Evaluation of additional crops for Dutch list of ecological focus area

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Abstract: This report provides answers to the research question posed by the Ministry of Agriculture of the Netherlands: Could *Miscanthus*, *Silphium perfoliatum* and fallow sown in with melliferous plants comply with the expectations of the EU greening policy to be added to the Dutch general list for ecological focus areas? In addition to that the Ministry wants to know if it will be wise to accept sunflowers in seed mixture of catch crops. *Miscanthus* should not be considered for the EFA list, whilst *Silphium perfoliatum* is a suitable permanent crop. A list of melliferous plants suitable for green fallow land practice is compiled based on pollen and nectar quality as well as the timing of flowering. Sunflowers bring an added value to catch crop seed mixtures.

Keywords: Ecological Focus Areas, *Miscanthus*, *Silphium perfoliatum*, melliferous plants, biodiversity, bees, green fallow, sunflower

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Photo cover: Cup plant (*Silphium perfoliatum*), English Wikipedia (2018)

Contents

Summary

In order to comply with the regulations, farmers in the EU have to fill in at least 5 % of the arable land of their holding as ecological focus area (EFA). Member States designate a number of different land use options from which the farmer can choose. The Dutch government put the following management practises on this National list: nitrogen fixing crops, willow coppice, catch crops, buffer strips, landscape features, non-cultivated field margins, ponds, hedgerows, trees in a line, solitary trees, strips along forest edges and small groups of trees. Meanwhile, the discussion on EFA measures is still on going. Recently, the European Parliament extended the list of ecological focus area types, from which countries could choose from, with Miscanthus, *Silphium perfoliatum* and fallow sown in with melliferous plants. Therefore the Dutch Ministry of Agriculture, Nature and Food quality requested additional information with the following question: Could Miscanthus, *Silphium perfoliatum* and fallow sown in with melliferous plants comply with the expectations of the EU greening policy to be added to the Dutch general list of EFA types? In addition to that the Ministry wants to know if it will be wise to accept sunflowers in seed mixture of catch crops.

Miscanthus and *Silphium perfoliatum* are both classified as permanent and energy crops. In order to judge on their suitability for the EFA list, including their impact on the environment, their requirement of fertilizers and plant protection products should also be considered. Based on an extensive review of relevant literature, we concluded that due to its exotic origin and the lack of nectar producing flowers, Miscanthus will have only limited ecological value. As a drawback is Miscanthus establishment highly dependent on herbicides application. Fertilizer requirements are low on nutrient rich soils, but in later years of production, nutrient application might be necessary to cover the requirements of the crop. We advise not to add Miscanthus to the Dutch general list for ecological focus areas. Silphium on the other hand could become an interesting crop for ecological focus areas producing biomass for the bioenergy sector. In case of Silphium, cultivation without fertilization and the use of plant production products will not be too difficult and the crop will have an added value for insects, especially honey bees. Therefore we advise to add the *Silphium perfoliatum* to the EFA list.

To derive to an advise over ‘multifloral green fallow seed mixtures with melliferous plants’, plant species used in commercial fauna friendly seed mixtures were evaluated. The species were scored for pollen and nectar quality as well as timing of flowering. This evaluation resulted in a list of 25 suitable plant species (Table 1). Farmers should choose at least ten species from this list with a total rate of at least 10 kg seed per ha and at least 0,2 kg per ha for each of the ten species. The melliferous plant seed mixture (10 kg) could be blended into a seed mixture of 10 kg seeds per ha of slow growing grasses, like red fescue (*Festuca rubra*), tall fescue (*Festuca arundinacea*), common meadow grass (*Poa pratensis*) or bristle oat (*Avena strigosa*). The mixture with in total 20 kg seed per ha at maximum should be sown before 15^{th} of May and stay at least for six months on the field. Additional nutrient application by fertilisation might out-compete the melliferous plants due to an increased growing rate of the grasses, therefore we advise not to fertilise this fallow land.

Blending sunflowers in catch crop seed mixtures may enhance the value of the mixture after an early harvest of the main crop. Sunflowers will have beneficial characteristics as catch crop for biomass production, nutrient accumulation and the allopathic properties. The sunflowers may flower in October, but then the ecological value for insects and birds will be very limited.

1 Introduction

1.1 Ecological focus area

In EU regulation 1307/2013 the regulations on direct payments to farmers under support schemes within the framework of the common agricultural policy are elaborated. One of the components is the establishment of an Ecological focus area (EF). Where the arable land of a holding covers more than 15 hectares, the farmer shall ensure that, from 1 January 2015 onwards, an area corresponding to at least 5 % of the arable land of the holding is considered to be ecological focus area. The 'greening' objectives are related to soil and water quality, biodiversity, landscape preservation, and climate change mitigation and adaptation (EU, 2013).
Member States can choose a number of the following management options for ecological focus areas:

- land lying fallow;
- terraces;
- landscape features;
- buffer strips, including buffer strips covered by permanent grassland;
- hectares of agro-forestry;
- strips of eligible hectares along forest edges;
- areas with short rotation coppice with no use of mineral fertiliser and/or plant protection products;
- afforested areas;
- areas with catch crops, or green cover established by the planting and germination of seeds;
- areas with nitrogen-fixing crops.

The Dutch government put the following management options on the National general list: nitrogen fixing crops, willow coppice, catch crops, buffer strips, landscape features, non-cultivated field margins, ponds, hedgerows, trees in a line, solitary trees, strips along forest edges and small groups of trees (RVO, 2018). Next to these management options, member states may decide to accept equivalent practices that contribute at least to equivalent or higher benefits for climate and environment compared to one or several of the options mentioned above (EU, 2013). The Dutch government has so far accepted three national environmental certification schemes: *Field margin package, Skylark certificate* and *Fibre hemp package*. Every year arable famers may choose the measures they want to implement on their EFA area. To facilitate their choice the Government has compiled a general list of crop species from which farmers can choose plant species and mixtures listed in the above mentioned packages as for example catch crops and nitrogen-fixing crops (RVO, 2018).

A review on greening measures in Europe carried out by the commission (European Union, 2017) showed that, for the EU as a whole 9 % of the farm land is under EFA instead of the 5 % minimum EFA area that farmers are required to implement. This means almost double the percentage that farmers are legally required were met due to the use of weighting factors applied to some of the EFA measures. The ratio of the EFA area to total arable land, as calculated before weighting factors are applied, was 14 % in the EU as a whole. The ratio was particularly high in the Netherlands and Malta (26 %), Belgium (23 %) and Croatia (20 %).
The analysis of EFA types showed clear geographical patterns.

