Netzwerk
Lebensraum
Feldflur

Energy from Wild Plants

Practical tips for the cultivation of wild plants to create biomass for biogas generation plants

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I INTRODUCTION

With a total of over 7,500 biogas generating plants, Germany is in the lead as far as the production of biogas is concerned. According to estimates of the Bundeslandwirtschaftsministerium (Federal Ministry of Food, Agriculture, and Consumer Protection), there are around four million hectares of land available with the potential for growing energy plants. Of this, around two million hectares are actually in use presently (status as of 2013). This is the equivalent to an approx. 17.5% share of the total agricultural crop land in Germany. Currently, it is mainly maize and cereals which are cultivated for whole crop silage (WCS). However, these intensively farmed, annual crop systems are sometimes detrimental to the biodiversity of our cultivated landscape as well as to the preservation of soils and water bodies. Since the discontinuation of obligatory land set-asides in 2007 and the 2nd draft of the Renewable Energies Act (EEG) in 2009, the decline of typical species in the agricultural landscape has gained significant momentum.

In contrast to the production of foodstuffs and animal feed, biogas production provides an opportunity to grow a great variety of plant species and types in pure and mixed stands and to use the entire growth for methane production. Seed mixes made up of high-yield and flower-rich annual and perennial native, wild, and cultivated species offer innovative ways of aligning energy production from biomass more closely with the goals of landscape, nature, and species protection.

Ecological benefits of wild plant mixes for energy production:

- Perennial mixes provide food and cover for wildlife both in summer and in winter.
- Longer flowering periods and large flowering areas increase the food supply for insects.
- Flowering mixes enhance the rural landscape and increase the recreational value of a region.
- Since such crops are not harvested before the end of July, losses of ground-nesting birds and young animals due to mowing are reduced.
- To prevent the spread of invasive plant species, only indigenous wild plants are used in the mixes.

Economic benefits of wild plant mixes for energy production:

- Wild plant mixes are eminently suitable for use as permanent crops and do not require annual soil tillage or sowing.
- For the most part, no mineral fertilisers or chemical pesticides are required.
- Soil erosion is counteracted and the humus balance is improved.

The following cultivation recommendations are the result of the practical and scientific experience of the partners in the Field Habitat Network. The aim of these recommendations is to encourage the spread of wild plant cultivation systems and thus to make a positive contribution to their further development.

Netzwerk Lebensraum Feldflur

In autumn 2012, actors from the spheres of hunting, nature conservation, beekeeping and the power supply industry joined together to form the Field Habitat Network. Together, they want to pinpoint ways of bringing energy generation from biomass into closer alignment with species and nature protection. The network's objective is to establish high-yield mixes of blossom-rich annual and perennial indigenous, wild, and cultivated species as an ecologically necessary and economically sustainable alternative to conventional energy plants used in agriculture. However, it will only be possible to achieve this objective in a process of best practice sharing with the farmers.

The Field Habitat Network is coordinated by the Deutscher Jagdverband[1], the Deutsche Wildtier Stiftung[2] and the International Council for Game and Wildlife Conservation (CIC).

[1] German Hunting Association
[2] German Wildlife Foundation

2 RECOMMENDATIONS FOR AGRICULTURAL PRACTICE

2.1 Cultivation System and Seeds

2.1.1 Spring sowing of perennial and annual species (seed mix BG 70)

To accommodate varying production processes on individual farms, three options for establishing mixes of wild plants for energy generation have been developed. These include: a) spring sowing of perennial mixes with some annual plant species, b) direct summer sowing of perennial mixes without annual species, and c) spring sowing of a mix of pure annuals.

