BIOSUBSTRATE

SCREENING AND DEMONSTRATION TRIALS

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AGENDA

1. **Introduction**
2. **Screening assays**
   - 2.1 *In-vitro* assay
   - 2.2 Greenhouse assay
3. **Selection results**
4. **Demonstration trials**
5. **Conclusion**

BACKGROUND

- Soilless cultivation in horticultural bussiness
  - Porous material
  - Free of phytotoxic compounds
  - Good water holding capacity
  - Easy to compact and transport
  - Easily adjusted pH
  - Standardized material

Northern Hemisphere:
Peat-based media

- Environmental concerns
- Growth of the horticultural industry
- Renewable and bio-based material

TEKNOLOGISK INSTITUT

AST Advanced Substrate Technologies

PINDSTRUP

NY VRAA BIOENERGY

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DEPARTMENT OF AGROECOLOGY

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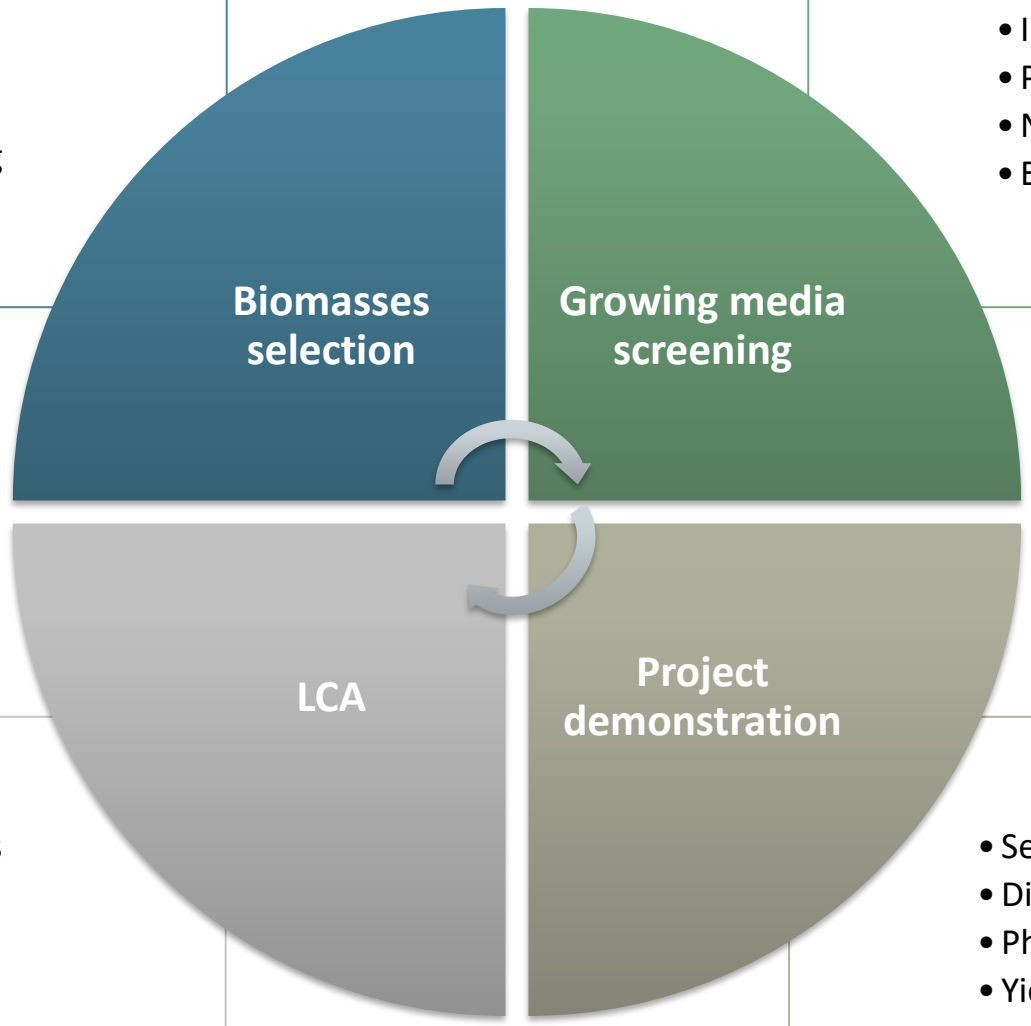
- Selection of raw material
- Biomass processing



- In-vitro assay
- Pot trial
- Nutrient analysis
- EC and pH

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- Selected biomasses from screening

