Effect of different doses of an amendment and an organo-mineral fertiliser on the production of forage maize

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Abstract

Animal feed is the main cost on dairy farms. Maize can produce quality silage for dairy cattle at less cost than silage from grass, and at the same time increases milk yield and milk protein content. Moreover, supplementation with concentrates can be reduced and profitability is improved. The correct use of amendments and fertilisers could improve maize production and its nutritional content and also reduce costs. The aim of this study was to evaluate the effect on forage maize production of different application rates of an amendment (5, 15, 25 and 35 Mg ha^{-1}) and an organo-mineral fertiliser (50, 100, 150 and 200 kg N ha^{-1}) developed with organic matter from industrial wastes and with inorganic sulphur from a refinery, in comparison with the mineral fertilisation usually carried out in the area where the experiment was conducted (Spain). The results obtained did not show a significant effect of the different rates of the amendment on maize production, probably because the amount of N applied to the soil was similar. However, high rates of the organo-mineral fertiliser increased the production of forage maize, probably by the soil fertility improvement associated with this treatment.

Keywords: dairy farms, nutrition, yield, management, *Zea mays*

Introduction

On dairy farms, green fodder is the most valuable and cheapest source of animal feed. Maize occupies a key position as one of the most important fodder crops for animal consumption because of the high production of maize in comparison with other fodder crops (Muzaffar *et al.*, 2014). Moreover, maize produces quality silage for dairy cattle at less cost than silage made from grass, which reduces the need for supplementation with concentrates and improves the farm profitability (Ali *et al.*, 2012). On the other hand, the correct use of amendments and fertilisers is vital for the success of the crop because it greatly influences not only the yield of the crop and its nutritional content but also its production costs. New products developed from wastes from industries could be used as amendments and fertilisers. This could reduce the use of inorganic fertilisers at the same time as residues are recycled. Several studies have shown that the use of wastes from industries as amendments and fertilisers can increase crop yields and quality and result in significant economic returns for producers (Hue, 1992). The aim of this study was to evaluate the effect on forage maize production of different rates of application of an amendment (5, 15, 25 and 35 Mg ha^{-1}) and of an organo-mineral fertiliser (50, 100, 150 and 200 kg N ha^{-1}) developed with organic matter from industrial wastes and with inorganic sulphur from a refinery. The results obtained were compared with the mineral fertilisation usually carried out in the area of Spain where the experiment was conducted.

Materials and methods

The experiment was established in León (NW Spain) in 2013 when the soil was ploughed and the experimental plots were established. Each plot occupied 11.25 m^2 and in spring of 2013 the plots were sown with forage maize (*Zea mays* L.). The distance between plant rows was 0.55 m and the distance between plants in each row was 0.155 m. The experiment was arranged as a randomized complete block design with four replicates and nine treatments. The treatments consisted of the application of four rates of an amendment (5, 15, 25 and 35 Mg ha^{-1}) and four rates of an organo-mineral fertiliser (50, 100,

150 and 200 kg N_{total} ha^{-1}) developed with organic matter from industrial wastes and with inorganic sulphur from a refinery. The amendment was developed from compost and industrial wastes from the dairy and meat industries and the fertiliser consisted of a mixture of chicken manure and waste from the dairy industry to which was added magnesium oxide. In the amendment, the concentrations of N, P and K were 18.2 g kg^{-1}, 7 g kg^{-1} and 2.9 g kg^{-1} of the amendment on dry matter basis, respectively. In the case of the organo-mineral fertiliser, the N concentration was 20.3 g kg^{-1}, the P concentration was 14.5 g kg^{-1} and the K concentration was 6.9 g kg^{-1}. Moreover, a control mineral treatment (MIN) was also included which consisted of the mineral fertiliser usually carried out in the area: 800 kg of 8% N, 15% P_2O_5, 15% K_2O ha^{-1} and 243 kg N ha^{-1}. The mineral treatment was also applied to the amended plots. The amendment and the fertilisers were applied before sowing in 2013 and 2014 and incorporated into the soil through tillage with a disc harrow. The calculation of the required amounts was conducted according to the dry matter percentage in the amendment (36.06%) and in the organo-mineral fertiliser (47.15%) and the N_{total} concentration, considering that only around 20% was mineralised and therefore available. The maize was irrigated during the experiment. To estimate the production of forage maize, ten plants per plot were harvested and weighed fresh in November 2014. In the laboratory, the plants were separated into the components: aborted cobs, cobs without grains, stems, leaves and grains. These components were dried and weighed to estimate the dry matter production. Data were analysed using ANOVA and differences between averages were shown by the LSD test, if ANOVA was significant. The statistical software package SAS (2001) was used for all analyses.

