



"Non-food Crops-to-Industry schemes in EU27"

WP1. Non-food crops

D1.5 Matrix with non food crops and their multiple end use potentials and allocation factors

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INTRODUCTION

The aim of this report is to record the multiple use possibilities for the under study non food crops and define the best range of end use allocation factors.

The multi-purpose potential of the non food crops has been acknowledged in literature as a key element which increases their added value both in terms of economics and sustainable management. Therefore, it is considered essential to develop a matrix with the non food crops and their multiple end use potentials.

METHODOLOGY

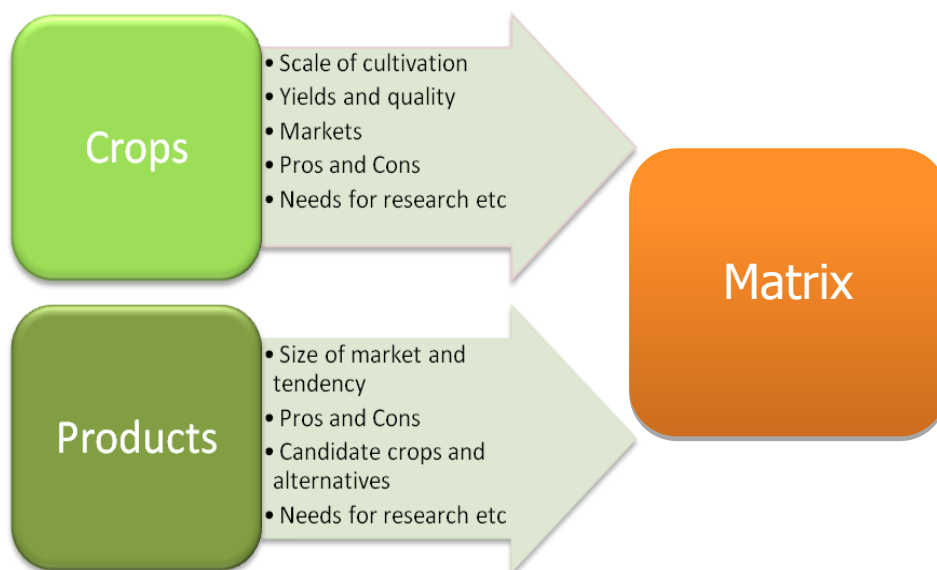
A matrix of crops and their multiple use possibilities is designed and highlighted in Figure 1 based on the findings of the 'Work Package 1 - Non-food crops' and 'Work Package 3 - Biobased products', which are summarized in relevant tables included in Deliverables D1.1 - D1.4 as well as in Deliverables D3.1-D3.4 respectively.

The summary tables of crops include information on:

- ↪ Origin
- ↪ Area of EU cultivation [ha]
- ↪ Yield [t/ha]
- ↪ Product/market
- ↪ Pros (+)
- ↪ Cons (-)
- ↪ Needs (research, policy, etc)
- ↪ Remarks

Likewise, the summary tables of products contain information on:

- ↪ Products/raw material
- ↪ Market size in EU (t), real or estimated
- ↪ Tendency of the market
- ↪ Pros (+)
- ↪ Cons (-)
- ↪ Candidate crops
- ↪ Competitive alternative crops/raw materials
- ↪ Needs (research, policy, etc)
- ↪ Remarks



'End use allocation factors' are determined in order to evaluate both the type (e.g. seeds, straw, husks, etc.) and the amount of material that would be used for each end product. The end use allocation factors were defined by both the scientific and industrial experts participating in the project.

A scale from 0 to 3 was applied.

0: technically very difficult or impossible

1: technically possible but with low or no interest

2: technically possible

3: already used for this application or good candidate

Because a number of crops are used also for food/feed purposes, end allocation factors were identified for the food products; however, they were not taken into account in the final ranking of crops-to-products streams.

To integrate different crops with more or less homogenous markets, separate matrixes were designed for the oil, fiber, carbohydrates and other specialty crops.