- Selected species
- Different nurseries
- Physical properties
- Yield responses

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HUNSBALLE GRØNT

GARTNERIET Kjærgårdsminde ApS

GLORIA MUNDI ØKOLOGIHAVEN® Friske Krydderurter

Ministry of Food, Agriculture and Fisheries of Denmark
gudp

AIM

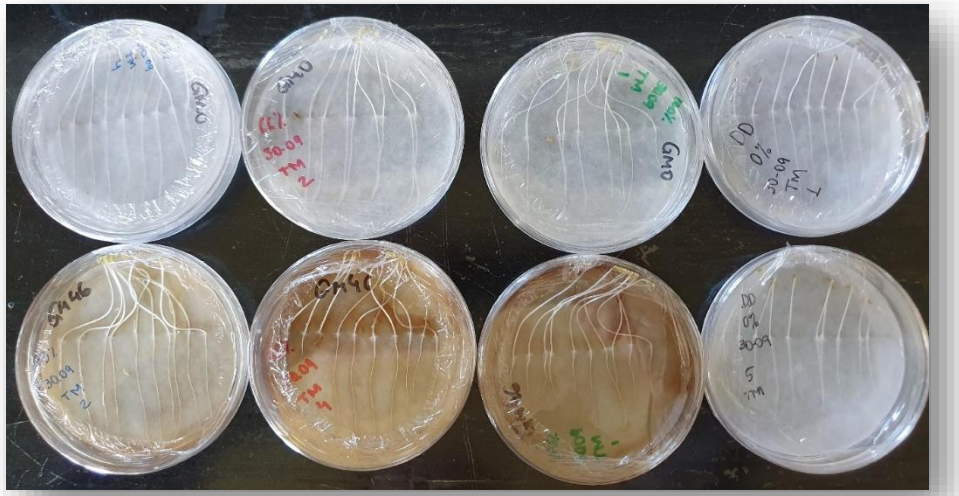
- To develop a **plant growth media** to fully or partially replace the **peat/sphagnum**
- Fulfill a circular economy establishing a Danish self-sufficiency production

Test different

- **biomasses** (willow, miscanthus, meadow grass, straw, fodder grasses, wood chips)
- **residual products** (fiber fractions from biogasification and protein juice production)

Total candidates: 53 growing media (GM)

ASSAYS



In vitro assay

- Germination counting (24, 48, 72, 84 and168 hours)
- Root growth measuring (48, 72, 84 hours)

Lettuce
(*Lactuca sativa*)

Chinsese cabbage
(*Brassica rapa*)

Cress
(*Lepidium sativum*)

Greenhouse assay

- Nutrient composition - Eurofins
- pH, EC of the substrates and dilutions
- Germination rate
- Plants fresh and dry weight
- Root evaluation

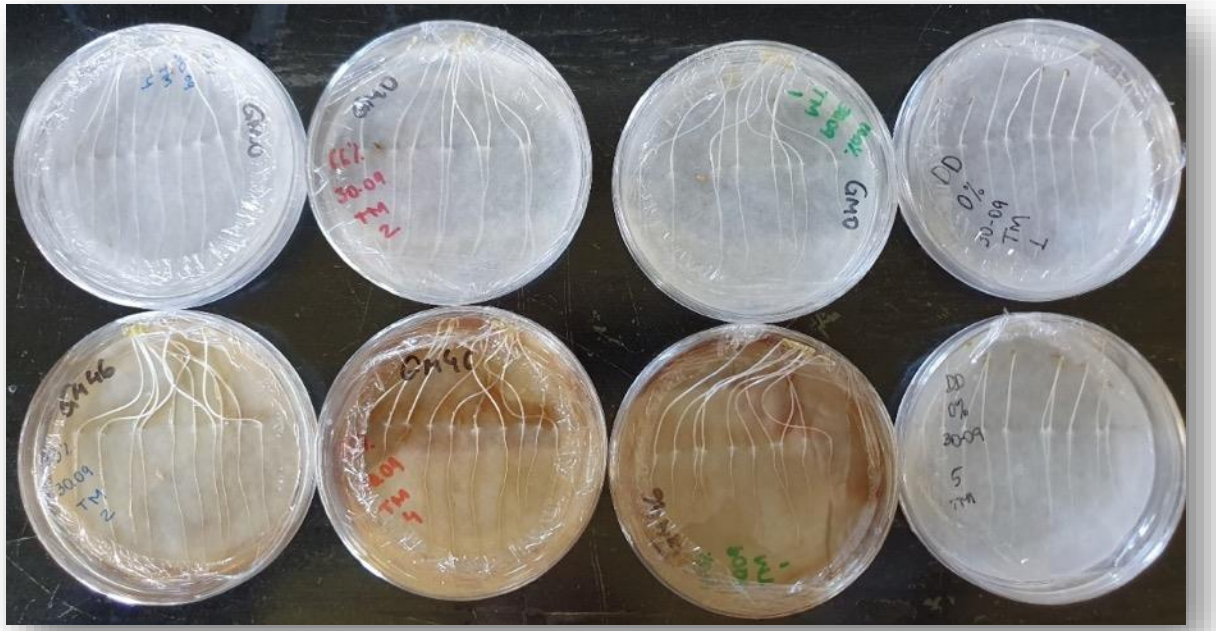
DESIGN OF ASSAYS

Total of 180 mixes were tested in 3 years

Control **100% GM** **66% GM** **33% GM**

(Pindstrup 1)

