Topic: Fiber and Cellulosic Crops

ENERGY YIELD DECLINE OF SIDA (*SIDA HERMAPHRODITA* L. RUSBY) IN A SUMMER HARVEST REGIME FOR BIOGAS PRODUCTION

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In Germany, the interest in perennial cropping systems for bioenergy feedstock production has increased significantly over the past decade. For example, the area under cup plant (*Silphium perfoliatum* L.) has increased from 500 to 10,000 ha since 2015. The reasons for this are primarily the environmental and societal ecosystem services that are more pronounced in cup plant compared to silage maize (*Zea mays* L.), such as biodiversity enhancement, and erosion mitigation.

To promote the diversification of energy supply even more sustainably through another equally promising perennial flowering bioenergy crop, *Sida hermaphrodita* L. Rusby (hereafter referred to as *Sida*), also known as Virgina mallow, was investigated in field trials at University of Hohenheim (southwest Germany). Up to now, *Sida* has been widely considered as a solid biofuel in research and practice. For this use, the dead aboveground *Sida* biomass is harvested in spring before the plants' regrowth. Consequently, the research question of this study was, in how far *Sida* performs as a biogas crop in comparison with cup plant and silage maize, which is commonly used for commercial biogas production. Therefore, the vegetative biomass of *Sida* was harvested in the vegetative stage, i.e. green biomass in summer, to evaluate its methane yield employing batch tests. Due to the perennial nature of *Sida*, regular summer harvests were conducted over a longer period (2014-2018) to clearly evaluate the overall plant performance.

A comparison of the average dry matter yields (DMY) showed that *Sida* performed considerably weaker (12.3 t/ha) than cup plant (22.4 t/ha) and maize (20.1 t/ha) when harvested in summer. Moreover, there was a clear trend of a gradual decline in DMY for *Sida* from 18.2 t/ha in 2015 to 9.2 t/ha in 2018. Against this, cup plant and maize showed relatively stable DMY throughout the observation period (i.e. for cup plant from 2015-2018). The average substrate-specific methane yield (SMY) of *Sida* (278.4 l_N CH_4/kg_{VS}) was similar to cup plant (264.3 l_N CH_4/kg_{VS}), while maize yielded highest (335.2 l_N CH_4/kg_{VS}), as was expected for this positive control. However, for *Sida* a minor increase in SMY (circa 10 l_N CH_4/kg_{VS}) was observed from 2016 to 2017, which might be due to the change in *Sida* biomass composition.

Based on these results, the methane yield per hectare (MYH) was calculated (MYH = DMY × SMY). Here, for *Sida*, the large decrease in DMY was shown to have a stronger impact on MYH than SMY, as MYH also decreased by 45.4% from 4643.2 m^3 CH_4/ha or 167.2 GJ/ha (1 m^3 CH_4 equals 36 MJ) in 2015, to 2537.3 m^3 CH_4/ha or 91.3 GJ/ha in 2018. In contrast, the MYHs of cup plant and maize showed stable MYHs of 5261.4 and 6610.6 m^3 CH_4/ha, respectively.

We suggest that the steady decrease in DMY, which can be considered as the main reason for the energy yield decline of *Sida*, is a consequence of the early harvest of the *Sida* biomass in summer. Such yield declines were not observed for *Sida* biomass harvests in winter. In this case, *Sida* can translocate nutrients and assimilates back to the root system allowing for a stronger regrowth in spring.

It can be concluded that *Sida* is rather not suitable for biogas production due to cutting intolerance in a continuous summer harvest regime.

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