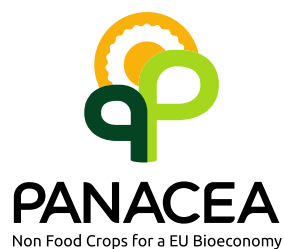




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D1.1. List of Data sources





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Abstract

PANACEA deliverable D 1.1 “List of data resources” delivers an inventory of projects on the cultivation, agronomic management, harvest and logistics of non food crops (NFC) for the bio-based industry. The inventory includes 217 projects carried out in Europe approximately between 1995 and 2017 and identifies 93 NFC crops, including lignocellulosic, oilseed, carbohydrates and speciality crops, which have been experimented in European agricultural frameworks and can provide renewable feedstock for bio-based applications. The projects inventory serves as a database of experiences and skills on specific NFC crops that PANACEA will disseminate and make available to farmers, bio-based industries and all potential stakeholders of bio-based chains. The projects inventory is accompanied by a library of 954 scientific agronomic articles relevant to the most novel and less known NFC crops to the European agriculture. The library is meant to show the research effort put into the adaptation of such crops to European agriculture conditions, and can foster confidence in new crops and bridge farmers’ and industries’ interests.



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Library of research articles.zip	

D 1.1

List of data resources



List of data resources

Aim of PANACEA projects inventory and relevant research data

PANACEA aims at facilitating the exchange of knowledge and innovative ideas on the production of biomass for the bio-based industries among researchers, farmers and industries. Several research projects have been funded in recent years for the identification of suitable plant sources and set up of agronomic practice and supply chains. However, the results achieved by those projects have not been spread and uptaken by the practitioners, either because the agriculture and market were not mature for such new concepts or because the research remained confined to isolated projects disconnected from existing agriculture chains, or the information did not reach the relevant stakeholders.

The aim of WP1 of PANACEA is to collect research data and innovative ideas from such past projects in order to make them available in an integrated and organized way to farmers and industries, through the dissemination of near-to-practice crops and solutions that can serve as a background of experiences to refer to for the promotion of bio-economy chains.

The final result of WP1 is an inventory of scientific results which is screened, through the sieve of farmers' and industries' needs and prospects (WP2) and the results of value chain events among stakeholders (WP3 and WP4), to identify the most near-to-practice non-food crops (NFC). The inventory is built in three steps: 1) data collection of relevant projects and research data, 2) selection of NFC crops near to implementation in agricultural practice and 3) analysis of opportunities or limitations for the implementation of the relevant value chains. Deliverable 1.1 covers the first step and delivers a list of projects and relevant research data.

Methods

Criteria for the selection of relevant projects for PANACEA projects inventory

All PANACEA partners provided a list of EU and national relevant projects in which they had actively worked or were aware of. We then browsed the EU platforms "Cordis" and the database of Life projects for further projects. We used collective nouns as keywords, such as "oil crops", "fibre crops", "lignocellulosic crops", "carbohydrate crops" or starch "crops", "speciality crops", "aromatic plants", "non food crops", "industrial crops", "bio-based" "biomass" etc. in order not to restrict our search to the crops of our knowledge and direct expertise, but have a broader overview of the European state of the art.

Of the several hits that appeared for each search, we selected those projects that dealt with cultivation, harvest, logistics and biomass chains.

For each project we entered the crop species and the main crop category focus of the project (i.e. oilseed crops, lignocellulosic crops (including fibre crops), carbohydrate crops and/or speciality crops), the aim of the project and which step of the biomass supply chain was addressed by the project (either cultivation/agronomic management or harvest/logistics, or other), in addition to the title, the contact of the coordinator or of a known scientific contact, and the link to the website of the project. Projects that had no website were linked to the project results published in Cordis.

Criteria for the selection of relevant research data for PANACEA projects inventory

This search was done in two ways.

- 1) For each project we looked for collections of reports, abstracts, books etc., resulting from events (for instance workshops) organized by the project or specifically produced by the project. The link to these collections of documents are reported in a spreadsheet entitled "web" next to the spreadsheet of the "projects".