Control **100% GM** **66% GM** **33% GM**



33% GM **66% GM** **100% GM** **Control**

ddH_2O


P1
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GROWING MEDIA 2019

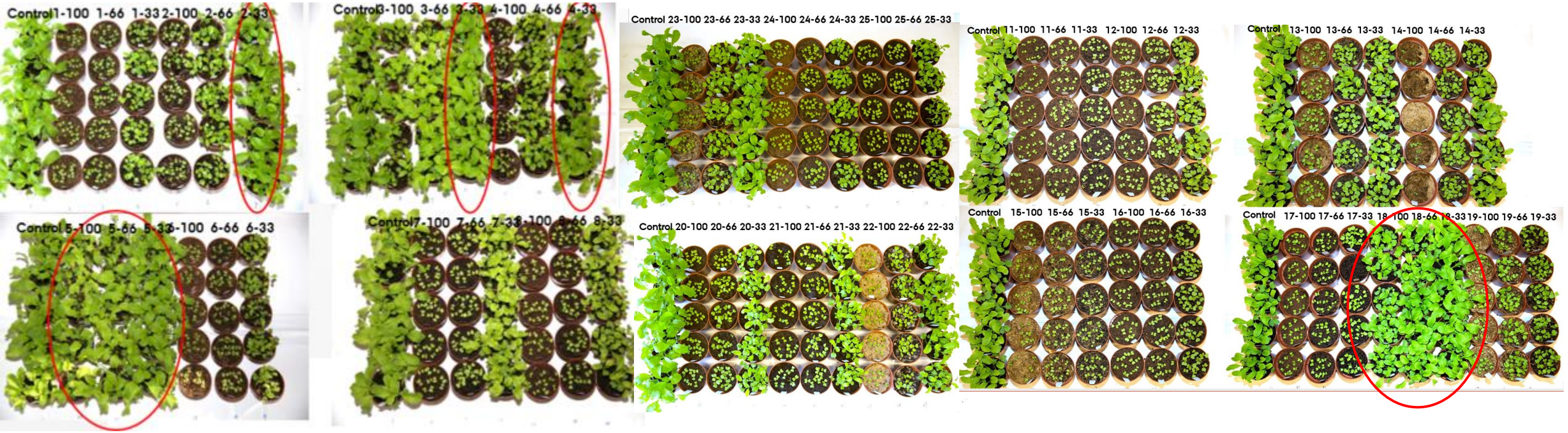
Total of GM tested: **25 new GM** + 1 commercial GM
(3 batches)

Growing medium	Test serial number	Raw material	Processing	Provider
1	1	Willow chips from two-year shoots, fine sized	Untreated	Ny Vraa
2	1	Willow chips, medium sized + 15% chicken manure	Composting, 3 months, aeration 5 times	Ny Vraa
3	1	Willow chips, medium sized + 30% chicken manure	Composting, 3 months, aeration 5 times	Ny Vraa
4	1	Willow chips, fine sized + 15% chicken manure	Composting, 3 months, aeration 5 times	Ny Vraa
5	1	Willow chips, fine sized + 30% chicken manure	Composting, 3 months, aeration 5 times	Ny Vraa
6	1	Willow chips, coarse sized	Defibration, mechanical	Pindstrup
7	1	Willow compost, coarse sized	Defibration, mechanical	Pindstrup
8	1	Willow chips, coarse sized, willow compost, chalk	Composting for two years, no aeration, hammer milling with 10 mm screen prior to testing	Ny Vraa
9	1	Willow chips, coarse sized, chalk	Composting for one year, no aeration, hammer milling with 10 mm screen prior to testing	Ny Vraa
10	1	Willow chips, coarse sized, willow compost, chalk	Composting for one year, no aeration, hammer milling with 10 mm screen	Ny Vraa

Growing medium	Test serial number	Raw material	Processing	Provider
11	2	Forest wood chips	Extrusion	AU BCE
12	2	Miscanthus	Extrusion	AU BCE
13	2	Protein extracted grass fiber	Fresh / as received	AU BCE
14	2	Protein extracted grass fiber	Air-dried	AU BCE
15	2	Wheat straw	Extrusion	AU BCE
16	2	Degassed plant based AD digestate fibre	Dewatered, compacted and dried	AST
17	2	Degassed manure based AD digestate fibre	Dewatered, compacted and dried	AST
18	2	Combined livestock and plant based AD digestate fibre	Dewatered, compacted and dried	AST
19	2	Seed grass straw	HTC	AU BCE

Growing medium	Test serial number	Raw material	Processing	Provider
20	3	AD digestate fiber	As received	AU BCE
21	3	Compact fiber	Dewatered and twin screw pressed	AU BCE
22	3	Wood fiber	High temperature, extrusion	Pindstrup
23	3	Wood fiber	High temperature, extrusion	Pindstrup
24	3	Willow chips, fine sized	Extrusion with thermophilic composting	AU BCE
25	3	Miscanthus	Extrusion with thermophilic composting	AU BCE
AU BCE = Aarhus University Biological and Chemical Engineering;				
AST = Advanced Substrate technologies				

