PRELIMINARY RESULTS REGARDING YIELDS OF VIRGINIA MALLOW (*Sida hermaphrodita* L.) AND CUP PLANT (*Silphium perfoliatum* L.) IN DIFFERENT CONDITION OF EUROPE

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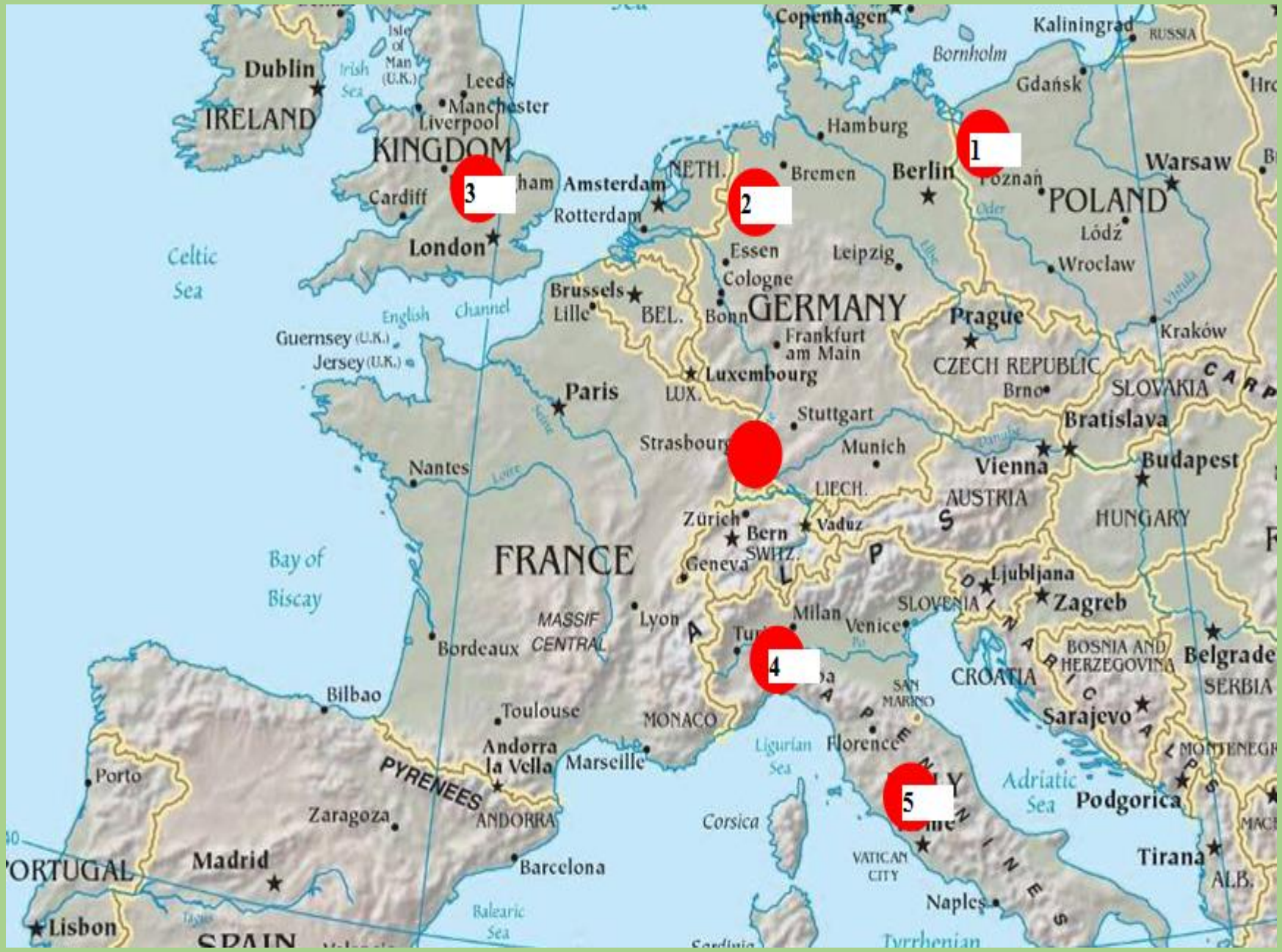
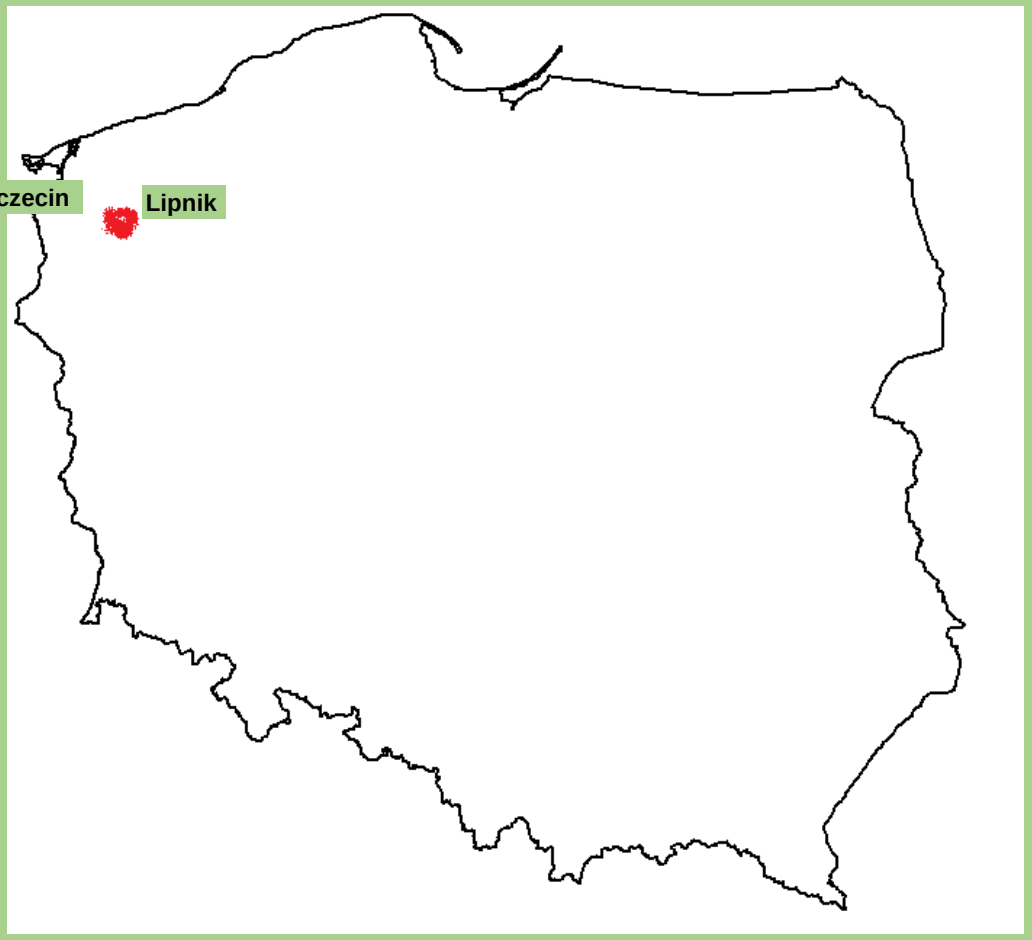
The perennial crops used for biomass production for energy purposes have economic advantages (low cost of cultivation and management) in contrast to annual energy crops.