- 2) For the most unknown crops of PANACEA projects inventory we searched for scientific literature that addressed either the cultivation/agronomic management or harvest/logistics or provided a broad review of the species and its uses. We used the reference manager “Mendely desktop ver. 1.17.13” to create a library of linkable references organized both by crop and chain stage (i.e. cultivation and harvest). The search was focused on NFC species that are new to the European agriculture and poorly known as crops. We left out species that have a long domestication and agriculture tradition, such as for instance *Brassica napus* (oilseed), *Glycine max* (soybean), *Helianthus annuus* (sunflower) which are also a valuable source of NFC biomass for the bio-industry. The search was focused on herbs (both annuals and perennials) of agronomic interest.

PANACEA projects inventory

The project inventory (attached “PANACEA projects inventory.xlsx” file) includes 217 projects carried out between approximately 1995 and today. Of these 148 are EU-financed projects (including 7 Life projects), 65 are national projects that were pursued in the 10 countries of PANACEA consortium (Greece, The Netherlands, Italy, United Kingdom, Portugal, Spain, France, Romania, Lithuania and Poland), two are projects developed within cooperation agreements between countries (Portugal-Brazil) and two are relevant projects carried out in the US.

Of the 217 projects, 125 concern lignocellulosic crops (including fibre and wood), 58 concern oilseed crops, 41 concern speciality crops and 37 carbohydrates crops (several projects include more than one crop category). 109 projects are about the cultivation and agronomic management of these NFC crops, whereas 77 concern harvest and logistics. Other chain stages addressed by the inventoried projects are breeding, biomass processing, uses of biomass or of the extracted molecules, establishment of cooperations or networks among the stakeholders of the bio-based chains, environmental impact, policy and market, which were addressed along with the cultivation and/or harvest of the NFC crop. Three projects produced three databases, one about bio-compounds produced by the floras of Europe, Africa, Asian-Pacific and Latin America, one about projects addressing the bio-technology for the conversion of industrial crops and waste biomass in Europe and India, and one is an inventory of industrial crops updated as at 1999.

In total 93 NFC crops were recorded in the projects inventory (Fig. 1 and Annex 1 with scientific and vulgar crop names), of which 60 are dedicated herbaceous crops, 15 are trees that can be either coppice or prunings, and 17 are well established food crops (like sunflower for instance) that produce non-food oils or other bio-compounds along their food chains, or their residuals (shoots and leaves after removing the seeds) are a source of energy (like wheat straw, maize etc.) Of the 60 dedicated crops 33 are either new herbaceous crops introduced to Europe or previously abandoned crops that have been revisited for their biomass compounds, and 27 are minor crops that have already a supply chain and a market in Europe as medicinal and aromatic plants or as fodder crops. Of the new 33 new crops, 14 are annual crops (*Brassica carinata* (oil), *Camellina sativa* (oil), *Cannabis sativa* (fibre), *Corchorus* spp. (fibre), *Coriandrum sativum* (oil and aromatic compounds), *Crambe abyssinica* (oil), *Crotalaria juncea* (energy), *Dimorphoteca pluvialis* (oil), *Euphorbia lagascae* (oil), *Hibiscus cannabinus* (energy), *Luffa* spp. (fibre), *Lunaria annua* (oil), *Plantago* spp. (medicinal/aromatic compounds), *Sorghum bicolor* (fibre and energy)) and 19 are perennials (*Arundo donax* (energy), *Cichorium intybus* (carbohydrates), *Cytisus* spp. (fibre), *Dactylis glomerata* (energy), *Echinacea* spp. (medicinal/aromatic compounds), *Helianthus salicifolius* (oil, energy), *Jatropha curcas* (energy), *Juncus acutus* (water treatment), *Lupinus mutabilis* (chemical compounds), *Miscanthus x giganteus* (energy), *Pachyrhizus ahipa* (oil and chemical compounds), *Panicum virgatum* (energy), *Parthenium argentatum* (rubber), *Phragmites australis* (water treatment and energy), *Sida hermaphrodita* (energy and chemical