RESULTS – CHINESE CABBAGE (2019)



Chinese cabbage tiral

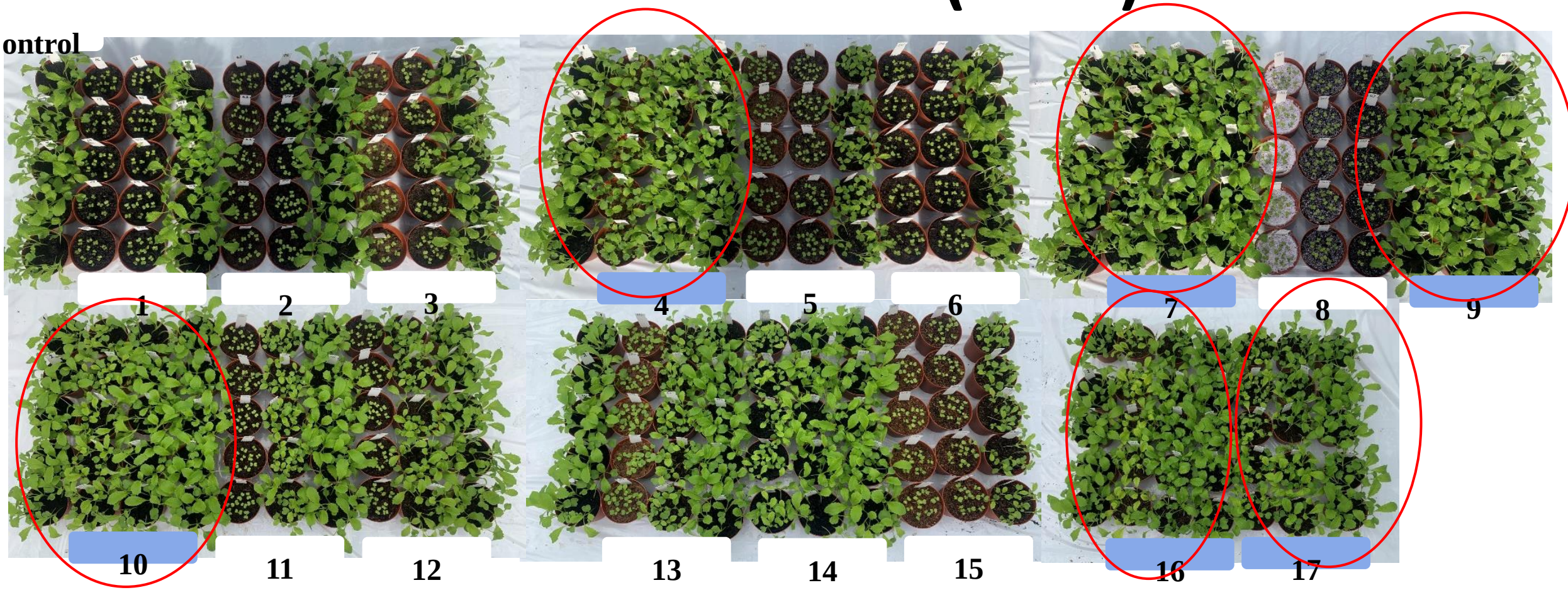
Total of 78 mixes were tested

Willow composted with a N source

GROWING MEDIA 2020

Sample ID	Planned bag code	Processing	Biomass provider
1	1-1st screen	six month composted spring composted extruded miscanthus	AU
2	2-1st screen	six month composted spring composted extruded willow	AU/ NyVaa
3	3-1st screen	short composted (2 month) green miscanthus	AU
4	4-1st screen	Sven-darker than forest gold	Pindstrup
5	5-1st screen	steam extruded green miscanthus	AU
6	6-1st screen	insitu washing and extrusion spring miscanthus	AU
7	7-1st screen	brunkol	AU
8	9-1st screen	extruded cotton textile, lots of fungi-2020.06.23	AU
9	10a-1st screen	extruded bark (spank bark)	AU/ pinstrup
10	10b-1st screen	extruded bark (barkfris)	AU/ pinstrup
11	11-1st screen	GS 80 AST	AST
12	12-1st screen	GS 70 AST	AST
13	14-1st screen	Forest gold	Pindstrup
14	16-1st screen	willow /polar biochar	AU/ Nyvaa
15	No. 1 from aarslev	willow	Nyvaa
16	No. 2 from aarslev	willow, 15% chicken manure	Nyvaa
17	No. 3 from aarslev	willow, 30% chicken manure	Nyvaa

RESULTS – CHINESE CABBAGE (2020)