- A substantial share of landscape features and buffer strips is found only in Ireland, the UK and Malta.
- Land lying fallow is more present in Mediterranean countries like Spain, Portugal and Cyprus and in Member States located in the boreal biogeographical region, like Finland and Latvia.
- Nitrogen-fixing crops are prevalent in Croatia, Czech Republic, Italy, Poland and Romania.
- Catch crops are more widespread in Belgium, Denmark, Germany, Luxembourg and the Netherlands (EU, 2017).

Terwan et al. (2017) went into more detail and concluded, based on information from RVO (Netherlands Enterprise Agency, part of Dutch Ministry of Economic Affairs) that 97.5 % of Dutch arable farms had chosen measurements from the general list and only 2.5 % had chosen an equivalent package via one of the greening certificates (Skylark certificate or Field margin package). From the general list a total of 170,000 ha EFA were realised, filled for 96% (2015) and 97% (2016) with catch crops. After application of the weighing factor 0.3 for catch crops, still 90% of the EFA exists of catch crops, 6 % of N-fixing crops and only 1-2 % of landscape features.

The discussion on EFA measures is still ongoing. Recently, the European Parliament extended the list of ecological focus area types with *Miscanthus*, *Silphium perfoliatum* and fallow sown in with melliferous plants (EU, 2017b).

1.2 Objective

Member states will get an opportunity to acknowledge these three crops to the list of ecological focus area. The Dutch Ministry of Agriculture, Nature and Food quality asked us: ***Could Miscanthus, Silphium perfoliatum and fallow sown in with melliferous plants comply with the expectations of the EU greening policy to be added to the Dutch list of ecological focus area?***

In addition to that the Ministry asked us also if it will be wise to accept sunflowers in mixtures for catch crops, to provide a list of melliferous plants for fallow land and to advise on how to deal with fertilizers and plant protection products on *Miscanthus* and *Silphium perfoliatum.*

1.3 Background

In 2014 a broad variety of crops was evaluated as possible ‘equivalent measure’ for EFA according to their expected contribution to the greening performances in the European Common Agricultural Policy. (Den Belder et al., 2014). In 2016 an additional evaluation was made for soybean (Korevaar, 2016). Land laying fallow for melliferous plants (pollen and nectar rich species) is now considered as a potential new category of land laying fallow. Miscanthus and *Silphium perfoliatum* are classified as permanent crops and energy crops, in order to consider their suitability for the EFA list the use of fertilizers and plant protection products should be considered.

Agricultural production is largely depending on pollination services by honey bees, bumble bees or wild bees. The market value of crop pollination in open fields in the Netherlands is estimated by 4 million Euro (Blacquière, 2009).
Bees require a large floral diversity in order to collect nectar and pollen throughout the season. The pollen are required to feed the brood with proteins. The nectar can be directly consumed and is stored as honey for later energy and vitamins provision during the winter. In turn the bees provide pollination to the plants/crops. Often, changes in land use have negative effects on insects. An example for that is fragmentation; this means long flight distances for pollen and nectar collection (Steen and Cornelissen, 2015). Another example is the use of plant protection products, as for example insecticides containing neonicotinoids, with serious effects on health for the bees (Blacquière et al., 2012). These changes in land use affect the habitat provision in such a way that insect health and survival is threatened, thus resulting to declining numbers of bees (Blacquière, 2009). In the Netherlands land use is characterized by a few crop types. Especially in regions were land use for dairy production is dominated by maize and ryegrass. Also in regions of arable production the crop diversity is rather low. The limited plant diversity and lack of abundance of flowers, means a reduced provision of nectar and pollen for bees (Blacquière, 2009). Next to the reduced diversity, the flowering season of most crops is too short to support insect communities.

Promoting biodiversity with a diversity of crops and other plant species in ecological focus areas means food and habitat provision to insect populations as for example honey bees and wild bees. Their specific feeding and nesting requirements need to be addressed. Honey bees are for example generalists and can collect pollen and nectar from a wide range of plants within a range of approximately 3-5 km distance from a hive (Steen and Cornelissen, 2015; Blacquière, 2009). Compared to the domesticated honey bees, wild bees are more site and plant specific. For example the mining bee *Andrena agilissima* breeds in warm dry sandy soil in southern Netherland and feeds preferably on pollen and nectar of the white mustard and rapeseed (Koster, 2018). On top of that wild bees also require natural landscape elements as for example scrubs, dead wood and stalks of old grasses for nesting and overwintering.

Plants require time for the development of flowers in order to produce nectar and pollen. Management, as for example mowing, needs adjustment to provide a continuous flower availability during spring, summer and autumn. To guarantee a long flowering season with high value pollen and nectar availability a high floral diversity will benefit bees and other insects. These factors require consideration when evaluating the benefits of plant species for the ecological focus areas.

2 Miscanthus

2.1 The use of Miscanthus

Miscanthus is a tall, perennial, rhizomatous C4 grass of the *Poaceae* Family*,* originating from Asia with a wide application range in the biobased economy. Depending on the time of harvest, the fibrous rich biomass can be directly used as fodder or straw in animal production systems or is being further processed for as biogas or bioplastics (De Boer and Koning, 2012). These days, the plant is highly appreciated for its ornamental value in gardening in the Netherlands. Meanwhile large scale production as an energy crop is limited although the climatic and soil conditions are generally suitable for Miscanthus production in the Netherlands. The situation is different in the UK, where the focus on energy crop production is much stronger. In 2015 6,905 ha of Miscanthus was produced by 409 growers with an estimated yield of 10-15 ton dry matter per hectare (Department for Rural affairs, 2016). In comparison to the UK, where, Miscanthus is mainly produced on marginal land at reduced production intensity, the Miscanthus yield under optimum cropping conditions in Germany is higher with 15 and 20 ton dry matter per hectare (Fritz and Fromowitz, 2009).

2.2 Miscanthus cultivation

2.2.1 Establishment

Deciding on the allocation of production area for Miscanthus cropping, requires long term commitment. Once established, the biomass crop produces biomass for up to 30 years. Site requirements are similar to general crop production, since optimum yields will be achieved in moist nutrient rich soils without compaction and good drainage (Fritz and Fromowitz, 2009). The crop prefers a precipitation of 700-800 mm during the growing season (Fritz and Fromowitz, 2009). In case of dry summer periods, irrigation might be necessary to maintain high yields in the summer season since drought significantly reduces yield quality and quantity (Van der Weijde et al., 2016; Zub and Brancourt-Hulmel, 2010).

Seed bed preparation is required prior planting to optimize soil conditions and to reduce weed competition. Compacted layers need tillage (Lewandowski et al., 2000). Consequent weed management is mandatory. A common method is the application of herbicides at a rate of 3-5 l per ha prior planting or seeding of the rhizomes in April to May and if necessary 3 L per ha in the second year again (Boelke, 2000 in Fritz and Fromowitz, 2009). Mechanical weeding after plant establishment is less effective and causes growth depression due to damage to the rhizomes (Fritz and Fromowitz, 2009).