Results and discussion

The total production of forage maize obtained in this study when the amendment (12.98-16.45 Mg ha^{-1}) and the organo-mineral fertiliser (7.32-14.55 Mg ha^{-1}) (Figure 1) were applied was similar to the production found by Moreno-González (1982) (13.4 Mg ha^{-1}) and by Lloveras (1990) (14.07 Mg ha^{-1}) in Galicia (NW Spain). However, in the case of the mineral fertiliser, the total production of forage maize obtained (10.16 Mg ha^{-1}) was lower compared with the production found by these authors. Galicia is a region characterised by high precipitation distributed throughout the year, with the exception of the summer months, and this usually implies a higher production of maize in Galicia compared with the area in which this experiment was established. However, irrigation and the use of the amendment and organo-mineral fertiliser in our study probably implied that the maize production obtained was similar to that found by Moreno-González (1982) and by Lloveras (1990) in Galicia.

There were no significant effects of the different rates of amendment applied on the production of the different components of maize (P>0.05). This was probably because the amount of N applied to the soil with the different rates of amendment was similar (5: 314 kg N ha^{-1}, 15: 327 kg N ha^{-1}, 25: 340 kg N

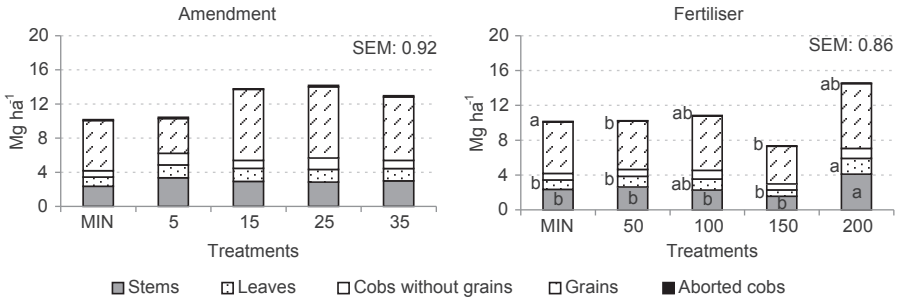

Figure 1. Production of the different components of forage maize (aborted cobs, cobs without grain, stems, grains and leaves) (Mg ha^{-1}) under the different treatments in 2014. MIN = mineral; 5, 15, 25 and 35 Mg amendment ha^{-1}; 50, 100, 150 and 200 kg N ha^{-1}; SEM = standard error of the mean. Different letters indicate significant differences between treatments.

ha^{-1} and 35: 353 kg N ha^{-1}). The application of high rates of the organo-mineral fertiliser (200 kg N ha^{-1}) increased the production of stems and leaves of the forage maize (P<0.05) more than the other fertiliser rates (50, 100 and 150 kg N_{total} ha^{-1}) and the mineral fertilisation (MIN). This result could be explained by the higher inputs of nutrients to the soil with the high rates of fertiliser than with the low rates. Other authors, such as Černý *et al.* (2012) in studies established in Czech Republic also observed an increment of maize production when a waste as sewage sludge was used as a fertiliser, mainly with the highest rates of sewage sludge applied to the soil (240 kg N ha^{-1}). Finally, the production of aborted cobs was higher in the MIN treatment than when the low and the intermediate rates (50 and 150 kg N_{total} ha^{-1}) of fertiliser were applied (P<0.05). This also demonstrates the advantages of the use of the organo-mineral fertiliser used in this study on the production of forage maize compared with the traditional management carried out in the area. Therefore, the use of this fertiliser could increase the production of the crop and at the same time provide a cheap source of N and decrease the environmental risks associated with mineral fertilisers.

Conclusions

Forage maize production was not significantly modified by the different application rates of the amendment, probably because the amount of N applied to the soil was similar and very high. However, the highest rate of organo-mineral fertiliser (200 N ha^{-1}) increased the production of forage maize due to higher inputs of nutrients to the soil. Therefore, the use of high rate of organo-mineral fertiliser as shown in this study should be recommended because the production of the crop increases and at the same time it provides a cheap source of N and decreases the environmental risks associated with mineral fertilisers.

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