Chinese cabbage tiral

Total of 52 mixes were tested

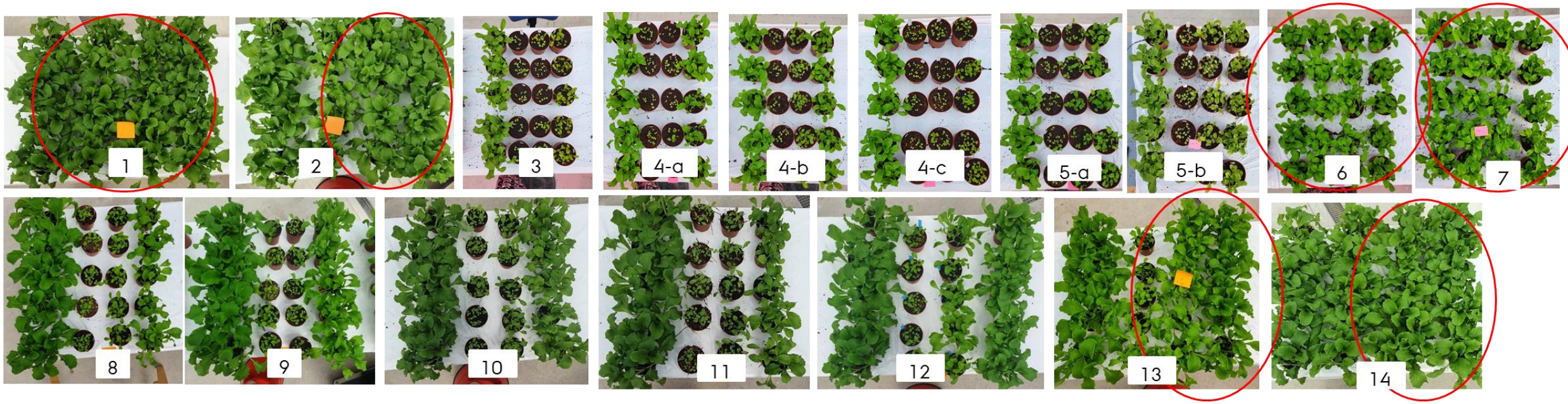
Willow composted with a N source
Biogas fibre, Brunkol and Bark fibre

GROWING MEDIA 2021

GM	Description
1	Willow composted with grass (50/50)
2	70/30 Willow composted with grass + extruded willow
3	50/50 Willow composted with grass + extruded willow
4a	Willow harvested with leaves and composted +chicken manure
4b	Willow harvested with leaves and composted + NH4
4c	Willow and leaves + insect frass
5a	Extruded willow +NH4
5b	Extruded willow + Insect frass
6	Willow and Insect frass composted
7	Willow with microorganism (cold compost)

GM	Description
8	AST 1 (2v) with 80% TS is based 100% on degasified fiber.
9	AST 2 (2v) 75/25 with 80% TS is based on 75% degasified fiber and 25% compromised sawdust
10	AST 3 (2v) 75/25 with 80% TS is based on 75% degasified fiber and 25% comprom. AST 3 is similar to AST 2 – the only difference is the pH regulation by use of organic acidised sawdust
11	Straw + horse manure
12	Wood fibers + horse manure
13	Willow 7 time starter
14	Willow 40 times starter

RESULTS – CHINESE CABBAGE (2021)