These days, micro and macro propagation of rhizomes is a common method for propagation of seeding material. There is a limitation in available specialized machinery for Miscanthus rhizome seeding, for example the *Hvidsted Energy Forest* from Denmark (Lewandowski et al., 2000). In general other farm machinery is used for seeding as for example the potato seeder, that plants rhizomes at 4 to 8 cm depth, or a fertilizer spreader, that broadcasts the rhizomes over the field and tilled under (Fritz and Fromowitz, 2009). The seeding distance depends on adjustments of the machines available and range between 1 to 3 plants per m^2 (Fritz and Fromowitz, 2009) to 2 to 5 plants per m^2 (Zub and Brancourt-Hulmel, 2010).

Seedling establishment is challenging. Best results with crop establishment and rhizome survival have been achieved with rhizomes sized between 4-8 cm (Fritz and Fromowitz, 2009). Plants grow at a daily mean air temperature of 7 ^{0} C (Zub and Brancourt-Hulmel, 2010). Irrigation in the first years improves seedling survival under mid European conditions (Lewandowski et al., 2000). Juvenile plants are highly susceptible to frosts. The survival rate during the winter months is low with a losses up to

15-20 % or even higher due to heavy rain, snow or frost periods (Fritz and Fromowitz, 2009). A delayed seeding in autumn even increases losses throughout the first winter (Fritz and Fromowitz, 2009). As a consequence of this poor survival rate, replanting by hand in the first spring after establishment is often required in order to avoid patchiness or uneven growth. The workload in the first 2-5 years is thus high.

Thanks to activities on seed propagation at various research institutes and seed companies, seeding and replanting costs will reduce in future. However initial investments costs will remain high, due to laborious slow crop establishment.

2.2.2 Fertilizer requirements

So far no consistent fertilizer application recommendations have been reported. In well drained nutrient rich soils highest yields are expected. Especially in the year after planting, the slow growing Miscanthus plants require a limited amount of nutrients. This means that surplus of nutrient application will leach out into the environment. On top of that does surplus nitrogen availability for a juvenile crop result in weak, overdeveloped shoots and reduced winter survival of the rhizomes (Fritz and Fromowitz, 2009). Therefore it is strongly advised not to plant Miscanthus on recently ploughed grassland. On nutrient poor soils an initial application of fertilizer had been recommended by Fromowitz and Fritz (2007).

In following years the extended root systems has improved access to nutrients, consequently manure management needs to be adjusted according to the nutrient uptake until harvest. An example of nutrient application was the advice of Fritz and Fromowitz (2007) with an application of 70 - 100 kg nitrogen per hectare. In a later publication the nitrogen application was revised. Fritz and Fromowitz (2009) stated that in Germany more than 50 kg nitrogen per hectare would result in over-application, thus leaching out of the soil. For the Netherlands an application rate of 80 of 140 kg nitrogen per hectare is advised by Kasper et al. (2017). From this we can conclude that manure application in a well-established crop remains challenging. Soil injection of manure application will cause damage to the rhizomes (Fritz and Fromowitz, 2007).

2.2.3 Yield

The potential yield of the Miscanthus can reach up to 20 ton dry matter per hectare, with plants up to 4 m height (Fritz and Fromowitz, 2009). In the Netherlands the average yield was 12.6 kg dry matter per hectare with an calorific value of 17 MJ per kg dry matter (Conijn en Corré, 2012). Due to the slow establishment only 30 % of the yield will be harvested in the second year. The first yield of a fully developed crop will be harvested after 3 years when optimum production conditions have been reached. In case of suboptimum growing conditions, the full yield potential will be reached after 5 years.

Biomass harvest can be done either in autumn or in spring. Current harvest experiments in the Netherlands recorded potential yield gain at autumn harvest (Kasper et al., 2017) which could be 27 – 50 % higher according to Zub and Brancourt-Hulmel (2010). Whereby the biomass harvested in autumn requires drying before further processing. Previous literature review warned that autumn harvest would lead to higher initial yield gain, but continuous autumn harvest will weaken the plant and cause yield reduction. In order to plant Miscanthus on ecological focus area sites, preference must be given to spring harvest. Nutrients are reallocated into the rhizomes in autumn and leafs will fall on the ground before harvest and nutrients from these leafs are recycled back into the soil by decomposition (Fritz and Fromowitz, 2009). The stalks will provide habitat and shelter for biodiversity in the winter.

2.2.4 Pests and diseases

Miscanthus is highly susceptible to weed competition. A common practice is the application of herbicides before and during crop establishment (see 2.2.1). Weed management by hand is laborious and mechanical weeding after plant establishment is less effective and causes growth depression due to damage to the rhizomes. When planting the Miscanthus in ecological focus areas, the use of herbicides is under debate, When no herbicides are allowed yield reduction might be significant. A reduction of 90 % yield was found in an experiment without herbicide application in Korea by Song et al. (2016) a without herbicide application were found. Application of fungicides and insecticides are not required in Miscanthus stands (Lewandowski et al., 2000).

2.3 Miscanthus and biodiversity

In a typical arable landscape characterised by a few crops, the introduction of Miscanthus as a perennial crop may have a positive impact on plant diversification. Under these circumstances might fauna species as insects, birds and mammals benefit from Miscanthus cropping. Positive feedback on Miscanthus production and biodiversity had been reported from monitoring programmes in the UK. , where the recovery of the threatened hare population was monitored in Miscanthus. Hares can find their nesting sites and hiding sites in extensive Miscanthus fields characterized by patchy vegetation cover and diverse vegetation layers (Petrovan et al., 2017). Forest and scrub bird species make use the dense canopy for shelter (Bellamy et al., 2009; Fritz and Fromowitz, 2009), but the presence of food remains limited. Interestingly, Sage et al. (2010) found that during summer the abundancy of birds was larger however the species diversity was reduced. Dauber et al. (2015) on the other hand argued that stable soil conditions as well as an extended root biomass increase earthworm abundance and activity over time), acting as an important food source for birds in Miscanthus fields. In the Netherlands Miscanthus however is considered as a useful crop to scare geese away from certain areas (to improve air safety around Schiphol airport), since they are not able to withstand in the scrubby stalky habitat (De Boer and Koning, 2012). Next to this, the function of noise absorbance by this tall grass species is an interesting side effect and gained attention in the Netherlands around Schiphol airport.