RESULTS

Table 1 Matrix with oil crops and their multiple end use potentials and allocation factors

	Lubricants		Paint	Polymer	Biodiesel	Other	Food
	Low quality	High quality					
Calendula (<i>Calendula officinalis</i> L.)	0	0	3	2	0		3
Cardoon (<i>Cynara cardunculus</i> L.)	1	0	2	0	2		
Caper/Wild spurge (<i>Euphorbia lagascae</i> SPRENG)	0	0	0	0	0	3	
Castor seed (<i>Ricinus communis</i> L.)	1	1	2	3	1		
Cotton (<i>Gossypium hirsutum</i> L.)	1	0	1	0	2		
Crambe (<i>Crambe abyssinica</i> Hochst.ex. R.E. Fries)		3	0	3	1		
Cuphea (<i>Cuphea spp</i> L.)	0	0	0	0	1	3	
Ethiopean mustard (<i>Brassica carinata</i> L)		3	0	3	1		
Honesty (<i>Lunaria annua</i> L.)		2	0	0	0	3	
Jatropha (<i>Jatropha curcas</i> L.)	1	0	0	0	2		

Linseed (<i>Linum usitatissimum</i> L.)	0	0	3	2	0	1
Rapeseed (<i>Brassica napus</i> L.)	2	0	0	3	3	3
Rapeseed (<i>Brassica napus</i> L.) (High erucic rape seed - HEAR)		3	0	3	1	
Rapeseed (<i>Brassica napus</i> L.) (High oleic low linoleic - HOLL)		3	0	3	1	
Safflower (<i>Carthamus tinctorius</i> L.)	0	0	2	0	1	1
Sunflower (<i>Helianthus annuus</i> L.)	0	0	2	0	2	3
Sunflower (<i>Helianthus annuus</i> L.) (Very high oleic – HOSO)		3	0	3	1	

Note:

- 0: technically very difficult or impossible
- 1: technically possible but with low or no interest
- 2: technically possible
- 3: already used for this application or good candidate

The best candidate streams appear to be:

1. Rapeseed, sunflower, caroon, cottonseed and jatropha for biodiesel
2. Sunflower (classic, HOSO), rapeseed (classic, HEAR, HOLL), ethiopean mustard, crambe, honesty, castor for lubricants
3. Sunflower (classic, high linoleic variety), calendula, linseed/flax, caroon, safflower for paints and inks
4. Sunflower (HOSO), rapessed (HEAR), ethiopean mustard, crambe, castor, linseed/flax for polymers

Table 2 Matrix with fiber crops and their multiple end use potentials and allocation factors

	Textiles	Non-woven	Paper & pulp	Composites	Biomass-Biofuels
Banana (<i>Mussa spp</i> L.)	0	0	1	0	0
Fiber flax (<i>Linum usitatissimum</i> L.)	3	3	3	3	3
Giant reed (<i>Arundo donax</i> L.)	1	0	1	2	3
Fibre hemp (<i>Cannabis sativa</i> L.)	3	3	3	3	3
Kenaf (<i>Hibiscus cannabinus</i> L.)	1	3	3	3	3
Loofah (<i>Luffa cylindrical</i> L.)	0	0	0	0	1
Miscanthus (<i>Miscanthus x giganteus</i> GREEF et DEU)	0	0	1	3	3
Nettle (<i>Urtica dioica</i> L.)	1	0	1	3	1
Reed canary grass (<i>Phalaris arundinaceae</i> L.)			1	3	3
Yucca (<i>Yucca gloriosa</i> L.)			1	2	0

Note:

- 0: technically very difficult or impossible
- 1: technically possible but with low or no interest
- 2: technically possible
- 3: already used for this application or good candidate

The best candidate streams appear to be:

1. Fiber flax and fibre hemp for almost all applications.
2. Almost all apart from banana, loofah and yucca are suitable for energy purposes.

Table 3 Matrix with carbohydrate crops and their multiple end use potentials and allocation factors

	Composite materials	Construction materials, resins	Biomass/biofuels	Food-feed/ Pharma/	Overall ranking (without including food)
Cassava (<i>Manihot spp</i> L.)	1	1	1	2	3
Potato (<i>Solanum tuberosum</i> L)	1	1	2	3	4
Sugarbeet (<i>Beta vulgaris</i> L.)	0	0	3	3	3
Sweet sorghum (<i>Sorghum bicolor</i> L.)	1	1	3	2	5
Maize (<i>Zea mays</i> L.)	1	1	3	3	5

Note:

- 0: technically very difficult or impossible
- 1: technically possible but with low or no interest
- 2: technically possible
- 3: already used for this application or good candidate

The best candidate streams appear to be:

1. Maize, sweet sorghum for biofuels and potato for energy purposes (using the residues from peeling off the potatoes)
2. Potato for composite and construction materials

Table 3 Matrix with other specialty crops and their multiple end use potentials and allocation factors

	Pharmaceutical	Cosmetics	Repellent	Paints/Dyes	Ornamental	Food
Coneflower (<i>Echinacea angustifolia</i>)	3	2	0	0	2	0
Lavender (<i>Lavandula angustifolia</i>)	3	3	3	0	2	0
Peppermint (<i>Mentha piperita</i>)	3	3	2	0	0	2
Pot marigold (<i>Calendula officinalis</i>)	3	3	0	3	3	2
Ribwort plantain (<i>Plantago lanceolata</i>)	3	2	0	0	0	2