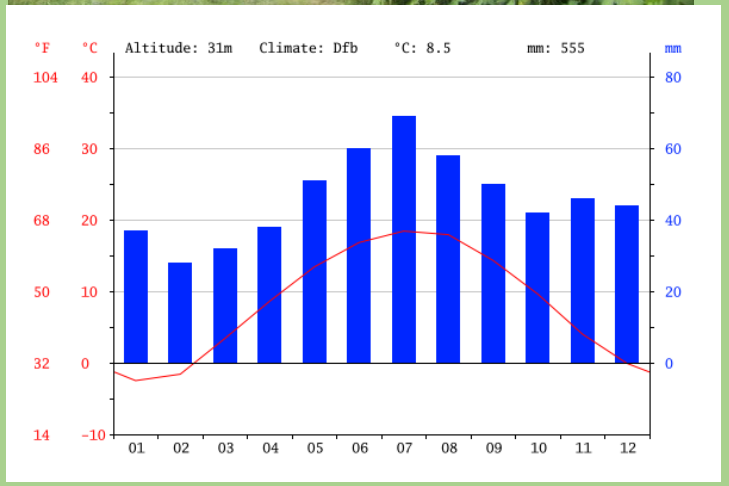
Especially the "novel and innovative", more efficient species like **Virginia** or **Pennsylvania mallow** (*Sida hermaphrodita*) and **cup plant** (*Silphium perfoliatum*), besides their high yield potential, provide additional environmental profits (biodiversity, protection and benefit for pollinators, especially honey bees and bumblebees) and as well as good products to biogas plants.