PANACEA. Non Food Crops For a EU Bioeconomy

New strategies for the development and promotion of NFC in Europe

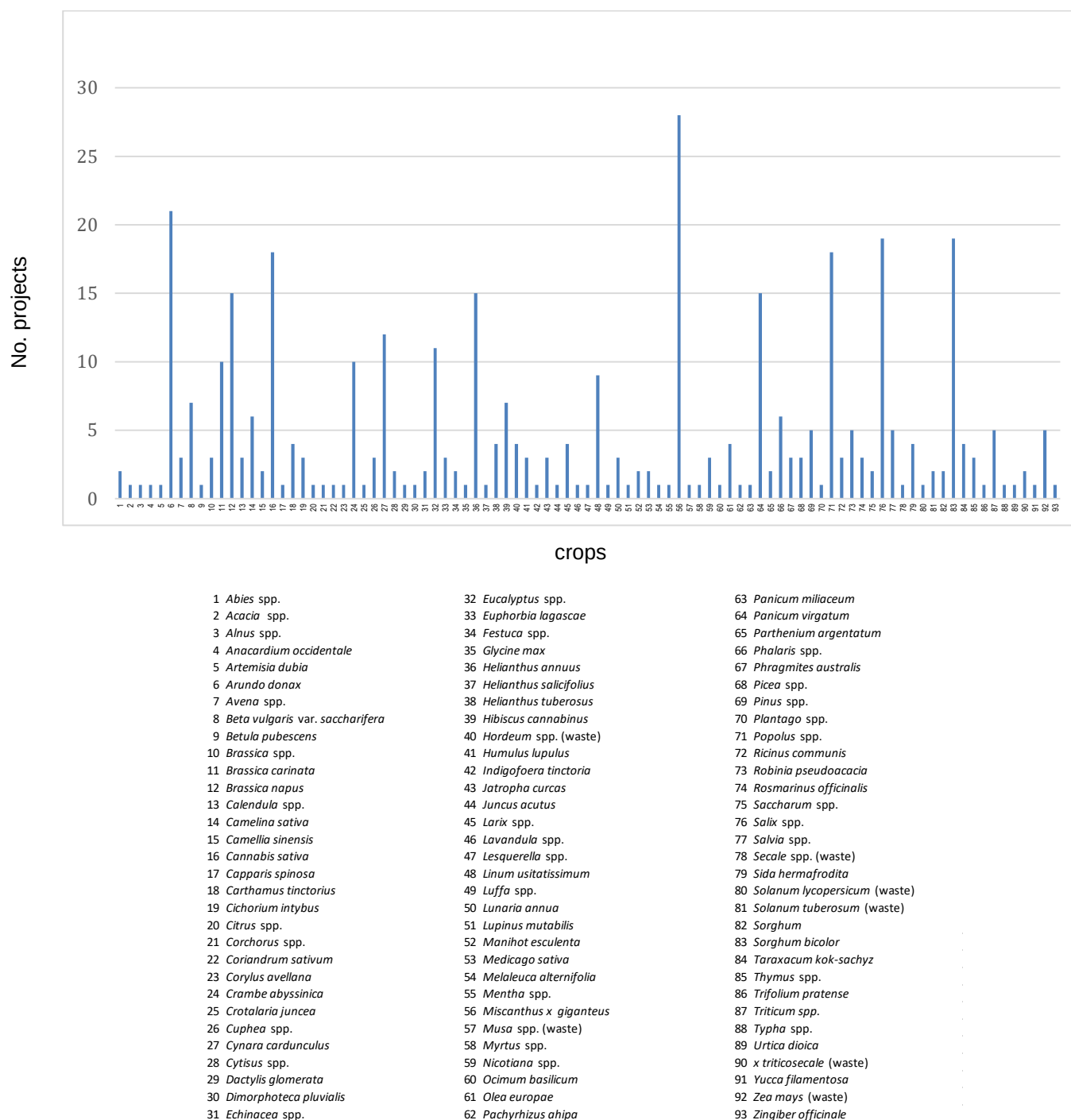
compounds), *Taraxacum kok-sachys* (rubber), *Typha* spp. (water treatment and energy), *Urtica dioica* (fibre) and *Yucca filamentosa* (fibre). Many of these crops can provide feedstock for different uses. The 27 already established crops include the genera *Artemisia*, *Calendula*, *Capparis*, *Lavandula*, *Mentha*, *Myrtus*, *Ocimum*, *Rosmarinus*, *Salvia*, *Thymus*, *Zingiber* and *Helianthus tuberosus* (cultivated for their medicinal/aromatic/chemical compounds), *Brassica*, *Cuphea*, *Humulus*, *Physaria* (syn. *Lesquerella*), *Ricinus* (cultivated as oilseed crops), *Avena*, *Festuca*, *Medicago*, *Phalaris*, *Sorghum*, *Trifolium* and *Panicum milaceum* (cultivated as fodder crops), *Linum usitatissimum* (cultivated as fibre), *Carthamus tinctorius* and *Indigofera tinctoria* (cultivated as dyes).

