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DPPP – A WORLDWIDE SEARCH FOR PALUDICULTURE PLANTS AND THEIR POTENTIAL TO STOP PEAT DEGRADATION

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SUMMARY

Paludiculture ('palus' lat. for swamp) is the productive use of wet and rewetted peatlands in a way that the peat body and essential ecosystem services of mires such as carbon store, water regulation and biodiversity conservation are preserved. Next to the few well-established paludiculture plants, a wealth of wetland species is promising for paludiculture. The identification and description of such crops is essential for the wide implementation of paludiculture. The Database of Potential Paludiculture Plants (DPPP) was established to gather information on the variety of useful wetland plants and to present the first global overview of potential paludiculture plants. Paludiculture is a new and diverse land-use concept with fundamental differences in design and management depending on the species cultivated and the crops produced. Paludiculture plants vary from trees, to grasses, mosses, herbs or berry producing shrubs. In order to assess their different potential for peatland sustainability we developed easy accessible criteria for their potential for paludiculture. To date the database contains information on 1128 plant species, of which 735 species grow in the tropical Ecozone (FAO) and 463 in the subtropics. For 469 plant species the current potential for paludiculture is considered to be good because a market exists for products made of their aboveground parts. A large group of Database entries (40%) are assessed as "not defined", which means that the market demand could not be defined. More research and a better data gathering especially in the tropics can precise these unknown number of more potential paludiculture species.

***Keywords**: paludiculture, wetland plants, peatland utilisation, rewetting, peat conservation*

INTRODUCTION

Conventional peatland utilisation for agriculture, forestry or peat extraction requires drainage which results in enormous emissions of greenhouse gases and nutrients. In total an area of c. 460,000 km² of degrading peatlands exists worldwide (Barthelmes 2016). 25 % of worldwide carbon dioxide (CO_2) emissions within the sector land use, land use change and forestry (LULUCF) is caused by drained peatland (Joosten *et al.*, 2012). Rewetting drained peatland is required to avoid further peat degradation and mitigate greenhouse gas emissions.

In many regions worldwide, the pressure of land utilisation continuously increases by a growing population along with their need for shelter, infrastructure, raw materials and not least food. In recent time the losses of usable land occurred due to overexploitation, climate change and new land claims, among other things due to the intensified use of bioenergy and raw materials, which are additional strong drivers of the growing demand for land (Wichtmann *et al.*, 2016). The current focus of extending drainage and thus also degradation of peatlands is on Southeast-Asia (Miettinen *et al.* 2012, Joosten *et al.* 2012), where the amelioration measures lead to accelerated degradation processes for climatic reasons and therefore have often a more severe impact on the environment, economy and living conditions (e.g. Yule 2010)

Paludiculture ('palus'– latin for 'swamp'), the productive use of wet peatlands, may combine the provision of essential ecosystem services of mires such as carbon storage, water regulation and biodiversity conservation with the production of useful biomass (Wichtmann et al. 2016). The precondition for paludiculture is that the peatland is so wet that the peat soil is conserved and that new peat may even accumulate. Paludicultures are currently concentrated in the temperate climate zone but everywhere in the world the same necessities, challenges and possibilities exist in relation to a sustainable peatland use. Specific literature about paludiculture plants is rare and scattered between disciplines (e.g. Haslam 2010, FAO Case studies 2015, Giesen 2013, Oehmke & Abel 2016), meta studies searching for transferable information on wetland plants for paludiculture are more or less not existent.

To facilitate land use change towards paludiculture we developed the Database of potential paludiculture plants (DPPP) for the identification of new peatland crops (Abel *et al.* 2013). Plants suitable for paludiculture must grow under wet conditions, produce biomass in sufficient quantity and quality and their cultivation should conserve the peat soil (Wichtmann & Joosten 2007). But which concrete criteria define whether a wetland species will be suitable for paludiculture?

Here we present the current state of the DPPP and the theoretical considerations to assess the paludiculture potential of wetland plants with special attention to peat conservation and market demand. Furthermore, we want to stress the necessity for the improvement of the tropical plant entries within the DPPP.

METHODS

The DPPP - Database of Potential Paludiculture Plants was constructed using Microsoft Office Access 2010. For every species the DPPP create a 'plant portrait' that contains information on plant characteristics and morphology, distribution and natural habitat, modes of cultivation and propagation as well as utilisation options, if available (Fig. 1). In Europe and North America the availability of data was much easier than in the tropics or Asia. Several online databases provide information about useful plants in English. The accessibility of data in the tropics and in Asia was difficult due to language barriers and lack of online publications.