Tab.1: Composition of wild plant mixture Biogas I/BG 70

Marshmallow	*Althaea officinalis*
Yellow chamomile	*Anthemis tinctoria*
Mugwort	*Artemisia vulgaris*
Lesser knapweed	*Centaurea nigra*
Common chicory	*Cichorium intybus*
Wild carrot	*Daucus carota*
Wild teasel	*Dipsacus sylvestris*
Viper‘s bugloss	*Echium vulgare*
Buckwheat	*Fagopyron esculentum*
Fennel	*Foeniculum vulgare*
Nigerseed	*Guizotia abyssinia*
Sunflower	*Helianthus annuus*
Elecampane	*Inula helenium*

Vervain mallow	*Malva alcea*
Mauretanian mallow	*Malva mauritanica*
Wild mallow	*Malva sylvestris*
Chinese mallow	*Malva verticilata crispa*
Lucerne	*Medicago sativa*
Honey clover	*Melilotus albus*
Yellow sweet clover	*Melilotus officinalis*
Common sainfoin	*Onobrychis viciifolia*
Dyer's rocket	*Reseda luteola*
White campion	*Silene alba*
Red camption	*Silene dioica*
Tansy	*Tanacetum vulgare*
Mullein	*Verbascum ssp.*

The wild plant mix BG 70 is made up of 25 high-performance annual and perennial wild and cultivated species, including long-living herbaceous perennials, achieving a comprehensive site adaptation over five and more years of exploitation. This wild plant mix is of German origin and production, and consequently there is no risk of adulteration of the natural flora.

True herbaceous perennials need three years of growth before they can supply their full biomass yield. However, spring sowing of the perennial wild plant mix BG 70 is capable of yielding up to 10 tons of dry matter in the first year. At this stage, the main yield contributors are sunflowers, mallows and annual clover. Early sowing on a well settled, crumbly seedbed promotes reliable establishment of the standing crop, as this allows a more efficient utilization of the winter moisture. In the first year of growth of this seed mix, nitrate fertilisation should not exceed 80 kg total nitrogen per hectare so that the yield producers in the subsequent harvest years have sufficient chance to develop in the lower layers. If the nitrogen supply is too high, sunflowers also tend to form stockpiles, which can be an impediment during harvesting.

In the second year, viper‘s bugloss and common chicory are among the main contributors to the yield, since at this stage the herbaceous perennials have still not reached their full performance potential. Only from the third year of growth onwards will the crop stand be dominated by the long-living plant species, i.e. the herbaceous perennials such as mugwort, tansy, marshmallow and lesser knapweed. Up to this point, the crop mix runs through a cycle of „planned succession“, i.e., the species composition changes each year.

Fig.1: 1st year of growth, left: cup plant, right: Biogas I

Fig.2: 2nd year of growth Biogas I

Fig.3: 3rd year of growth Biogas I

Fig.4: 4th year of growth Biogas I

Tab. 2: Composition of seed mixture BG 80

Niger seed	*Guizotia abyssinia*
Mexican aster	*Cosmos bipinnatu*
Linseed	*Linum usitatissimum*
Bishop's flower	*Ammi majus visnaga*
Tree mallow	*Lavatera trimestris*
Common marigold	*Calendula officinalis*
Sunflower	*Helianthus annuus*
Wild mallow	*Malva sylvestris*
Chinese mallow	*Malva verticiliata crispa*
Honey clover	*Melilotus albus*
Yellow clover	*Melilotus officinalis*

2.1.2 Summer sowing of perennial species (seed mix BG 90)

The aim of this assortment is to establish a low-risk plant stand following the early clearing of winter barley or whole crop silage on arable land where strong weed infestation is likely. This mixture does not produce any exploitable biomass yield in the year of sowing. However, the yield is achieved through the preparatory culture. Biennials and herbaceous perennials can become very well established by the end of the vegetation season due to the lack of pressure exerted by high-growing sunflowers and mallows. Self-seeding volunteer grain should be suppressed by a commercially available grass herbicide (note the certification conditions!). If initial development is slow, it is expedient to spread a nitrate fertiliser with approx. 40 – 50 kg nitrogen (also in the form of fermentation residues) per hectare. The continued development of the crop stand from the second year of growth is similar to the option for spring sowing of wild plant mixture BG 70.