Chinese cabbage tiral

Total of 53 mixes were tested

Willow composted, Willow composted blend with extruded willow

RESULTS – CHINESE CABBAGE

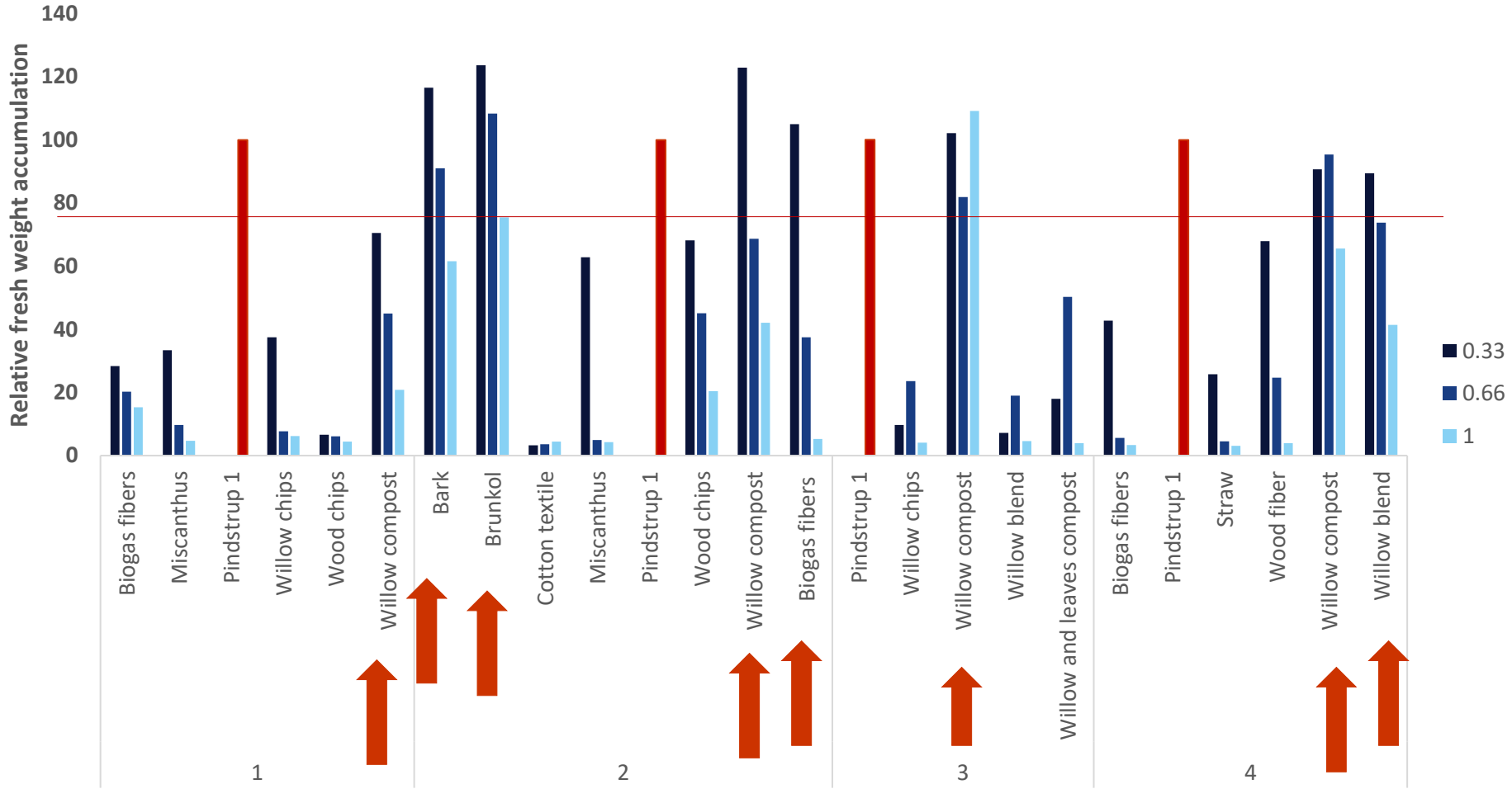


Figure: Relative average fresh weight of chinesse cabagge grown in differente biomasses. The biomasses were dilluted with Pindstrup 1 in a proportion of 33, 66 and 100%.

RESULTS – GREENHOUSE

The more diluted with a Peat-based GM , the higher the germination rate and dry matter accumulation

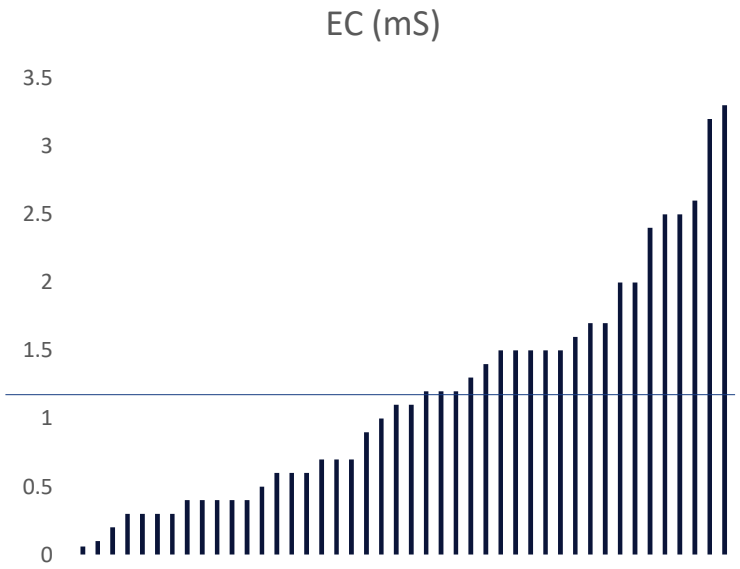
The average of seed germination rate (%) of the three species on day 2 and day 5

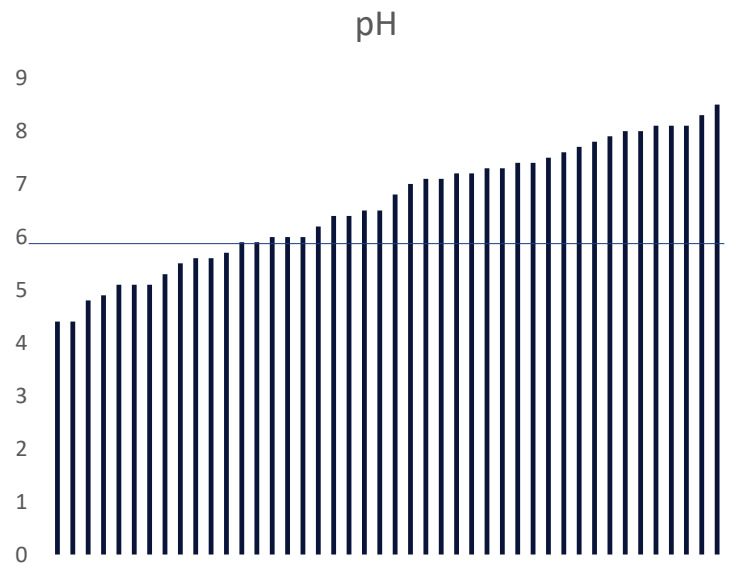
Proportion		Lettuce		Chinese cabbage		Cress	
New medium	Pindstrup 1	D2	D5	D2	D5	D2	D5
100%	0%	52.6	71.2	63.3	89.8	79.9	88.6
66.67%	33.33%	67.3	90.6	77.4	97.9	92.8	96.3
33.33%	66.67%	79.6	91.8	81.9	97.2	94.0	96.6
Pindstrup 1	100%	94.0	96.0	77.33	97.33	97.33	99.33

