Effect of nitrogen, sulphur and zinc application on sorghum biomass yield

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Abstract: Sorghum is known for its ability to grow in localities with limited water supply. Not only plant structure but also balanced nutrition is important for coming through shortage water stress. Especially zinc plays role in plant dealing with water stress and this microelement appears to be suitable for improving sorghum biomass yield. The aim of this study was describing the effect of foliar zinc application in combination with nitrogen and sulphur fertilizations on green forage and dry matter sorghum yield in condition of small-plot experiment in Žabčice. Fertilizer with nitrification and urease inhibitors ALZON neo-N (contains nitrogen), fertilizer with nitrification inhibitor ENSIN (contains nitrogen and sulphur) and ZINKOSOL forte with ZnSO₄ form of zinc were used. Sulphur positive effect on sorghum yield did not prove but variants with zinc foliar application shown enhancing of sorghum biomass yield (but not significantly). The highest green forage yield (48.6 t/ha) and the highest dry matter yield (9 t/ha) was found in variant with application of ALZON neo-N and ZINKOSOL forte.

Key Words: sorghum, green forage yield, dry matter yield, foliar zinc application, nitrogen and sulphur fertilization

INTRODUCTION

Drought is one of the most limiting factors which threaten agricultural production. The advantage of sorghum cultivation is its tolerance to drought. Sorghum (Sorghum vulgare var. sudanense) has large root system which contributes to better access to water and it is cultivated mainly for silage or biogas production in the Czech Republic (Podrábský 2008). Not only function of root system but also the growth of whole plant is influenced by right nutrition.

Quality of sorghum forage is important for livestock production and it is involved mainly by nitrogen fertilization which enhances the content of protein and increases biomass yield (Hermuth et al. 2012). Zinc (Zn) plays role as functional, structural or regulatory cofactor of many enzymes (Marschner 2012), it also participates in chlorophyll synthesis and it is responsible for synthesis of proteins which are necessary for growth hormone auxin production (Havlin 2014). Carvalho (2008) states that sufficient content of zinc in plant is necessary to reduce drought stress by contributing to detoxification of reactive oxygen species. Zinc sulfate, which is part of some fertilizers, has important function in adjusting stomata and ionic balance in plant which decrease shortage water stress. Therefore, some authors (Karam et al. 2007, Babaeian et al. 2010) recommend using of zinc foliar application (especially of zinc sulfate fertilizers) in dry conditions. Ehdaie et al. (2008) reported that plants are not demanding to zinc but if it has not sufficient amount of zinc, various enzyme systems and metabolic functions related to zinc are inefficiency. According to Richards et al. (2002) the lack of zinc causes the major problems for producing crops, particularly in dry and semi-arid regions with water shortage. Erdem et al. (2006) claim that is crucial importance of zinc usage to enhance the growth and yield of plants in these areas.

This experiment should contribute to describe effect of zinc foliar application in combination with nitrogen and sulphur fertilization on sorghum green forage and dry matter yield.

MATERIAL AND METHODS

Sorghum variety KWS Tarzan was used as a modal crop in precise small-plot experiment which was established at the Field Trial Station in Žabčice in Southern Moravia (GPS 49°01′30.714″N,
Sorghum was seeded on 25 April 2019. The size of one plot was 30 m² and the soil of the experiment field was light sand. Fertilizer with nitrogen (N) and sulphur (S) were applied in single doses 7 days after plant emergence (27 May 2019), zinc foliar application (ZINKOSOL Forte) was made in 8-leaf growth stage (26 June 2019) according to the scheme in Table 1. All variants were conducted in four replications.