In this report the suitability of Miscanthus in ecological focus area with special attention on insects and bees deserved special attention. Literature revealed that Miscanthus can have a positive effect on bees. Dauber et al. (2016) reported that pollinator species benefit from Miscanthus in areas of English ryegrass and maize monoculture in Germany. These benefits were previously confirmed in the research of on farm monitoring in Ireland carried out by Stanley and Stout, 2013. Likewise to Dauber et al.(2016) they found that effects clearly depend on the size of the field and the pre crop. Clerment et al. (2015) found that bee colony decline throughout the winter season was reduced in the presence of Miscanthus fields in Luxembourg, where the presence of Miscanthus helped bees surviving throughout the winter season. This was surprising since Miscanthus will not provide nectar to the pollinators and therefore bees are still required to forage on other crops. Limited knowledge is available on wild bees nesting in Miscanthus stands. If insects make use of the stalks as nesting site, harvesting should be avoided in autumn.
Even if in literature positive observations on pollinator species and birds have been reported, the proximity of natural landscape elements had the highest impact on insect and birds diversity and abundance (Stanley and Stout, 2013; Dauber et al., 2015; Clerment et al., 2015). Insects require diverse and variable habitat sites for foraging, nesting, mating, oviposition, larval feeding and overwintering (Stanley and Stout, 2013).

Also other insects benefit from stable soil and crop conditions. Fritz and Fromowitz (2009) reported on research carried out in Bavaria (Germany) that diversity and abundance of beetles and spiders in Miscanthus was comparable to reed. They also found that numbers of beetles and spiders were higher in Miscanthus fields as compared to maize fields. Opposite observations were made in Ireland, where plant species richness and activity and density of spiders and ground beetles were negatively associated with Miscanthus yield (Dauber et al., 2015). Since increased intensity means reduced weed establishment.
Miscanthus can play a vital role in rebuilding soil quality and soil biodiversity, especially in soils after long term mono-cropping with maize. The compacted soil layers can be broken up by the strong and dense root system with a penetration depth down to 2.5 meters into the soil. Absence of soil disturbance as well as decaying root biomass rebuilt soil organic matter content (1.1 tonne C per hectare per year) in the top 60 cm of soil (Emmerling and Pude, 2017; Zub and Brancourt-Hulmel,

2010). The increase in soil organic matter and decaying root biomass supports rebuilding of earthworm populations.

Escaping Miscanthus in nature areas and displacing natural vegetation might become a problem for biodiversity. In America for example, the invasiveness of Miscanthus species on roadsides and forest is a well-known threat according to the global invasive species database (GISD, 2018). Comparable findings were made by the Dutch NGO RAVON for research and monitoring of reptiles, amphibians and fishes (Ode and Beringen, 2016), who warned that Miscanthus in Dutch nature areas is becoming an increasing problem replacing natural vegetation.

2.4 Does Miscanthus fit in the ecological focus area concept?

Integrating Miscanthus in the ecological focus area concept requires careful consideration. On the one hand has the crop potential to fulfil multifunctionality on land use level as bioenergy crop and habitat and food provision for biodiversity. However, Miscanthus production without application of chemical plant protection products during the years of crop establishment is not feasible. Especially in the first two years weed control is absolutely necessary to supress heavy competition by weeds in the slow developing Miscanthus crop. As a consequence of herbicide application, weeds and also wild flowers providing nectar or pollen for wild bees and other insects are eliminated (Schmid-Egger and Witt, 2014). The necessity of fertilizer application depends strongly on the initial soil fertility at planting. Surplus of nitrogen on a juvenile crop will result in weak, overdeveloped shoots with reduced winter survival of the rhizomes (Fritz and Fromowitz, 2009) and nutrient losses by leaching. Therefore it is recommended not to plant Miscanthus on recently ploughed grassland. Otherwise in later years fertilization is needed to cover nutrient requirements of the crop. Farmers should be aware of the high establishment costs of Miscanthus and the fact that it will take three years until full crop establishment. Harvesting should be carried out in spring only. Yearly harvests in autumn will weaken the plant and over long term autumn mowing will result in yield reduction.

When Miscanthus is planted in ecological focus areas the focus might not be on high biomass production, since there is the negative relationship of increased Miscanthus yield (field cover) and biodiversity (Dauber et al., 2014). There is no data available on the use of Miscanthus by wild insects. The plant is exotic to Europe. Miscanthus only provides pollen, therefore its suitability as food provision for honey bees is low. Miscanthus will provide nesting sites and shelter during the winter season for insects.

When comparing Miscanthus with the earlier evaluation by Den Belder et al. (2014), the added value of Miscanthus for biodiversity and especially for pollinators is limited. The conclusion from the present evaluation did not reveal new information to change this view. Growing Miscanthus without the use of herbicides will be difficult to establish a proper Miscanthus crop. On nutrient rich soils the nutrient status of the soil will be ample for establishment, but in following years nutrient application will be necessary to cover the requirements of the crop. Due to its exotic origin and the lack of nectar producing flowers, Miscanthus will have only limited value for honey bees, wild bees and other pollinating species.

We advise not to add Miscanthus to the Dutch general list for ecological focus areas.

3 The cup plant (*Silphium perfoliatum*) in de Netherlands

3.1 The use of *Silphium perfoliatum*

The perennial plant *Silphium perfoliatum* (C_3) is an Asteracea, originating from the wetland areas of northern America. Similar to Miscanthus, the cup plant reaches yields up to 12-20 ton dry matter per hectare per year for at least 10 years or longer (Dauber et al., 2016) with a plant height of 1.8 to 3 meters. The plant is free of toxic elements for animals, thus highly suitable for the production of palatable silage (Frölich et al., 2016). In the former GDR they were aware of these benefits of Silphium in animal fodder production, when introducing the plant from Russia in a search for alternative fodder crops. The plant is characterized by a high protein content of 24 % (Stepanov and Usenko, 2009) as well as a high yield potential. In Germany, research on the cup plant continued until today with focus on seed propagation to reduce establishment costs and on yield improvement for the bioenergy sector (Biertümpel et al., 2013). In 2011 300 ha of Silphium were produced in Germany (Biertümpel et al., 2013). Little attention has been paid on the cultivation of the cup plant in the Netherlands so far.

3.2 Silphium cultivation

3.2.1 Establishment

Deciding on allocation of sites for cup plant establishment requires a long term planning and commitment, since the perennial plants remains productive for up to ten years or longer. The cup plant performs well on a range of soils at a pH above 5.5 (Frölich et al., 2016). Soil conditions should be moist, but not water logged. Optimum growing conditions will be reached at 20 ^{0}C at full sun exposure. Different to Miscanthus, does the cup plant withstand frosts as low as −30 ^{0}C (Gansberger et al., 2015). As result of frost, the above ground vegetation is dying off. The plant can withstand drought periods, with a minimum water requirement around 400 and 500 mm per year and around 200 and 250 mm during the vegetation period, similar to maize (Grebe et al., 2012 in Gansberger et al., 2015). Once established, the deep rooting system allows water uptake from deeper soil layers and the ability of the leaf axils, which are also called cups, to store water like rain water and dew. With this adaptation to drought conditions the plants can survive hot and dry summers.