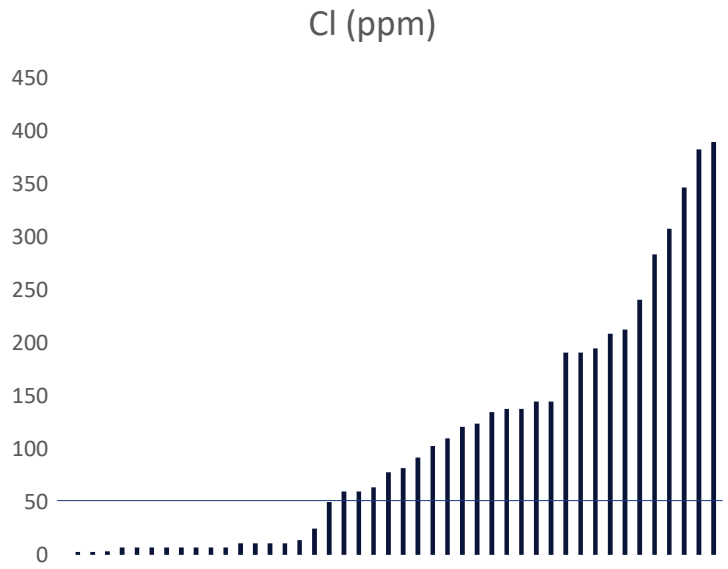
The average of fresh and dry weight per seedling (FW_p and DW_p) from the three species after harvest

Proportion		Lettuce (g)		Chinese cabbage (g)		Cress (g)	
New medium	Pindstrup 1	FW_a	DW_a	FW_a	DW_a	FW_a	DW_a
100%	0%	0.42	0.032	0.71	0.074	0.45	0.049
66.67%	33.33%	0.71	0.060	1.30	0.131	0.73	0.08
33.33%	66.67%	1.63	0.124	2.62	0.258	1.71	0.15
Pindstrup 1	100%	3.83	0.193	6.24	0.453	3.92	0.28

