automated procedure for the determination of soluble carbohydrate in herbage. Journal of Science of Food and Agriculture, 28: 639-642.

Zhao Y.L., Steinberger Y., Shi M., Han L.P., Xie G. H. (2012). Changes in stem composition and harvested produce of sweet sorghum during the period from maturity to a sequence of delayed harvest dates, Biomass and Bioenergy, 39: 261-273.

Zhu Y., Bai C.S., Guo X.S., Xue Y.L., Ataku K. (2011). Nutritive Value of Corn Silage in Mixture with Vine Peas. Animal Production Science, 51: 1117-1122. DOI: https://doi.org/10.1071/AN11125.