Preceding crop establishment, seed bed preparation, preferably ploughing, is required. Silphium suffers from growth depression in water logged compacted soils (Dauber et al., 2016; Gansberger et al., 2015).
Mechanical weeding or herbicide application are mandatory. A common practice is herbicide application prior planting, whereas later in the cropping season only mechanical or hand weeding is possible, since there is no selective herbicide available. Seedlings are transplanted during April until May. If available, vegetable planting machines or strawberry planting machines can be used for planting (Biertümpel et al., 2013). An example of planting density was presented by Biertümpel 2011 with 4 plants per m^2 when planted in rows (Biertümpel, 2011). Research in northern Germany is experimenting with direct seeding as well as undersowing in maize crop in April - June. These new advances may help to reduce costs and the work load of hand planting (Frölich et al., 2016).

3.2.2 Fertilizer requirements

If Silphium is planted on sites with high nutrient availability, no fertilizer application is required in the first year. On nutrient poor soils an application of 60-80 kg nitrogen can help establishment. In later years nitrogen application should be matched to biomass removal, with an average application of 120-

150 kg nitrogen per hectare per year (Biertümpel et al., 2013; Frölich et al., 2016). Surplus application of nitrogen cause yield reduction, since it is toxic for the plant and overdevelopment of the shoots with an increased risk of lodging (Gansberger et al., 2015).

3.2.3 Yield

Harvesting can be done once or twice a year, with highest yields obtained at two harvests per year (Stepanov and Usenko, 2009). In their experiment in Russia, Silphium was grown with fertilization and produced 15.6 ton dry matter per hectare and a crude protein yield 3.2 ton per hectare per year (= 20.5 % crude protein in the biomass). In Estonia yields of 18 ton kg dry matter a year were reached at a calorific value of 17.48 MJ per kg dry matter (Jasinkas et al., 2014).

A single harvest is more conventional in Europe, either in late August or early September (Aurbacher et al., 2012 in Gansberger et al., 2015; Dauber et al., 2016). When harvested twice, the first harvest is typically in the middle of June and the second harvest is in September (Gansberger et al., 2015; Stepanov and Usenko, 2009). Harvesting is currently carried out with common maize-harvester (Gansberger et al., 2015). Alternatively, Silphium could be chopped and after wilting used for silage making.

3.2.4 Pests and diseases

Silphium is susceptible to invasion by pests and infection with pathogens. Several larvae of specific moth species were found on the plant for example silvery moth (*Autographa gamma)*. Some ground dwelling beetle feed on the roots of Silphium.
Yield-reducing damage on the stems and the seeds can also be caused by fungi. Moist weather conditions during the summer months encourages fungi growth of *Sclerotinia* spp., *Fusarium* spp., *Alternaria* spp. and *Botrytis* spp. Specific fungicides for application to Silphium are not available (Biertümpfel et al., 2013; Gansberger et al., 2015). Stolzenburg and Monkos (2012) in Gansberger et al., 2015, also found a bacterial infection by *Pseudomonas syringae*.

3.3 Silphium and biodiversity

Silphium can help to diversify land use in areas where only a few crops dominate as for example areas with grass and maize production (Dauber et al., 2015). In contrast to non-flowering crops, Silphium provides valuable structures and food sources for insects and thereby promotes bee health and an attractive agricultural landscape (Gansberger et al., 2015; Dauber et al., 2016). The canopy closes already at the end of April (Dauber et al., 2016), in comparison to many other plants which close their canopy later in the season as for example mustard and willow. During the long flowering season, pollen as well as nectar are produced (July-September) (Dauber et al., 2016). The extended season of pollen production helps to collect healthy food for honey bees for the winter (Dauber et al., 2016). The sugar content in the pollen is very high, comparable to *Echinacea* plants. The nectar and pollen contain a range of valuable amino acids which might promote the honey bees health (Dauber et al., 2015). Under Polish conditions honey bees can collect up to 450 kg honey per hectare during the summer (Jablonski and Koltowski, 2005). In Austria up to 150 kg honey per hectare per year was collected by the honey bees (Gansberger et al., 2015). In the same research, visitation by bumble bees was described. Visitation of Silphium fields by wild insects such as wild bees and hoverflies is still highly dependent on natural elements or the presence of natural vegetation in the close proximity (Dauber et al., 2015). Same observations were made by Jablonski and Koltowski (2005) in Poland, they described the visitation of cup plants by generalists as for example honey bees and diphtera. Wild bees on the other hand are highly specialised in collecting pollen or nectar from specific plants and will not make use of the exotic vegetation (Schmid–Egger and Witt, 2014).

The above mentioned benefits on insects are based on monitoring of Silphium crops harvested in late autumn. In the Russian experiments with double harvests, in order to achieve highest yields (Stepanov and Usenko, 2009), a significant shorter flowering season was observed. This might affect insects directly.

Another limitation on the availability of flowers to the insects is the dependency of flower development on water availability. In case of draught periods or changing weather conditions the provision of nectar and sugars is significantly and rapidly reduced. Insects like bumble bees are likely affected, since they store insufficient food for bare times (Schmid–Egger and Witt, 2014; Dauber et al., 2016; Burmeister and Walter, 2012). On Silphium fields in Germany it was observed that under changing weather conditions as drought and on marginal production areas, the plant quickly adapted by producing less flowers on the short term (Dauber et al., 2015; Dauber et al., 2016). Demonstrating the variability in flower production within a season and dependency on either nutrient rich soils or manure management in order to guarantee a stable production of pollen and flowers throughout the year. Especially bumble bees will suffer from inconsistent flower development.

Silphium does restore intensively managed soils, but soil fauna diversity and density is less developed as compared to grasslands (Schorpp and Schrader, 2016). For insect populations living on the soil, the perennial crop is beneficial. Higher numbers of spiders and ground beetles have been recorded as compared to maize (Dauber et al., 2016). Absence of tillage and an extended root system results in soil organic matter build up. Earthworms and collembolan benefit from these conditions and increase in diversity, density and activity over the years (Dauber et al., 2015; Frölich et al., 2016)

The impact on biodiversity *by* Silphium crops was in the most cases assessed during the first years after establishment when the plants are juvenile. During these years patchiness in the field was still an artefact and helped to provide a diverse habitat for wildlife and insects. With increasing age of the Silphium crop, the inner field diversity might be reduced, thus effects on biodiversity might change (Dauber et al., 2016).