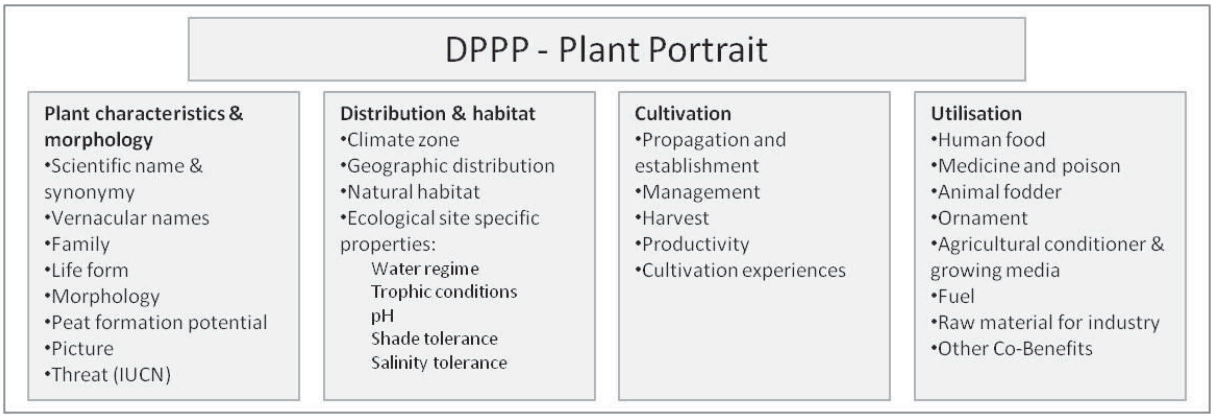

Figure 1: Structure and content of the DPPP 'Plant portrait' entries.

Since not every useful wetland plant will be suitable for paludiculture we developed a decision tree (Fig. 2) to analyse the paludiculture potential in four levels of suitability (promising, good, limited and very low potential). The tree uses as a first step information on the persistency (annual vs. perennial plant) and the used plant parts (above- vs. belowground biomass) to assess the peat conservation potential, followed by questions related to market demand (yes or most likely in future vs. unlikely) and if the plant is already cultivated in paludiculture (yes vs. no).

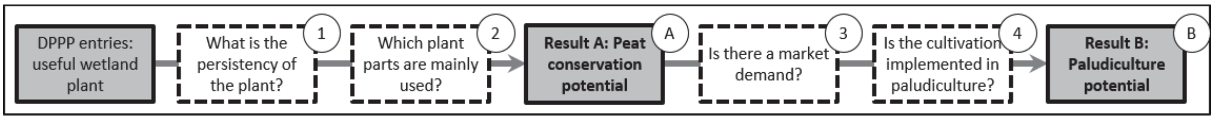

Figure 2: Decision criteria (1-4) and process for the assessment of the peat conservation potential (A) and paludiculture potential (B).

RESULTS AND DISCUSSION

The DPPP - Database of Potential Paludiculture Plants registers currently 1131 plant species (Fig. 3). 469 species listed in the DPPP have a promising or good potential, 272 have only limited or very low potential for paludiculture. The potential of 485 plants could not be assessed because of unknown market demand or missing knowledge about the used plant parts. Here, more and better data gathering especially in the tropics can precise the unknown number of potential paludiculture species. Since the data gathering was done mostly from Germany, a regional analysis would achieve much better results.