The 20 food crops include *Beta vulgaris* var. *saccharifera*, *Camellia sinensis*, *Cynara cardunculus*, *Glycine max*, *Helianthus annuus*, *Manihot esculenta*, *Zea mays* and multiple species of the genera *Brassica*, *Hordeum*, *Saccharum*, *Secale*, *Solanum*, *Triticum*, *x tritico-secale*. Of these *Camellia sinensis* (tea) and *Manihot esculenta* (cassava) are new potential food crops to Europe producing chemical compounds and carbohydrates (*Manihot esculenta*) also for non-food uses.

The 15 tree species include both species new to Europe and species for which Europe has a long forestry and coppicing tradition. The new tree species were considered either as biorefining coppice (*Acacia* spp. and *Robinia pseudoacacia*) or for their oils (*Anacardium occidentale* and *Melaleuca alternifolia*). The species for which Europe has a consolidated experience in forestry belong to the genera *Abies*, *Alnus*, *Betula*, *Eucalyptus*, *Larix*, *Picea*, *Pinus*, *Populus* and *Salix*. Other projects concern the tree species *Corylus avellana* (hazelnut), *Olea europaea* (olive tree) and species of the genus *Musa* (banana trees) which were regarded as feedstock of biomass and chemical compounds from their wastes (nutshells, oil and peel) or their cultivation was promoted in the Mediterranean region for their aromatic compounds (*Citrus* spp., i.e. agrumes).

Figure 1 provides a synthesis of the crops of PANACEA projects inventory, and reflects the skills of PANACEA Consortium and the experience in the cultivation and harvest of NFC crops build up in the countries of PANACEA Consortium. Crops that have received more research efforts and attracted more funds in these countries are lignocellulosic crops, with the herbaceous crops *Arundo donax*, *Cannabis sativa*, *Miscanthus x gigantea*, *Sorghum bicolor*, and the trees poplars and willows scoring more than 15 projects each. These crops are followed by *Panicum virgatum* and *Cynara cardunculus* (cardoon, a food crop), and eucalypts (trees) as feedstock for the energy chain with more than 10 projects. Among the oilseed crops, *Brassica carinata*, *Camelina sativa* and *Crambe abyssinica* score between 5 and 10 projects and appear the first oilseed option after the conventional crops of *Helianthus annuus* (sunflower) and *Brassica napus* (rapeseed). While lignocellulosic and oilseed crops projects have focused on the development of a few high yielding crop species, carbohydrate and speciality crops projects have looked at a variety of crops in order to differentiate the molecules and compounds that can be sourced from NFC biomass. For this reason these last two crop categories include several crop species, but score lower in number of projects per species (less than 5 projects) than lignocellulosic and oilseed crops.

Figure 1. NFC crops of PANACEA projects inventory. The height of the bars corresponds to the number of projects that concerned a specific crop. Crops are indicated by a number under the bar and the numbers are detailed in the legend below the graph.