3.4 Does Silphium fit in the ecological focus area concept?

Silphium is an exotic species for Dutch farmers. The plant is suitable for biomass production for bioenergy and might be of interest as alternative fodder crop. Silphium provide pollen and nectar over a long season to generalist insects as for example honey bees. Visitation by wild bees has not been monitored. Silphium plants are generally less demanding on soil fertility and quality than for instance Miscanthus, but also for Silphium limited nutrient and water availability immediately affect flower development. Therefore it will remain challenging to sustain a stable flower production throughout a year, with reduced manure application or dry summers. This may reduce the suitability for insects without food storage systems as for example bumble bees. Silphium establishment is possible without chemical plant protection. Even though it is labour intensive in the initial phase, mechanical weeding or hand weeding may be necessary and successful. The long term commitment benefits soil (e.g. organic matter build up) and biodiversity. In later seasons pathogen infections are possible. With careful crop observations interference on time is possible without the use of plant protection products. An option is the removal of the infected crop by mowing.

That overall conclusion may be that *Silphium* could become an interesting new crop for ecological focus areas, producing biomass for bioenergy production and even fodder with a good protein content for animal nutrition. Cultivation without fertilization and the use of plant production products will not be too difficult and the crop will have an added value for insects, especially honey bees.

4 Multifloral green fallow with melliferous plants

Fallow land is farmland taken out of production and includes different land use measures (Den Belder et al., 2014) as for example seeding in with green manure for soil conservation (to increase soil organic matter content) or bare soil with spontaneous vegetation. Green manure mixtures are seed mixtures with grass, grass clover or legumes. Green manure produces roots and above ground biomass, covering the soil during the winter months. When ploughed under the nutrients become available to the following crop and biomass enhances soil organic matter. Legumes are able to fix nitrogen and add nitrogen to the system. Bare soil, as fallow, has limited implementation under Dutch conditions.

Another practice are catch crops as a follow up in the second part of the growing season after highly productive crop grown with high fertilizer application rates. This is done to catch surplus nutrients after the harvest. After maize growing a catch crop is mandatory on sandy soils in the Netherlands. In ecological focus areas catch crops are very popular in the Netherlands to meet the EFA targets (see Chapter 1.1). One of the main differences between fallow and catch crops are the fact that catch crops are grown at the end of the season for only a few months (at least 8 weeks) and fallow is implemented for a longer period (at least six months).

Allowing seed mixtures containing melliferous plants, to provide nectar and pollen to insects like honey bee and wild bees, could enhance multifunctionality of green fallow. There are two methods to seed green fallow with melliferous plants. Either as flower strips, aside with crops for production (for instance on field margins) or as whole fields. There are already a few seed companies selling seed mixtures. These mixtures often fulfil multifunctional purposes, since they contain seeds of plant species suitable for pollen and nectar provision for bees and other insects, seeds of plant species producing seeds for foraging birds (especially in autumn and winter) as well as producing biomass for green manure. These mixtures are developed for fields under agri-environmental schemes.

Honey bees are generalists and will benefit from a broad spectrum of melliferous plants. Wild bees are more site specific and often require specific plants and nesting sites. In order to benefit insects, certain aspects of management need to be addressed. For seeding, a sunny location need to be chosen. Bees and other insects are depending on warm and dry conditions. Once the green fallow is established, rotational mowing (not the whole field at once) is the appropriate management to maintain flowers and habitat during the whole growing season.
Buffer strips in fragmented areas are not always accessible for bees since flying distances for some species are too long (Schmid–Egger and Witt, 2014). Providing additional habitat by green fallow with melliferous plants supports the connectivity in the landscape and benefits insects.

In this report we present an overview of plant species used in a number of commercially available seed mixtures and evaluated their suitability as melliferous plants on land designated as fallow in ecological focus areas (Annex1). The species were derived from popular seed mixtures in the Netherlands as the Tübinger mixture (phacelia, buckwheat, white mustard, coriander, calendula, oil radish, malva, dille, borage) and the Landsberger mixture (crimson clover, Italian ryegrass, vetch). Next to the two seed mixtures mentioned above we included species from different seed mixtures used by ANV Wierde & Dijk in Groningen. The plants species were scored for bee attractiveness based on their nectar and pollen production according to Pritsch (2007)and included categories for pollen and nectar quality and flowering period according to Pritsch (2007) are: 4 = high, 3= good, 2= sufficient/ average, 1= poor.
We also summarized information on flower visitation by wild bees, bumble bees, honey bees and butterflies from Neve and Van der Ham (2014) and Koster (2018).

From this gross list (see Annex 1) we have selected 25 species presented in Table 1. The selection criteria were: A) Early flowering, B) Nectar and pollen attractiveness value for bees higher than 3 and C) Flower visitation monitored by a high insect diversity (Table 1). All these plant species have positive features for bees and related insect species, however some of these plant species will be not highly appreciated by farmers due to their invasive character or persistence of their seeds. Including all plant species in our advice will provide the farmers and seed companies with options to choose on the compilation of the seed mixture. To achieve a predominant 'multifloral green fallow mixture with melliferous plants', farmers should make a choice for at least ten species from the species of Table 1[1]. These seeds can then be added to the green fallow seed mixture with a total rate of at least 10 kg seed per ha and at least 0,2 kg per ha for each of the ten species. The plant diversity is important to provide plants with a long flowering season, a diverse and high quality of nectar and pollen suitable for different insect species. This should go in line with appropriate management which means mowing in phases, not the whole field at once (Koster, 2018; Pritsch, 2007). We propose that the mixture should be sown before 15th of May and last at least for six months on the field. Continuation of the green fallow for a second year will be better, while several of these species are biannual or perennial. They will flower in the second year more abundant.

In order to have the ground covered and prevent weed infestation by undesired weeds, the 10 kg (or more) of melliferous plant seed mixture could be blended into a seed mixture of at maximum 10 kg per ha of some common used seeds for green fallow, to apply in total 20 kg seed per ha at maximum. We advise to use slow growing grass species. When using fast germinating and vigorous growing grasses like Italian ryegrass, the grass will compete too much with the melliferous plant species. Therefore we advise to use red fescue (*Festuca rubra*), tall fescue (*Festuca arundinacea*) common meadow grass (*Poa pratensis*) or bristle oat (*Avena strigosa*). An extra advantage of bristle oat is its nematode suppressive effect, therefore bristle oat is already added to the Dutch general list of catch crops.
The nutrients from the previous cropping season will be sufficient for melliferous flower establishment, Additional nutrient application by fertilisation might out-compete the melliferous plants due to an increased growing rate of the grasses. We advise not to fertilise this fallow land.

[1] We can imagine that for some species seed supply and availability might be limited, or that farmers want to make their own choices in the composition of the seed mixture. Also some species fit better on sandy soils, other on clay soils. Therefore we advise to allow farmers to make their own choice from the list in Table 1.

Table 1. List of attractive plant species for honey bees, wild bees and other insects.

