THÜNEN

Project brief

Thünen Institute of Organic Farming 2021/15a

Maize intercropped with climbing beans: from cultivation to feeding

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- **Maize and climbing beans can be sown at the same time in alternating rows or in the same row in a pre-mixed mixture. The seed density should be 8 maize and 6 climbing bean seeds per m².**
- **The runner bean varieties Tarbais and Anellino verde achieved the highest bean yields in the mixtures.**
- **The use of heterofermentative lactic acid bacteria is recommended for good fermentation and silage qualities.**
- **The digestibility of the organic matter as well as the metabolizable energy and the net energy lactation of maize-bean silages were higher than with pure maize silages.**
- **Maize-bean silages can be used for feeding dairy cattle and fattening pigs without problems.**

Background and objective

The EU organic regulation sets the goal of 100% organic feeding. This requires the development of new cropping systems in order to produce animal feed rich in energy and protein. Intercropping of maize and runner beans is traditionally practiced for human consumption in the region of origin of maize. In Europe, intercropping of maize with climbing beans is regionally located in Austria and France. Maize and climbing beans can complement each other ideally: The bean fixes nitrogen from the air and climbs up on the maize plant. In the harvested product, the maize-bean silage, the energy-rich maize is enhanced by the protein-rich bean.

In the present project, the cultivation system was optimized, and the suitability of this feedstuff for ensiling, its digestibility as well as its use in ruminant feeding and fattening pigs were examined.

Approach

In multi-year field trials, we have optimized the maize-bean intercropping system with regard to bean type and variety, sowing time and density of the beans and undersown crops at two locations (Trenthorst: organic, Braunschweig: conventional). The quality of the silages was determined on the basis of nutritive and anti-nutritive components and digestibility tests on wethers. In the Thünen Institute's research herd, a two-year trial was conducted to determine whether replacing the maize silage with maize-bean silage in the mixed ration affects feed intake, health and performance of dairy cows. In the case of the fattening pigs, it was checked in several runs whether the choice of roughage (grass-clover silage vs. maize-bean silage) influenced feed intake, fattening performance, carcass quality, meat quality and animal welfare.

Results

The field trials in organic farming showed no differences in the total yield between sole cropped maize and the intercropped maize with climbing beans. The bean yields varied considerably between the years, although they were significantly higher with sufficient water supply. The runner bean varieties Tarbais and Anellino verde showed the highest bean yields. The variety Tarbais had the highest yield in 2015 with 1.97 t dry matter (DM) ha^{-1}, corresponding to a 13.4% yield. Intercropped scarlet runner beans mostly showed lower yields than runner beans and, due to their very high thousand-seed weight, they are not suitable for the cultivation on farm level. An increase in the seed density of the beans from 6 to 9 grains m^{-2} only increased the bean yields by 0.3 t DM ha^{-1} and is therefore not recommended due to the significantly higher seed costs.

Under conventional cultivation conditions, the mean total yields of the maize-bean mixtures compared to the pure maize were always significantly lower over the years. The earlier the beans began to grow and the more biomass was produced by the bean variety, the more the yield decreased, but with a higher proportion of bean yield in the mixture. The highest bean yield was achieved in 2016 with simultaneous sowing of maize and beans with the variety Tarbais with 3.2 t DM ha^{-1}, corresponding to a yield share of 19.1%.

The ensiling results showed that almost all harvested crops were highly contaminated with yeast and mold that negatively affected fermentation. Good quality silage with sufficient aerobic stability could often only be achieved by adding

heterofermentative lactic acid bacteria. The pure maize and the maize-bean mixtures did not differ in this regard.
The feed evaluation showed higher crude protein contents of the climbing beans mixtures than in pure maize silages. The mixtures with the runner bean Tarbais showed the best results in all years of the study, with large variations between the years (figure). However, these variations were also evident in pure maize.

