Multidisciplinary uses of sweet sorghum and its environmental effect

mgr inż. Lilianna Głąb

Sorghum (*Sorghum bicolor* (L.) Moench) is relatively new species in temperate climate and some aspects of sorghum production are still unknow. Therefore, this dissertation shows two research area in transdisciplinary approaches. On the one hand it is focusing on large sorghum uses and the other hand indicating effects of sorghum production on environment. This species can be use as forage, biofuels (bioethanol and biogas) feedstock and allechochemicals donor to weeds control. Environmental aspects of this paper included GHG emission in terms of different feedstock management technologies and energy efficiency of bioethanol and biogas production. Moreover, another issue of this dissertation is possibility of application waste products (sewage sludge and digestate) as fertilizer of circular economy management.

Same sorghum hybrids, the related Sudangrass and hybrids between these two species are important forage crops, particularly in warm, dry regions. However, feeding with sorghum or Sudangrass can pose the threat of inadvertent NO^{3-} poisoning. A field experiment was conducted to test the impact of N fertilization management on sweet sorghum yield and NO_3^- accumulation in sorghum biomass and bagasse. Sorghum was grown under two levels of N dosses – 90 and 180 kg N ha^{-1}, once or split applied as enhanced-efficiency N fertilizer – polyolefin polymer coated urea and as common N sources – ammonium nitrate and urea. Polymer coated urea was used because some research indicated that this fertilizer improves nitrogen efficiency and crop yield and decreases N losses.

This study demonstrates that polymer coated urea at the rate of 90 kg N ha^{-1} provides biomass with a safe level of NO_3^- and can be recommended in sustainable sweet sorghum production for forage. In addition, in this paper an indirect strategy based on Soil Plant Analysis Development (SPAD) readings measured during growing season was proposed to predict NO_3^- level in biomass at harvest. Results showed that this non-invasive method could provide valuable information on potential NO_3^- accumulation and animal poisoning risk.

The next issues of this paper are assessing the fertilizer potential of biowaste products and evaluation the emission greenhouse gas (GHG) from sweet sorghum cultivation as a bioenergy crop. Three years experiment was carried out in the field condition. According to

obtained results, sewage sludge and digestate could be recognized as a nutrient substitute without sorghum yield losses.

Calculations of (GHG) were performed based on Intergovernmental Panel on Climate Change methodology. The quantification of GHG emissions was made according to ISO TS 14067 norm. The freely available BioGrace Excel GHG calculation tool was used to estimate the C footprint of sorghum production. Standard values containing conversion factors and LHV (lower heating values) from the database developed by IPCC were used for computing GHG emissions. Greenhouse gas emissions were divided into external and on-farm emissions. These emissions area result of production processes and application of agricultural inputs, such as pesticides, fertilizers, seeds, and combustion of diesel oil during farm operation. Nitrogen application had the greatest impact on the external GHG emissions. CO_{2eq} emissions decreased when sewage sludge and digestate were applied. This fertilization practice represents a promising strategy for low emission C agriculture and could be recommended to provide sustainable sorghum production as a bioenergy crop to mitigate GHG emissions.

One of the crucial factors in the sustainable production of energy crops is improvement of the energy balance and efficiency. Nitrogen demands contribute to the highest proportions of total energy consumption of all energy inputs for feedstock management. The effect of bio-based waste products – sewage sludge and digestate replacing urea – on the energy output of biofuels produced from two different hybrids of sweet sorghum (Rona 1 and Sucrosorgo 506) was evaluated.

In this study the evaluation of energy input included only feedstock production and transport. When sewage sludge or digestate was applied the total required energy inputs decreased by 1/3 in case of both varieties as compared with the application of urea. Conversion of fresh sorghum biomass into methane provided significantly more the gross energy output as compared ethanol production. Application of digestate allowed the highest energy efficiency ratio to be obtained in terms of ethanol production for both tested hybrids and in terms of methane for Rona 1. Sweet sorghum should be used as biogas feedstock in the temperate climate. The application of waste – sewage sludge and digestate – in feedstock management increased the energy efficiency of biofuel production.

As mentioned above, sorghum is multifunctional crop. Because of chemical composition it can be use in weed control. This report provides a comprehensive literature review of the applications of sorghum allelopathy in agriculture. A critical analysis of the

allelopathic properties of sorghum identified the following areas contributing to its ability to reduce weed infestation in agroecosystems:

1. a large number of compounds produced by sorghum have allelopathic properties,
2. allelopathic compounds can be applied in the form of mixed plant extracts or in combination with herbicides,
3. sorghum extracts have a broad spectrum of activity,

sorghum may be used to produce bioherbicides