English name	**Latin name**	**Early flowering**	**High attractiv-eness nectar production**	**High attractiv-eness pollen production**	**Habitat/ visitation by high insect diversity**	**Risks**
Caraway	*Carum carvi*	√				
Coriander	*Coriandrum sativum*		√			
Wild carrot	*Daucus carota*				√ √	
Common yarrow	*Achiella millefolium*				√ √	*persistant*
Pot marigold	*Calendula officinalis*				√	*persistant*
Corn flower	*Centaurea cyanus*		√		√	*persistant*
Chicory	*Cichorium*		√	√		
Sunflower	*Helianthus*		√	√		
Borage	*Borago officinalis*		√ √			
Blueweed	*Echium Vulgare*		√			
Lacy phacelia	*Phacelia tanacetifolia*		√ √	√		*persistent*
White mustard	*Sinapis alba*			√	√	*persistent*
Common bird's-foot trefoil	*Lotus corniculatus*	√				
Lucerne	*Medicago sativa*		√			
White melioth	*Melilotus albus*		√ √	√		
Esparcette	*Onobrychis viccifolia*	√ √	√ √	√ √		
Red clover	*Trifolium pratense*	√	√	√		
Vetch	*Vicia sativa*	√	√			
Linseed	*Linum usitatissimum*		√			
Mallow	*Malva*		√			
Papaver	*Papaver*			√		*persistant*
Buckwheat	*Fagopyrum esculentum*		√ √	√		
Love in a mist	*Nigella damascena*		√			
Plantain	*Plantago lanceolata*			√		
Crimson clover	*Trifolium incarnatum*	√	√	√		

We advise that for 'multifloral green fallow mixtures with melliferous plants', farmers should make a choice for at least ten species from the species summarized in Table 1 with a total rate of at least 10 kg seed per ha and at least 0,2 kg per ha for each of the ten species. The melliferous plant seed mixture (10 kg) could be blended in with a maximum of 10 kg seeds per ha of red fescue (Festuca rubra), tall fescue (Festuca arundinacea), common meadow grass (Poa pratensis) or bristle oat (Avena strigosa). The mixture should be sown before 15th of May and last at least for six months on the field.

5 Sunflower (*Helianthus annus*) in mixtures for catch crops

Sunflower is a common species used in fauna mixtures grown on field margins under agri-environmental management schemes. These mixtures are sown in spring producing flowers in summer (offering an attractive landscape to visitors and nectar and pollen to insects) and seeds to birds in autumn and winter. In some European countries (Germany and Belgium) sunflowers are added to seed mixtures used for catch crops. The idea is that sunflowers develop a high amount of aboveground biomass, that is valuable to improve organic matter content of the soil. The plant contains chemical compounds with allopathic properties. Release of these properties into the soil by root exudation or decomposing biomass, causes weed suppression (Jabran, 2017).

Normally, sunflowers are seeded as a single crop in green manure. Now the question was posed on their value when included in a seed mixture in a catch crop. In an experiment on catch crops in central/eastern Poland the decline in biomass production at a delayed sowing date was measured by Zaniewicz-Bajkowska et al. (2013). When sunflowers were sown pure on the 21^{st} July 7.4 ton dry matter per hectare was produced. When sown at the 4^{th} of August 5 ton dry matter and sown on 18^{th} of August only 2 ton dry matter per hectare was produced until harvest at the end of October. Comparing sunflower with other green manure plant species, they found that sunflower was highly efficient in the accumulation of nutrients and macro nutrients. The fact that sunflowers produce biomass with a high nutrient content in the biomass , makes the plant highly suitable as catch crop . When the biomass is incorporated in the soil for the following crop, slow nutrient release and natural weed suppression due to the allopathic compounds will occur. The decomposing biomass enhances soil organic matter content.

The benefits for biodiversity due to flower establishment and seed setting remain challenging when sunflowers are components of catch crop mixtures. In the Netherlands information was obtained from an organic farmer (G. te Voortwis, Winterswijk, personal communication) growing sunflowers for cut flowers during a number of years. In spring and summer it takes 3 months between seeding and flowering for sunflowers, when plants were seeded between mid-March to Mid-June. In autumn it takes only two months. Thus when sunflowers are seeded in August, flowering in second half of October is possible. However we have to take in mind that insect activity in second half of October will be limited and there will be no ripe seeds produced, so the value for birds in autumn and winter will be minimalized.

In conclusion, incorporation of sunflowers in catch crop mixtures may enhance the value of the mixture. The reasons for that are a high biomass production when seeded in after an early harvested crop. The biomass has a high nutrient content, thus a high potential to catch nutrients from the soil. This biomass will benefit organic matter built up when incooperated into the soil. The allopathic properties reduce weed pressure. Sunflowers sown after an early harvest of the main crop may flower in October, but the ecological value for insects and birds will be very limited.

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Annex 1 List of attractive plant species for bees and other pollinators

Plant species name			Family	Flowe-ring period	*Bee attractiveness value* *4=high, 3=good, 2=sufficient/ average, 1=poor*		Honey production potential kg/ha	Habitat and food provision for *HB=honey bees, WB=wild bees, BB=bumble bees, BF= butterflies, HV=hoverflies, B=beetles, S=spiders, F=flies, Bi=Birds*	Soil requirements	Longevity	Additional information
Dutch Name	**English name**	**Latin name**			***Nectar***	***Pollen***					
Dille	dill	*Anethum graveolens*	Apiaceae	June-Sept	2	2		HB, WB, BF	stony soil	biannual	persitant/invasive
Karwij	caraway	*Carum carvi*	Apiaceae	May-June	1	1	70–134		well drained, high pH	biannual	early flowering
Koriander	coriander	*Coriandrum sativum*	Apiaceae	July-Aug	4	1	100-150	HB, WB, BB	sandy silt or soil of higher fertility, high pH	annual	very sensitive to weeds; too much N enhances sensitivity to fungal infections
Wilde peen	wild carrot	*Daucus carota*	Apiaceae	June-Sept	2	1		HB, WB, HV, B, BB, Bi	sandy stony, nutrient poor soil	biannual	2 x mowing a year
Pastinaak	parsnip	*Pastinaca sativa*	Apiaceae	July-Sept	2	1		HB, BB	clay, riverclay, $CaCO_3$ rich, alkaline	biannual	persitant/invasive
Duizendblad	common yarrow	*Achiella millefolium*	Asteracea	June-Sept	1	2		HB, B, S, F, WB, BF	dry, N-rich soils	perennial	persitant/invasive
Goudsbloem	pot marigold	*Calendula officinalis*	Asteracea	June-Sept	2	2		HB, WB, BB, BF	loamy sandy nutrient rich soil, acid	annual	persitant/invasive
Korenbloem	corn flower	*Centaurea cyanus*	Asteraceae	June-Sept	3	2	350-600	HB, WB, BF, BB	sandy clay	perennial	persitant/invasive
Chicorei	chicory	*Cichorium*	Asteraceae	July-Sept	3	3		HB, BB, WB	loamy soil	annual	2 x mowing a year