Relevant research data for PANACEA projects inventory

The search of research data relevant to the NFC crops of PANACEA projects inventory produced a library of 954 scientific articles (attached “Library of research articles.zip” folder) relevant to the cultivation and/or harvest of 38 new or poorly known NFC crops (Table 1). The library is not meant to be exhaustive but to provide accessible relevant scientific literature that can guarantee agronomic expertise in PANACEA NFC crops, and may stimulate and satisfy the interest of farmers, industries and stakeholders in NFC crops. The different number of articles linked to each crop is not indicative of a different agronomic expertise level, but reflects a different research effort in the cultivation of the species, either because some species are more sensitive than others to the environmental conditions, or have a longer agriculture tradition, or can be cultivated in different ways depending on the compound of interest.

Table 1. Library of research articles on cultivation, agronomic management, harvest, logistics and general characteristics of new or poorly known NFC crops of PANACEA projects inventory.

Crops	No. articles
<i>Artemisia dubia</i>	12
<i>Arundo donax</i>	37
<i>Calendula</i>	19
<i>Camelina sativa</i>	38
<i>Cannabis sativa</i>	58
<i>Carthamus</i>	18
<i>Chorchorus</i>	3
<i>Cichorium intybus</i>	13
<i>Crambe abyssinica</i>	18
<i>Crotalaria juncea</i>	4
<i>Cuphea</i>	44
<i>Cynara cardunculus</i>	21
<i>Dimorphoteca pluvialis</i>	2
<i>Echinacea purpurea</i>	12
<i>Euphorbia lagascae</i>	16
<i>Helianthus tuberosus</i>	38
<i>Hibiscus cannabinus</i>	20
<i>Indigofera tinctoria</i>	4
<i>Jatropha curcas</i>	14
<i>Luffa</i>	5
<i>Lunaria annua</i>	5
<i>Lupinus mutabilis</i>	7
<i>Manihot esculenta</i>	19
<i>Miscanthus x giganteus</i>	11
<i>Pachyrhizus ahipa</i>	17
<i>Panicum virgatum</i>	29
<i>Parthenium argentatum</i>	48
<i>Phalaris</i>	23
<i>Phragmites australis</i>	23
<i>Physaria (syn. Lesquerella)</i>	27
<i>Plantago</i>	43
<i>Ricinus communis</i>	26
<i>Sida hermaphrodita</i>	7
<i>Sorghum bicolor</i>	56
<i>Taraxacum kok-sachyz</i>	9
<i>Typha</i>	16
<i>Urtica dioica</i>	9
<i>Zingiber officinale</i>	8
NFC Cultivation	129
NFC Harvest	46

Appendix 1. List of NFC crops of PANACEA projects inventory: latin and vulgar names of crop speceis