Project partners and Experimental sites

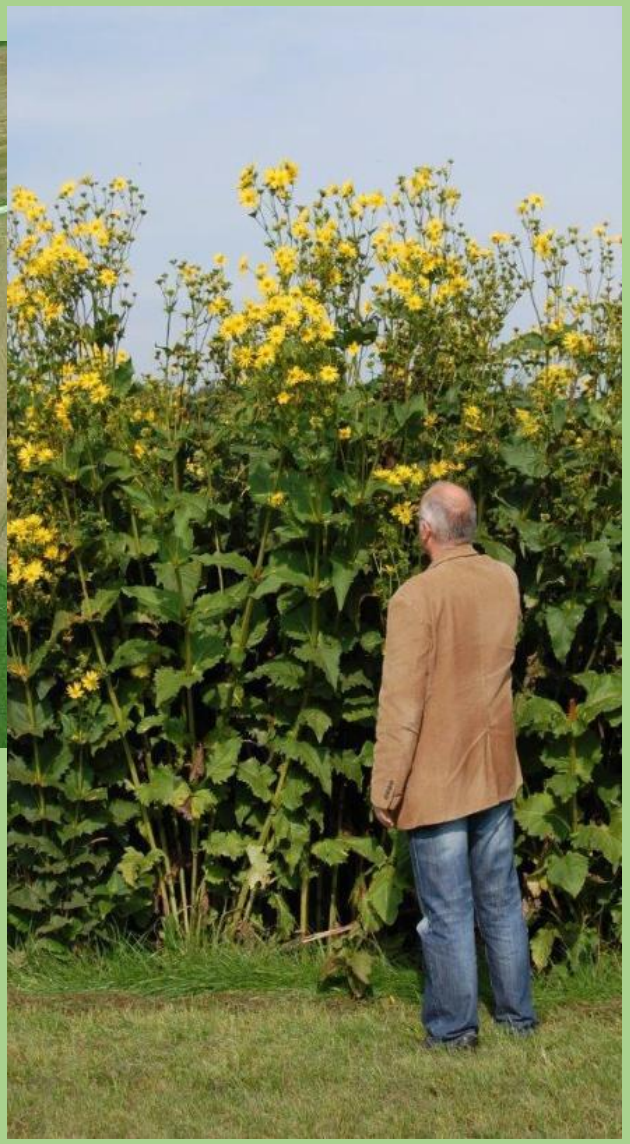


1 - Lipnik (53.20N; 14.58E) near **Szczecin** (North-Western **Poland**), the average annual temperature was 8.5°C, with an annual precipitation of 555 mm, which peaks in summer. The soil texture was sandy with an acid pH





2 - Werlte (52.85N; 7.67E) near Oldenburg (Germany), the average annual temperature was 9°C, with an annual precipitation of 768 mm and a summer peak in rainfall. Soil texture was sandy with an acid pH of 5.6.



3 - Silsoe (52.07N; 0.25W) near Bedford (United Kingdom), the average temperature was 9.9°C, with an annual precipitation of 657 mm. Soil texture was loam to clay, freely draining and slightly acid.

4 - Casale Monferrato (45.13N; 8.51E) near Milano (North Italy), the average annual temperature was 12.5°C, with an annual precipitation of 784 mm and a dry period in July. The soil texture was sandy loam with a pH of 7.8.