Fig.5: Successful establishment of herbaceous perennials and biennials following July sowing

2.1.3 Spring sowing of annual species (seed mixture BG 80)

This mixture consists purely of annual species, primarily multiflorous sunflowers, mallows, and clover. Since there is no need to take the development of subsequent plant generations into account, it is possible to work with a higher level of nitrogen (approx. 100 kg total nitrogen). Sowing and harvesting can be performed together with the maize.

Fig.6: This annual flowering assortment can be planted as a flowering framework around maize stands, and can be harvested simultaneously with the maize.

2.2 Sowing

2.2.1 Selecting the Land

Due to the abundance of species and hence its suitability for a wide spectrum of potential habitats, from moist/green to dry, the mixture Biogas I (BG 70 and 90) can be grown in most arable areas. Also, these mixes can cope with very different levels of lime in the soil. However, it is not advisable to utilise land which has been left fallow for more than one year. Providing that the land has been properly tilled and cultivated in the year prior to sowing, and adequate herbicidal measures have been carried out to control root weeds such as couch grass and thistles, the areas are suitable. In any case, summer sowing will help to minimise risk, as the first waves of weed development after ploughing and until sowing in June (no annuals and thus no yield) can be even better controlled.

2.2.2 Preparing the Land

We reap what we sow! Therefore, it is crucial, in particular for perennial cultures, to take particular care over soil preparation and sowing.

All the land to be used for such plantings must be prepared just as thoroughly as for cereals and other plant cultures.

Arable land which has just been taken out of active use should at least be grubbed before the winter. It is better to plough a winter furrow which will enhance the mineralisation of nitrogen. High nitrogen content is beneficial for the first year of development and also enables a reduced nitrogen application. Timely harrowing of the land as soon as the soil has dried out will encourage the germination of annual field weeds which can then be exterminated by a supplementary harrowing or by mechanical means during sowing. This step is necessary as it is not possible to use herbicides against dicotyledonous weeds.

Land which has been lying fallow for more than one year and arable land which has previously been extensively cultivated frequently display a high proportion of couch grass, thistles, and other site-specific annual weeds. Unless the land is subjected to intensive preparatory mechanical or chemical control measures, such weeds can effectively stifle the subsequent planting and hence prejudice its success. It is feasible to use total herbicides (glyphosates) for the preparation of the soil, but in this case it is imperative to take note of the applicable certification conditions of the substance.

Work steps for the conversion of old set-asides:

- Perform mulching in summer
- If necessary: use a total herbicide following re-greening, followed by tilling, grubbing and ploughing
- Consider the possibility of summer sowing, as this reduces the weed burden
- Spring ploughing of old set-asides is only feasible on lighter soils.

2.2.3 Time of Sowing

The time of sowing should be dependent on the natural conditions of the habitat, i.e. at the discretion of the farmer who can best judge the risk of late frost. As rule of thumb, we can say: the beginning of maize sowing (approx. 20 April) is also the optimum time for sowing biogas mixtures. In sites subject to spring drought, however, sowing ought to take place around the beginning of April. Even later sowing dates up to mid-May will still allow for a reliable crop establishment. It must be taken into account, however, that the optimum formation of dry matter (28-30% dry matter) is not normally reached until the end of September.

2.2.4 Sowing Techniques

The sowing density for wild plant mixtures is 10 kg per hectare. The seed mixtures do not have any particular technical requirements. The low seed quantities for small areas, the differing grain sizes, and the low charge quantities in cam-wheel seeders, are the most frequently mentioned drawbacks. These problems can be counteracted by adding crushed soy or cereal grain to act as filler material, i.e. to increase the seed quantity. In this case, the sowing density for the given area must be adjusted proportionately. Pneumatic drilling machines cope perfectly well with small seed quantities. In most types of seeding machines, segregation of the seed mix can be prevented by deactivating the agitator shaft.

It is imperative to sow Biogas mixtures on the soil surface, as they contain a large number of extremely fine-grain wild plant species (light-dependent germinators).

Fig.7: The thousand-kernel weight varies between approx. 40g for sunflowers and 0.12g for mugwort.