Crop species (scientific name)	Crop species (vulgar name)
<i>Abies</i> spp.	spruce
<i>Acacia</i> spp.	acacia
<i>Alnus</i> spp.	alder
<i>Anacardium occidentale</i>	cashew nut
<i>Artemisia dubia</i>	mugwort, artemisia,
<i>Arundo donax</i>	giant reed
<i>Avena</i> spp.	oat
<i>Beta vulgaris</i> var. <i>saccharifera</i>	sugar beet
<i>Betula</i> spp.	birch
<i>Brassica carinata</i>	Ethiopian mustard
<i>Brassica napus</i>	rapeseed
<i>Calendula</i> spp.	calendula, marigold
<i>Camelina sativa</i>	camelina, false flax, gold of pleasure
<i>Camellia sinensis</i>	black tea, green tea
<i>Cannabis sativa</i>	hemp
<i>Capparis spinosa</i>	caper
<i>Carthamus</i> spp.	safflower
<i>Chorchorus</i> spp.	juta
<i>Cichorium intybus</i>	chicory
<i>Citrus</i> spp.	agrumes
<i>Coriandrum sativum</i>	coriander
<i>Corylus avellana</i>	hazel nut
<i>Crambe abyssinica</i>	crambe
<i>Crotalaria juncea</i>	sunhemp
<i>Cuphea</i> spp.	cuphea
<i>Cynara cardunculus</i>	cardoon
<i>Cytisus</i> spp.	common broom
<i>Dactylis glomerata</i>	cock's-foot, orchard grass, cat grass,
<i>Dimorphoteca pluvialis</i>	white African daisy, Cape marigold, rain daisy
<i>Echinacea purpurea</i>	echinacea, coneflower
<i>Eucalyptus</i> spp.	eucalypt
<i>Euphorbia lagascae</i>	spurge
<i>Festuca arundinacea</i>	tall fescue
<i>Glycine max</i>	soybean
<i>Helianthus annuus</i>	sunflower
<i>Helianthus salicifolius</i>	willowleaf sunflower,
<i>Helianthus tuberosus</i>	Jerusalem artichoke
<i>Hibiscus cannabinus</i>	kenaf
<i>Hordeum</i> spp.	barley
<i>Humulus lupulus</i>	hop
<i>Indigofera tinctoria</i>	indigo
<i>Jatropha curcas</i>	jatropha, physic nut, nettlespurge
<i>Juncus acutus</i>	spiny rush, sharp rush, sharp-pointed rush
<i>Larix</i> spp.	larch
<i>Lavandula</i> spp.	lavander
<i>Lesquerella</i> (syn. <i>Physaria</i>) spp.	bladder-pod
<i>Linum usitatissimum</i>	flax
<i>Luffa</i> spp.	loofah
<i>Lunaria annua</i>	honesty
<i>Lupinus mutabilis</i>	tarwi, chocho, altramuza, Andean lupin, South American lupin, Peruvian field lupin, pearl lupin
<i>Manihot esculenta</i>	cassava
<i>Medicago sativa</i>	alfalfa
<i>Melaleuca alternifolia</i>	paperbarks, honey myrtles, tea tree
<i>Mentha</i> spp.	peppermint
<i>Miscanthus x giganteus</i>	miscanthus, silvergrass
<i>Musa</i> spp.	banana
<i>Myrtus</i> spp.	myrtle
<i>Nicotiana</i> spp.	tobacco
<i>Ocimum basilicum</i>	basil
<i>Olea europaea</i>	olive tree
<i>Pachyrhizus ahipa</i>	ahipa, Andean yam bean
<i>Panicum miliaceum</i>	millet
<i>Panicum virgatum</i>	switchgrass
<i>Parthenium argentatum</i>	guayule



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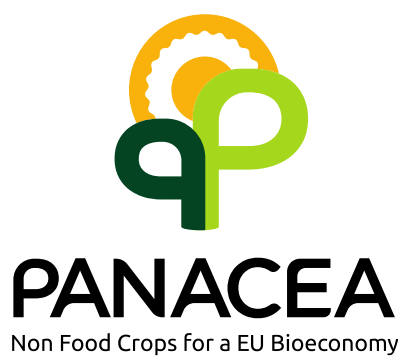
New strategies for the development and promotion of NFC in Europe

<i>Phalaris</i> spp.	reed canary grass
<i>Phragmites australis</i>	common reed
<i>Physaria</i> (syn. <i>Lesquerella</i>) spp.	bladder-pod
<i>Picea</i> spp.	red spruce
<i>Pinus</i> spp.	pine
<i>Plantago</i> spp.	plantains, fleaworts
<i>Populus</i> spp.	poplar
<i>Ricinus communis</i>	castor
<i>Robinia pseudoacacia</i>	robinia, black locust, false acacia
<i>Rosmarinus officinalis</i>	rosemary
<i>Saccharum</i> spp.	sugar cane
<i>Salix</i> spp.	willow
<i>Salvia</i> spp.	sage
<i>Secale</i> spp.	rye
<i>Sida hermaphrodita</i>	sida
<i>Solanum lycopersicum</i>	tomato
<i>Solanum tuberosum</i>	potato
<i>Sorghum bicolor</i>	fibre sorghum, sweet sorghum
<i>Taraxacum kok-sachyz</i>	Russian dandelion
<i>Thymus</i> spp.	thyme
<i>Trifolium pratense</i>	red clover
<i>Triticum</i> spp.	wheat
<i>Typha</i> spp.	cattail
<i>Urtica dioica</i>	nettle
<i>x triticosecale</i>	triticale
<i>Yucca filamentosa</i>	yucca
<i>Zea mays</i>	maize
<i>Zingiber officinale</i>	ginger



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New strategies for the development and promotion of NFC in Europe



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