5 – Montenero di Bisacce (41.95N; 14.78E) near Mafalda (Central Italy) the average annual temperature was 17.5°C, with an annual precipitation of 364 mm and a dry period from May to September (monthly reference evapotranspiration varied between 110-150 mm and precipitation was about 23 mm per month). Soil texture was clayey (44% of clay) with an alkaline pH.

Material and methods

Experimental sites

Established in 2016: Lipnik (Poland), Werlte (Germany) and Casale Monferrato (Italy)

Established in 2017: Montenero di Bisaccia (Italy) and Silsoe (England**)**

Experimental Design

Randomized block design with 4 replications on each site

Two provenances of Sida (Sida1 and Sida2) and one of Silphium

Establishment method: planting of rooted seedlings: 44,000 per ha

Management

Manual hoeing or three or four harrowing operations between the rows (chemical weed control only in Germany)

Fertilization: 60 kg N, 35 kg P and 80 kg K per 1ha before planting (depending on the soil fertility), 40-80 kg ha^{-1} N - by start of vegetation next years

Harvest

Biomass for direct combustion: February/ March

Biomass for biogas:

Silphium: October (one harvest)

Sida1 and Sida2: June and October (two harvests)

Results

Final harvesting of BIOMASS to combustion [$t \cdot ha^{-1}$ dry mass] on the Sida plots were carried during the dormant season (February/ March 2018 and 2019) when the shoots had a moisture content of less 30%.

Photo. 1. November 2018, experimental site in Lipnik (Poland) (M. Bury)

Photo. 2. February (26) 2018, experimental site in Lipnik (Poland) – before harvest (M. Bury)

Results

Final harvesting of BIOMASS to combustion [t·ha^{-1} dry mass] on the Sida plots were carried during the dormant season (February/ March 2018 and 2019) when the shoots had a moisture content of less 30%.

Table 1. Dry mass yield of plants for BIOMASS (t·ha^{-1})

Species	**Year**	**Lip[1]**	**Wer**	**Sil**	**Cas**	**Mon**	**×**
Sida1	2018	10.2	7.8	-	7.1	-	8.4
Sida2	2018	9.3	9.5	-	8.2	-	9.0
×		9.8	8.7	-	7.6	-	8.7
Sida1	2019	10.7	8.9	7.9[2]	5.8	10.6[2]	8.8
Sida2	2019	10.3	6.7	6.5[2]	6.5	10.6[2]	8.1
×		10.5	7.8	7.2	6.2	10.6	8.5

[1] **Experimental sites:** Lipnik (Lip), Werlte (Wer), Silsoe (Sil), Casale (Cas) and Montenero (Mon)
[2] **Second year**

Regrowth of plants in spring

Sida 1 (left) and Sida 2 (right)