These only germinate slowly, or not at all, if the seeds are „buried". In practice, this means that the sowing coulter should run just above the seedbed, or should be raised right up. The covering harrow should, if possible, be set to a low grip. On small areas, it is possible to use an electric centrifuging spreader, or to sow the mixture by hand. After sowing, the area should be rolled to achieve re-compaction of the seedbed. This enables connection with the capillary water, which in turn encourages rapid germination of the seeds and hence the future development of the crop.

Fig.8/9: The seeds need to „see the sky" after sowing

Fig. 10: Well developed crop five weeks after sowing

The early summer direct sowing of perennial species after cereal whole crop silage or an early-harvest thresh crop, without yield producers in the first stand year, is a newly developed method of establishing the crop. This method is low-risk and, according to experience gathered so far, is relatively simple to implement even under difficult practical conditions. Since the yield in the year of sowing is already achieved with the preceding culture, the costs for seeds and tilling represent the only business risks. The method is particularly suitable for areas with a high weed burden and those following old set-aside conversions. Sowing should take place by the end of July. For this method, it is expedient to use the so-called direct sowing technique, e.g., Horsch Pronto. In this case, it is necessary to omit the preliminary tilling stage (disc harrow), as the crop soil deposited by the preceding culture should be left untouched as far as possible. Using the direct sowing technique, the seeds can be sown up to 1 cm deep straight into the stubble. This in turn has the benefit of ensuring that there is connection with the capillary water and that the typical problem weeds are not encouraged to germinate. Should weeds develop at a later stage, the weed infestation can be controlled by mowing or mulching without suffering any yield loss. In the following year, the typical annual field weeds no longer pose any problem, as they do not receive the stimulus to germinate provided by the preliminary tilling of the soil.

Fig. 11/12: Successful stubble sowing – the target species have germinated and have reached the rosette stage (beginning of October).

Further methods of crop establishment, such as undersowing the mix in maize or summer and winter cereals, are also available as further sowing options. However, it must be taken into account that the development of the young crop in the subsequent year will be retarded since in the main vegetation period the plants are subject to a significant lack of light and during the maize harvest they suffer considerable damage. If spring undersowing of winter or summer cereals

Tab. 3: Summary of fertilisation

	Fertiliser N [kg/ha]		
Wild plant mix	**BG 70***	**BG 90****	**BG 80*****
First crop year	max. 80	50	max. 100
Second and subsequent crop years	Up to 150	Up to 150	–

is to be carried out, it is expedient to reduce the sowing density of the main crop, possibly extending the row width, and also to weigh carefully whether the use of herbicides is necessary. If the main crop is not to be used for whole crop silage, it is important to ensure an even distribution of straw and chaff, so that after threshing, the young plants are not suffocated by a straw cushion or that the volunteer grain does not require the subsequent application of herbicides.

Fig. 13: Undersowing demands a sure instinct on the part of the cultivator

* * *BG 70 Spring sowing of annual and perennial species*
** *BG 90 Summer sowing of perennial species*
*** *BG 80 Spring sowing of annual species*

2.3 Crop Care and Harvest

2.3.1 Fertilisation

For the basic nutrients P, K, CaO, and Mg, the medium supply level C should be maintained. The nutrient supply can be given both in mineral form and in the form of organic material such as fermentation residues or manure. From the second year onwards, nitrogen can be supplied in two doses; the first one should be given at the onset of vegetation and the second at the beginning of elongation growth.

Spring sowing of perennial and annual species (seed mix BG 70)

- First crop year: max. 80 kg total N/ha
- Second and subsequent crop years: up to 150 kg N/ha.

Summer sowing of perennial species (seed mix BG 90)

- Initial nitrogen dosage approx. 50 kg N/ha from September if development is weak (otherwise as for BG 70)

Spring sowing of annual species (seed mix BG 80)

- Max. 100 kg total N/ha.

2.3.2 Care

On croplands which are well-maintained, providing that the burden of annual field weeds is not excessive, no land care measures are required. Should a massive weed infestation still occur, the stand should be mulched or mown at the latest when the weeds start to flower. If rotary mowers are used, the cuttings must be removed and ideally could be utilised in the biogas plant.