Note:

- 0: technically very difficult or impossible
- 1: technically possible but with low or no interest
- 2: technically possible
- 3: already used for this application or good candidate

The best candidate streams appear to be:

1. All crops are suitable for pharmaceutical uses.
2. Calendula/Pot marigold and mentha are best suited for cosmetics
3. Calendula/Pot marigold, American coneflower and mentha have a number of intermediary products

DISCUSSIONS AND CONCLUSIONS

It is clear that the development of bio-based industries as well as several bioenergy options have an impact on food supplies.

Industries intending to produce bio-lubricants, polymers, paper and board, biodegradable plastics, adhesives and glues, agrochemicals, detergents, paints, cosmetics and toiletries, pharmaceutical, textiles, construction, super-absorption products and other chemicals as well as the bioenergy plants will rely heavily on biomass crops that are grown already for food purposes.

New non-food industrial crops could provide an alternative to feed the bio-based industries:

- ↪ Calendula can be used for paints,
- ↪ Caper spurge and honesty/lunaria for chemical reactives,
- ↪ Castorseed for polymers,
- ↪ Crambe for high quality lubricants and polymers,
- ↪ Cuphea for detergents,
- ↪ Sweet sorghum for bioethanol

However, agricultural research is not mature for most of these new crops and there are still restricting factors that significantly hinder the development of commercial plantations:

- ↪ Soil conditions, date of harvesting due to indeterminate growth, dehulling and refining difficulties, oil storage and low production for calendula
- ↪ Date of harvesting due to indeterminate growth, harvesting equipment, seed shattering, plant toxicity due to poisonous milky latex, low seed and oil yields, weed control for caper spurge
- ↪ Frost sensitiveness (opt. 20-25°C over 4.5-6 months), seeds contain ricin which is a toxic protein, harvesting has to improve to avoid seed losses and crop damage for castor
- ↪ Restricted genetic variability, highly sensitive to low temperatures at sowing and at flowering, weed control, low germination capacity, low seed and oil yields, high transportation costs, rapeseed as main competitor for crambe
- ↪ Still in wild, not grown in large-scale so far, low germination capacity, seed shattering, indeterminate flowering, long term maturation and high moisture content, overall stickiness to hinder harvest mechanization, harvested by hand difficulty to generate new hybrids for cuphea.
- ↪ Still at the developmental stage, not grown in large-scale so far, biennial nature, high vernalisation requirement, poor agronomy research, manual harvesting and cleaning of the seeds for honesty
- ↪ Small harvesting window and further need to research on crop logistics to avoid sugar degradation for sweet sorghum

Seeking for new industrial crops does not necessary means that new selected and tailored varieties of former food crops cannot be used for emerging green applications. These non-food crop varieties may serve as new and sustainable compounds feeding the green industry, without being in competition with the food market or with the lands dedicated to food crops, as they will simply grow in parallel cropping systems.

Such varieties are:

- ↪ High erucic rape seed (HEAR)
- ↪ High erucic ethiopean mustard (HEAR)
- ↪ High oleic low linoleic rape seed (HOLL)
- ↪ Very high oleic Sunflower (VHOSO)

From a commercial point of view, crops which are growing on commercial scale and produce high feedstock yields for versatile uses (food –non-food products) are preferable. The new selected and tailored varieties of former food crops mentioned above present high potential for yield and quality improvement, use existing agricultural practises and can have multiple uses in modern biorefinery infrastructures.

The non-food crops selected for the several industrial streams that are evaluated in technical, economic and environmental terms are listed below:

Oil market

- ↪ Rapeseed, sunflower for biodiesel
- ↪ Sunflower (classic, HOSO), rapeseed (classic, HEAR, HOLL) for lubricants
- ↪ Sunflower (classic, high linoleic variety), linseed/flax for paints and inks
- ↪ Sunflower (HOSO), rapessed (HEAR), linseed/flax for polymers

Fiber market and resins

- ↪ Fiber flax and fibre hemp and kenaf for almost all applications: texties,non-woven, paper and pulp, composites and energy
- ↪ Maize, sweet sorghum for biofuels and potato for energy purposes (using the residues from peeling off the potatos)
- ↪ Potato for composite and construction materials

Pharmaceutical and other specialty product markets

- ↪ All crops are suitable for pharmaceutical uses.
- ↪ Calendula/Pot marigold and menthe are best suited for cosmetics
- ↪ Calendula/Pot marigold, coneflower and menthe have a number of intermediary products