Silphium

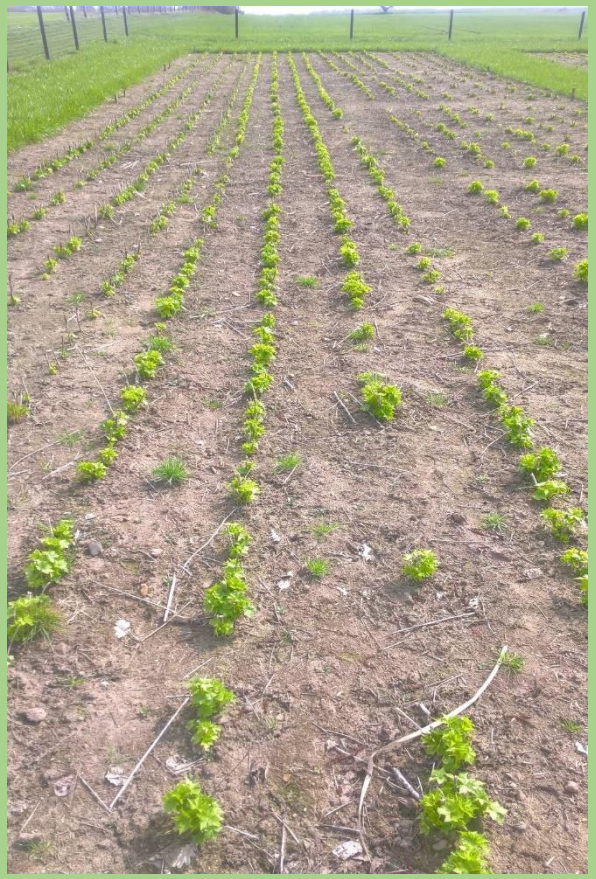


Photo. 3. April 2018, experimental site in Lipnik (Poland) – plant regrowth 1 month after harvest (M. Bury)

Results

The evaluation of the plant growth of Sida and Silphium was conducted during the growing season. In June (2017, 2018) and October (2016, 2017, 2018) plots of Sida were harvested to estimate biomass yield for BIOGAS and *Silphium* was harvested only once in October.

Photo 4. June 2018, experimental site in Lipnik (Poland) – harvest time of the first cut (M. Bury)

Sida1 (left), *Silphium* (right)
May 2018

Photo. 5. May 2018, experimental site in Lipnik (Poland) – plant regrowth 2 months after harvest (M. Bury)

June – Harvest for biogas, the first cut in Lipnk

Second regrowth of plants in summer
Silphium (left), *Sida* 2 seedlings (right)

Photo. 6. End of July 2018, experimental site in Lipnik (Poland) – plant regrowth 1 month after harvest (M. Bury)

Photo 7. LAI measurement by IAESTE student from Ghana (Sheriff N.) - September 2018 (M. Bury)

Experimental plots at 7.09.2018

Results

Table 2. Total dry mass yield of plants for BIOGAS ($t \cdot ha^{-1}$)

Species	Year	Lip[1]	Wer	Sil	Cas	Mon	×
Sida1	2017	15.1	9.2	-	14.9	-	11.8
Sida2	2017	14.8	9.0	-	9.6	-	10.3
×		14.9	9.1	-	12.2	-	11.1
Sida1	2018	6.7	19.5	11.4[2]	8.7	15.1[2]	12.3
Sida2	2018	8.5	16.4	11.8[2]	6.9	15.0[2]	11.7
×		7.6	17.9	11.6	7.8	15.1	12.0
Silphium	2017	26.6	14.6	-	14.4	-	18.5
	2018	14.3	18.0	10.2[2]	14.4	15.4[2]	14.5

[1] **Experimental sites:** Lipnik (Lip), Werlte (Wer), Silsoe (Sil), Casale (Cas) and Montenero (Mon)
[2] **Second year**

Conclusions

- Both investigated perennial plant species: Virginia mallow (*Sida hermaphrodita* (L.) Rusby) and cup plant (*Silphium perfoliatum* L.) grown from seedlings established well and provided harvestable yields at all experimental sites.
- Mean yields of Sida aboveground dry biomass grown for combustion ranged from 6.2 to 10.6 t ha^{-1} between two years and five sites. No differences were found in the biomass yield between the two Sida provenances.
- An alternative harvest method for Sida crops is two harvests for biogas production, the first in early summer and the second in early autumn. The total dry mass yields of Sida (7.6 to 17.9 t ha^{-1}) harvested for biogas production from two cuts were generally higher than biomass yields harvested from a single winter cut for combustion.
- At the sites in Germany, Italy and Poland cup plant (*Silphium perfoliatum*) produced more or a similar level of biomass as Sida. The mean annual yields of cup plant aboveground dry biomass grown for biogas production at the five sites ranged from 10.2 to 26.6 t ha^{-1}.

This presentation shows the results of a field study on the growth and yields of two innovative energy crops, Virginia mallow (*Sida hermaphrodita* (L.) Rusby) and cup plant (*Silphium perfoliatum* L.), tested in the frame of SidaTim project in Poland, Germany, Italy and UK.

Project: **Novel Pathways of Biomass Production: Assessing the Potential of Sida hermaphrodita and Valuable Timber Trees** = SidaTim

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Project partners:

Flowers of *Silphium* – Sept. 2018

Thank you very much for attention