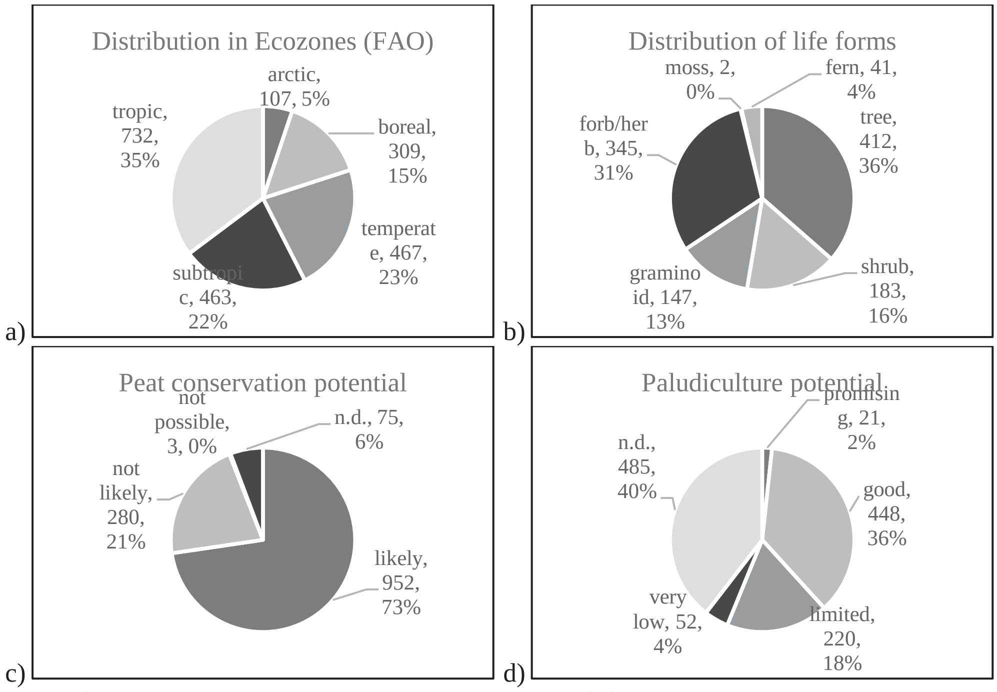

Figure 3: Distribution of the DPPP entries pertaining to a) the FAO Ecozones, b) life forms, c) peat conservation potential and d) paludiculture potential. Multiple selections possible for the ecozone assignment.

The peat conservation potential of a specific paludiculture is likely for 952 entries, 280 plant species show a 'not likely" potential and only of 3 species the potential to conserve peat under paludiculture is assessed as not possible. 75 species could not be assessed because of a lack of data.

Peat conservation is less likely when annual or short living plants are cultivated in paludiculture. Annual or short living plants usually need a regular mechanical preparation of the topsoil to prepare the seed bed or the planting site for the next crop rotation. Additionally, regular tillage is needed for weed control. These measures increase the decomposition rate by mobilizing nutrients as well as oxygen. The peat conservation potential of perennial plants is usually more likely. Due to the longer life span, the frequency of required soil preparation is usually lower.

We assume that the removal of that part of the biomass that is not necessary for peat accumulation won't have a negative impact on the peat conservation in paludiculture, neglecting the influence of management practice and harvest devices. The belowground biomass seem to be the main input for peat formation in peatlands that are dominated by vascular plants (e.g. Aerts et al. 1992, Barthelmes 2010, Bernard et al. 1988, Coleman 1976, Hartmann 1999, Hoyos-Santillan et al. 2015), in which the roots and rhizomes are growing into the already accumulated peat and form a so called 'displacement peat'. Harvesting the belowground plant compartments will disturb the soil stratigraphy and conflict with the goal of peat conservation. Harvesting the aboveground biomass, preferably without disturbing the peat soil and in a non-destructive way to sustain the plant cover for a rotational harvest will most likely be peat conserving. There is hardly any literature about the harvest influence on paludiculture (e.g. Kotowsky et al. 2013), further research is necessary to understand and adapt the management to conserve the peat in paludiculture.

Additionally, the installation of more demonstration areas is required to test and optimize cultivation techniques; study selection and propagation of suitable eco-types, development of site adapted machinery, and long-term environmental effects (peat hydraulics, peat formation, emissions, biodiversity). The growing demand for sustainable land use options can be expected to boost innovations in these fields.

The need for land use change on peatland is widely recognized (Joosten et al. 2012), but the cultivation of new crops can be counterproductive if the peculiarities of peat soils are insufficiently respected. Avoidance of peat degradation, greenhouse gas emissions and nutrient discharge requires permanent water saturation, minimal soil disturbance and careful nutrient management. Assessment of the paludiculture potential will help to avoid these counterproductive effects. Cultivation of plants with a promising and good potential will likely contribute to peat conservation and simultaneously sustain the provision of marketable biomass. Species with a limited potential may be suitable as well, but may first require the development of suitable peat conserving crop management techniques or the promotion of a market demand.

A book on potential paludiculture plants of the Holarctic (North America, Europe and Northern Asia) presenting a selection of 90 plant species of the Holarctic, is currently under preparation. This will be a synthesis of the data of the DPPP and further meta-analysis of literature concerning their potential cultivation in wet peatlands.

CONCLUSION

The DPPP provides valuable information on useful wetland plants worldwide. An improved data gathering in the tropical and subtropical zones is necessary to fill the gaps and complete the potential analysis of the entries. The potential for paludiculture is determined by the peat conservation potential and the market demand for products of the respective species. Promotion of species with a promising and good potential for paludiculture will likely contribute to peat conservation. Supporting measures for their promotion bear hardly any risk of being counterproductive as the practice will in any case not be worse than current drainage based land use. Nevertheless, the effects of management practices on carbon and nutrient emissions have to be addressed by further research whereas good practice guidelines must be developed from best practice examples and pilot projects.

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