Table 1 Scheme of small-plot experiment

<table>
<thead>
<tr>
<th>Variant</th>
<th>Fertilizer</th>
<th>Dose of</th>
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<tbody>
<tr>
<td>1 (N)</td>
<td>ALZON neo-N</td>
<td>N (kg/ha) 115</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S (kg/ha) 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zn (g/ha) 0</td>
</tr>
<tr>
<td>2 (NS)</td>
<td>ENSIN</td>
<td>N (kg/ha) 117</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S (kg/ha) 58.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zn (g/ha) 0</td>
</tr>
<tr>
<td>3 (N + Zn)</td>
<td>ALZON neo-N + ZINKOSOL forte</td>
<td>N (kg/ha) 115</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S (kg/ha) 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zn (g/ha) 450</td>
</tr>
<tr>
<td>4 (NS + Zn)</td>
<td>ENSIN + ZINKOSOL forte</td>
<td>N (kg/ha) 117</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S (kg/ha) 58.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zn (g/ha) 450</td>
</tr>
</tbody>
</table>

Legend: ALZON neo-N – urea with nitrification and urease inhibitors, contains 46% N; ENSIN – ammonium sulphate nitrate with nitrification inhibitors, contains 26% N and 13% S, ZINKOSOL forte – contains ZnSO₄ (11% Zn and 5% S).

The harvest of sorghum biomass was performed on 1 August 2019. The yield of sorghum green forage was determined from the harvest of whole plot. The content of dry matter was determined from sample of 10 plants which were crushed and dried to constant weight at the temperature of 105 °C. ANOVA analysis of variance and follow-up tests according to Fisher (LSD test) at 95% (P<0.05) level of significance in programme Statistica 12 CZ was used for statistical evaluation.

RESULTS AND DISCUSSION

As shown climograph of experimental locality in Žabčice (Figure 1), the precipitation during March and April 2019 was lower than normal precipitation for this locality. According to Venuto and Kindiger (2008) sorghum needs level of total precipitation at least 400 mm for right growth. Precipitation during next months was satisfying, but it was in combination with higher temperature than normal temperature of this locality.

Figure 1 Climograph of Žabčice

The highest yield was found in variant 3 (N + Zn), it was about 8% enhanced in comparison to the lowest yield from variant 2 (NS). Presented variants had range of dry matter content of biomass from 18.6% to 19.3% at harvest. Although the green forage yield of sorghum was not significantly
affected by fertilization, foliar application of zinc increased sorghum biomass yield in contrast to variants without zinc application (Figure 2). The green forage yield of variant 3 (N + Zn) was about 6.1% higher than variant 1 (N) without Zn, variant 4 (NS + Zn) had about 5.1% higher yield of green forage in contrast to variant 2 (NS). Similar positive effect of zinc on forage sorghum yield was found by Bhoya et al. (2014) who also observed increasing after zinc fertilization. Soleymani and Shahrajabian (2012) also mentioned increased level of biomass yield after foliar zinc treatment. Fertilizer ENSIN which contains nitrogen and sulphur was applied in variants 2 (NS) and 4 (NS + Zn) and in contrast to effect of zinc, positive effect of sulphur fertilization on yield was not found in this experiment.

**Figure 2** The green forage yield of sorghum (t/ha). Means with same letter are not significantly different (P<0.05)

Jiang and Huang (2002) mentioned that zinc has positive impact on the amount of chlorophyll which could contribute to increase of plant yield. The yield increasing after zinc application was obvious also on Figure 3, maximum dry matter yield was 9 t/ha and it was found in 3 (N + Zn) variant. The differences between the highest and lowest dry matter yield was not significant, but we found yield increasing about 7.1%. Variants 1 (N) and 4 (NS + Zn) had the same dry matter yield (Figure 3) which was slightly decreased in contrast to 3 (N + Zn). These results are in close conformity with Dambiwal et al. (2017) who also mentioned increasing of dry matter yield after foliar application of ZnSO₄.

**Figure 3** The dry matter yield of sorghum (t/ha). Means with same letter are not significantly different (P<0.05)
CONCLUSION

Sorghum has potential to be cultivated in regions with high temperature in combination with irregular rainfall. The sorghum yield depends not only on weather conditions but also on available nutrients. Nitrogen fertilization seems to be necessary for demanded biomass yield with good quality and micronutrient zinc plays important role in sorghum cultivation also. In our experiment, foliar application of zinc increased green forage yield and dry matter yield in compare with variants without zinc fertilization also. Variant with zinc application in combination with ALZON neo-N which contains nitrogen and nitrification and urease inhibitors had the highest green forage yield (48.6 t/ha) and dry matter yield (9 t/ha). The positive effect of sulphur fertilization did not show. Unfortunately, the results do not show statistically significant differences.

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REFERENCES