Gele ganzenbloem	corn marigold	*Glebionis segetum*	Asteraceae	June-Sept				HB, BB, BF	nutrient rich sandy soils	annual	
Zonnebloem	sunflower	*Helianthus annus*	Asteraceae	July-Sept	3	3	35-50	HB, BB, BF	nutrient rich, loamy soils	annual	
Kleine zonnebloem	thin leaf sunflower	*Helianthus Decapetalus*	Asteraceae	July-Sept	3	3		HB, BB, BF	nutrient rich, loamy soils	annual	
Magriet	oxeye daisy	*Leucanthemum vulgare*	Asteraceae	June-Sept	1	2		HB, BB, BF	loamy sandy soils	perennial	2 x mowing a year
Echte kamille	chamo-mile	*Matricaria chamomilla*	Asteraceae	May-Aug	0	2		HB, BB	generalist from sandy soil to clay soil	annual	poorly competive
Komkommer-kruid	borage	*Borago officinalis*	Boraginaceae	June-Sept	4	2		HB, WB	nutrient rich soil	annual	
Slangenkruid	blueweed	*Echium Vulgare*	Boraginaceae	May-Sept	3	2	182-429	HB, BB, BF	loamy stony soil, N-rich, $CaCO_3$-rich	biannual	max 2 x mowing a year
Phacelia	lacy phacelia	*Phacelia tanacetifolia*	Boraginaceae	July-Sept	4	3	214-496	HB, BB,		annual	green manure, persitant/invasive
Barabara-kruid	common winter-cress	*Barbarea vulgaris*	Brassicaceae	Apr-June					generalist from sandy soil to clay	biannual	2 x mowing, host plant cabage butterfly
Bladramme-nas	oil radish	*Raphanus sativus*	Brassicaceae	May-July	2	2		HB, BB, BF	nutrient rich soils	annual	green manure
Gele mosterd	white mustard	*Sinapis alba*	Brassicaceae	June, Aug-Sept	2	3	22-100	HB, WB, BF, BB	nutrient rich soils	annual	green manure, persitant/invasive
Bolderik	common corn-cockle	*Agrostemma githago*	Caryophyl-laceae	June-Aug					dry clay, loam	annual	plants and seeds are poisenous
Gewone rolklaver	common bird's-foot trefoil	*Lotus corniculatus*	Fabacea	May-Sept	2	2	16-60	HB, BB	nutrient rich, sand to clay	perennual	
Lupine	lupine	*lupinus angusttifolius*	Fabacea	June-July	1	1		HB, BB, BF	acid, nutrient rich sandy soil	annual	
Luzerne	lucerne	*Medicago sativa*	Fabacea	June-Sept	3	1	35-160	HB, BB, BF	$CaCO_3$ and nutrient rich soils	perennial	
Witte honigklaver	white melioth	*Melilotus albus*	Fabacea	June-Sept	4	3	200-600	HB, BB, BF	stony clay soils, rich in $CaCo_3$	annual	

Esparcette	esparcette	*Onobrychis viccifolia*	Fabacea	May-July	4	4	75-200	HB, BB	$CaCO_3$-rich sandy soils	annual	green manure
Serradella	seradelle	*Ornithopus sativus*	Fabacea	June-Aug	2	2			sandy soil, low pH, little nutrients	annual	green manure
Rode klaver	red clover	*Trifolium pratense*	Fabacea	May-Oct	3	3	20-150	BB	generalist from sandy soil to clay soil	perennual	
Kleine klaver	lesser trefoil	*Trifolium dubium*	Fabacea	May-Sept					acid soil	annual	
Alexandrijnse klaver	persian clover	*Trifolium resupinatum*	Fabacea					HB, BB, WB	generalist from sandy soil to clay soil	perennial	
Incarnaat klaver	crimson		Fabacea	May-Aug				HB., BB, BF, WB		annual	susceptibel to downy mildew
Voederwikke	vetch	*Vicia sativa*	Fabacea	May-Aug	3	1		HB, WB, BF, BB	laomy, clay soil, rich in $CaCO_3$	annual	
Erwt	pea	*Pisum sativum*	Fabacea					WB		annual	
Hennepnetel	hemp nettle	*Galeopsis tetrahit*	Lamiaceae	June-Sept	1	1		HB, BB	nutrient rich sandy soil	annual	persitant/invasive
Lijnzaad/Vlas	linseed	*Linum usitatissimum*	Linacea	June-Sept	3	2	2-12		sandy soil	annual	
Malva	mallow	*Malva*	Malvaceae	June-Sept	3	1	26-160	HB, BB, BF	generalist from sandy soil to clay soil	perennial	2 x mowing a year
Klaproos	papaver	*Papaver*	Papaveraceae	May-Aug	0	3		HB, BB	sandy dry soil	annual	persitant/invasive
Bleke klaproos		*Papaver dubium*	Papaveraceae					HB		annual	
Boekweit	buck-wheat	*Fagopyrum esculentum*	Polygonacea	July-Sept	4	3	90-490	HB, HF	poor sandy soil wih low pH	annual	
Veldzuring	common sorrel	*Rumex acetosa*	Polygonaceae						nutrient rich soil	perennial	
Wilde ridderspoor	forking lapspur	*Consolida regalis*	Ranuncula-ceae	June-Aug	1	2		HB, BB	$CaCO_3$-rich sandy soils	annual	
Juffertje in het groen	love in a mist	*Nigella damascena*	Ranuncula-ceae	June-July	3	2		HB, BB	nutrient rich soils	annual	
Timothee	thymothe	*Phleum pratense*	Poacea							perennial	

Smalle weegbree	plantain	*Plantago lanceolata*	Poacea	May-Sept	0	3	HB, BB	perennial
Italiaans raaigras	italien ryegras	*Lolium multiflorum*	Poacea					perenual
Gierst	millet and sorghum		Poacea					annual
Triticale	tritical		Poacea					annual
Westerwolds raaigras		*Lolium multiflorum*	Poacea					perennial
Zomergerst	barley	*Hordeum vulgare*	Poacea					annual
Zomertarwe	wheat	*Triticum aestivum*	Poacea					annual
Haver	oat	*Avena sativa*	poacea					annual
Kropaar	orchard grass	*Dactylis glomerata*	Poacea					perenual
Beemdlang-bloem	meadow fescue	*Festuca pratensis*	poacea					perennual
Roodzwenk-gras	red fescue	*Festuca rubra*	Poacea					perennual

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Report WPR-793