Fig.14: Even plant stands such as this are not lost!

Fig.15: This stand can be saved by mowing.

Sometimes annual weeds cause problems in the first crop year. From the second year onwards, strong weed infestation by the typical field weeds is no longer likely, as in order to germinate they require annual tilling of the soil.

Former set-asides, certain problem cropland areas and summer sowings following WCS or threshing corn, as well as older plant stands have a tendency to grass up, which can give rise to yield losses. If the stand is dominated by grasses, the use of a selective grass herbicide should be considered. When using such herbicides, comply with the applicable regulations (if necessary, apply for special permission in accordance with § 22 PflSchG[3]).

[3] Plant Protection Act

Fig.16: Here, grass control measures are urgently needed.

2.3.3 Harvest

The harvest of wild plant mixtures for energy generation can be carried out with conventional machines such as row-independent shredders or even using the batch method. However, the latter is not usually recommended, as it can introduce contamination into the silage. In the first year of growth, the optimum time for harvesting is reached at approx. 28% dry matter (DM) with the beginning of the silage maize harvest from mid-September. Depending on the sowing date, at this point one third of the sunflowers and mallows will be completely wilted.

From the second year of growth, the optimum time for harvest is approximately end of July/beginning of August, after the end of the main flowering. From this time on, it is no problem to achieve 30% DM and more. The harvest date should not be postponed too far into August, as the plants then begin to lignify, hence yielding less methane.

The potential yield performance of the mix is around 7-10 t of organic dry mass (ODM) in the first crop year, increasing to 12-16 t ODM from the third crop year. Experience so far shows that the mix is suitable for a stand duration of more than five years. Providing that the time of harvest is favourable, the methane yield per kilogram organic dry matter is comparable to that of green rye or similar crops.

Fig.17/18: Stand shortly before harvest; harvest on 11 August

Fig.19: The same stand on 23 August.

Fig.20: Before winter sets in, a knee-high layer of cover for wildlife develops.

2.4 Coding in the Combined Application (CAP)

There are various coding options available in the combined application. However, it is still advisable to discuss these with the responsible authority, as these differ from one Federal State to another[4] and changes could still take place in the context of the new CAP („greening", etc).

- **429** – Caution after 5 years grassland!
- **829** – Energy plants
- **790** – Other industrial crops – in some cases, the agricultural employers' liability insurance association may try to increase the insurance contribution.

[4] in Germany

2.5 Illustration Examples

2.5.1 Stand development

Fig.21. Three weeks after sowing, the annual species appear first.

Fig.23: After harvest in the first crop year: biennials and perennials have flourished well; this is the state of the stand at the onset of winter.

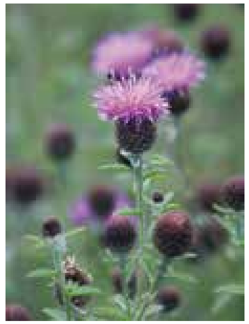
Fig.22: Stand development, July in the first crop year: blue: annuals, yellow: biennials, red: perennials.

Fig.24: After harvest in the second crop year: the density of plants per m² has been significantly reduced but by autumn, knee-high growth will still develop.

2.5.2 The main biennial and perennial species

Mugwort *(Artemisia vulgaris)*

Marshmallow *(Althaea officinalis)*



Lesser knapweed *(Centaurea nigra)*

Elecampane *(Inula helenium)*

Common sainfoin *(Onobrychis viciifolia)*

Tansy *(Tanacetum vulgare)*

Mullein *(Verbascum densiflorum)*

Lucerne *(Medicago sativa)*

White and yellow clover *(Melilotus albus) (Melilotus officinale)*

Red and white camption *(Silene alba) (Silene dioica)*

Wild teasel *(Dipsacus sylvestris)*

Common chicory *(Cichorium intybus)*

Wild carrot *(Daucus carota)*

Viper's bugloss *(Echium vulgare)*

Mauretanian mallow *(Malva mauretanica)*

Wild mallow *(Malva sylvestris)*

Yellow camomile *(Anthemis tinctoria)*

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