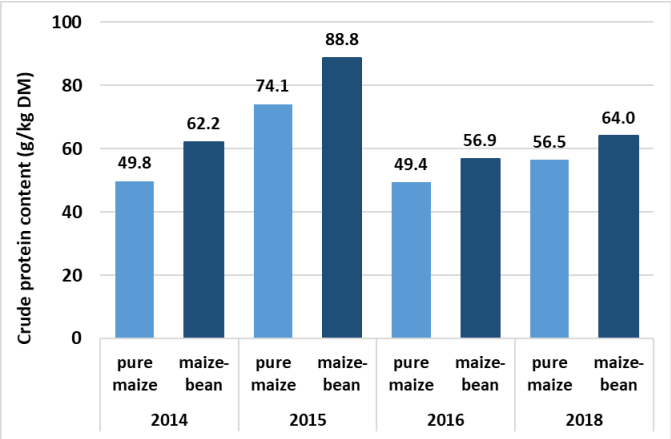

Figure: Crude protein contents (g/kg DM) of pure maize and mixtures of maize-with runner beans with the variety Tarbais in four years

The anti-nutritional substances in the beans, which are one of the factors that determine the amount used in animal feed, could be detected in different amounts in the mixtures over the four years. The lectin content was dependent on the bean variety in the mixture (table). The highest levels were measured in the mixtures with the runner beans Cobra and Grünes Posthörnchen. However, the relatively low levels in the harvested mixtures were reduced during the ensiling process to such an extent that they no longer had any anti-nutritional potential. The α-galactosides of the beans, which are responsible for the flatulence, were also degraded during ensiling and could no longer be detected in the maize-bean silages. The tannin content of the maize-bean silages was on a level comparable to that of pure maize silages.
Compared to pure maize silages, maize-bean silages led to a significant increase in the digestible organic matter in the study with wethers, regardless of the type and proportion of beans. This also translated into an increase in energy content, both metabolizable energy and net energy lactation.
In the feeding trials, silages with the white-blooming runner bean variety Tarbais were used. While the proportion of beans in the silage for dairy cows was 7 or 9% (based on the dry matter), this was set constant to 15% for the fattening pigs.

In the dairy herd, substitution of maize silage by maize-bean silage in the total mixed ration was investigated. No effect of maize-bean silage on milk yield and various welfare indicators were found. Only the milk urea content was slightly increased. However, the bean proportions in the mixtures were relatively low.
In the feeding trial with fattening pigs, the maize-bean silage was used as roughage in comparison to grass-clover silage, which were both fed in addition to a 100% organic concentrate feed mixture. During pre-fattening, the maize-bean silage was consumed less than the grass-clover silage; but there was no difference during the finishing period, which indicates a certain amount of adaption. Total feed consumption as well as fattening and slaughtering performance did not differ. Maize-bean silage is a suitable roughage for fattening pigs, but did not show nutritional advantages compared to grass-clover silage.

Table: Lectin contents of the maize-bean-mixtures at harvest and in silages

		Lectin contents (g/kg DM)					
year	variety	Anellino verde	Cobra	Grünes Posthörnchen	Tarbais	Preis-gewinner	Weiße Riesen
2014	at harvest	-	0.02	0.09	0.06	0.02	0.03
	silage	-	0.02	0.05	0.04	0.01	0.02
2015	at harvest	0.23	0.47	0.11	0.11	0.10	0.06
	silage	0.07	0.27	0.04	0.05	0.03	0.02
2016	at harvest	0.21	0.34	0.44	0.23	0.01	0.02
	silage	0.10	0.12	0.14	0.09	0.01	0.01
2018	at harvest	0.05	0.03	0.03	0.05	0.07	0.05
	silage	0.02	0.03	0.02	0.09	0.02	0.02

Recommendations

- Simultaneous sowing of maize and climbing beans in alternating rows or in the same row with a premixed mixture.
- The runner bean varieties Tarbais and Anellino verde resulted in the highest bean yields in the mixtures.
- With alternating rows, care must be taken to ensure that there is sufficient row spacing for hoeing in organic farming.
- In conventional cultivation, weed control is only possible in pre-emergence.
- Under northern German conditions, medium to late ripening runner beans are preferred in combination with early to medium early maize.
- A seed density of 8 maize and 6 runner beans per m² has proven itself.
- The use of heterofermentative lactic acid bacteria is recommended to ensure good fermentation and silage quality.
- Maize and bean silages can be used for feeding dairy cattle and fattening pigs without any problems.

Weitere Informationen

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Veröffentlichungen

Böhm et al. (2016)
Verbesserung der Protein- und Energieversorgung bei Wiederkäuern und Monogastriern durch Gemengeanbau von Mais mit Stangen- und Feuerbohnen, Kongress "Hülsenfrüchte - Wegweiser für eine nachhaltigere Landwirtschaft", Bundesanstalt für Landwirtschaft und Ernährung (BLE), Berlin, pp. 46-47.

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