RESULTS – GREENHOUSE







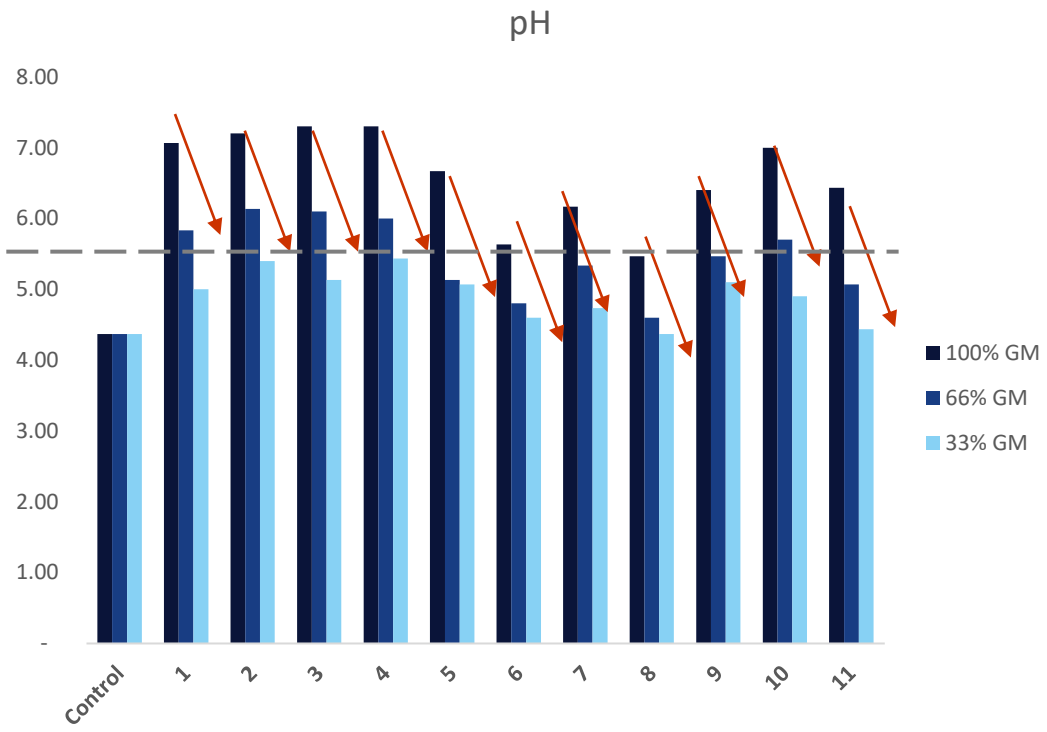
RESULTS – GREENHOUSE

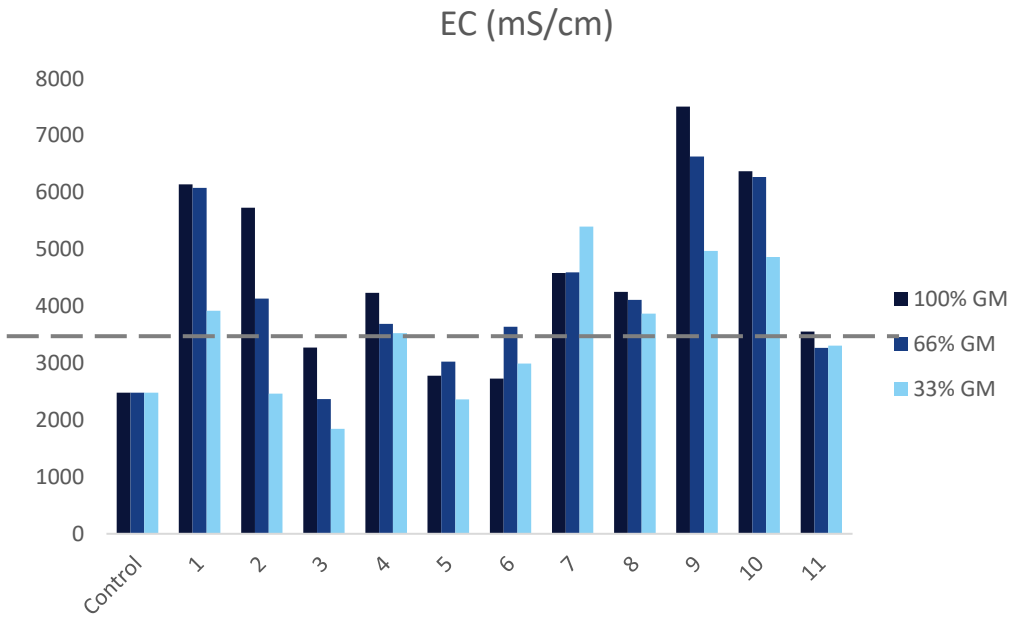
pH was negatively correlated with germination and growth

All species	EC	pH	G2	G5	FW per pot	DW_a	FW_e	DW_e
EC	-	0.520**	-0.185	-0.151	0.128	0.091	0.136	0.098
pH	-	-	-0.450**	-0.408**	-0.479**	-0.511**	-0.473**	-0.503**
G_2	-	-	-	0.771**	0.456**	0.505**	0.450**	0.495**
G_5	-	-	-	-	0.294**	0.335**	0.285*	0.319**
FW_a	-	-	-	-	-	0.974**	1.000**	0.972**
DW_a	-	-	-	-	-	-	0.975**	0.999**
FW_e	-	-	-	-	-	-	-	0.973**
Dw_e	-	-	-	-	-	-	-	-

Correlation analysis between EC, pH, germination rate and FW and DW accumulation of plants grown in 75 mixes.

PH AND EC





By adding 33% raw peat, pH decreased to a commercial desired range

DEMONSTRATION (2020/2021)

Test selected substrates at commercial growing conditions

Growing media

-Willow composted

-Wood fibers

-Peat

Plant production

-Biomass accumulation

-Fruit yield and size

-Leaf analysis (nutrient levels)

Crops

-Year-round fruit

(Strawberry production)

-Organic herbs

(Basil)

-Convetional ornamentals

(Salvie, Geranium, Kalanchoe)

DEMONSTRATION (2020/2021)

Aim to replace 50% of Peat in the mix

1	100% Strawberry substrate from Claus (Control)
2	100% Willow+Chickenpills(20%)
3	100% Willow+Grass
4	50% Willow+chickenpills and **50% Control substrate**
5	50% Willow+Grass and **50% Control substrate**
6	Improved substrates from Pindstrup (50% Komposteret Pileflis ØKO + **50% peat)**
7	Improved substrates with fiber from Pindstrup (50% Træfibre Hobby + **50% peat)**

Control

100% (composted willow+chicken manure)

100% (composted willow+grass)

50% Control + 50% (composted willow+chicken manure)

Control

50% Control + 50% (composted willow+grass)

50% Peat + 50% composted willow

50% Wood fibers + 50% Peat

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No. 4 and No.7 with equal plant growth as control after 6 weeks – middle of August

Ministry of Food, Agriculture and Fisheries of Denmark
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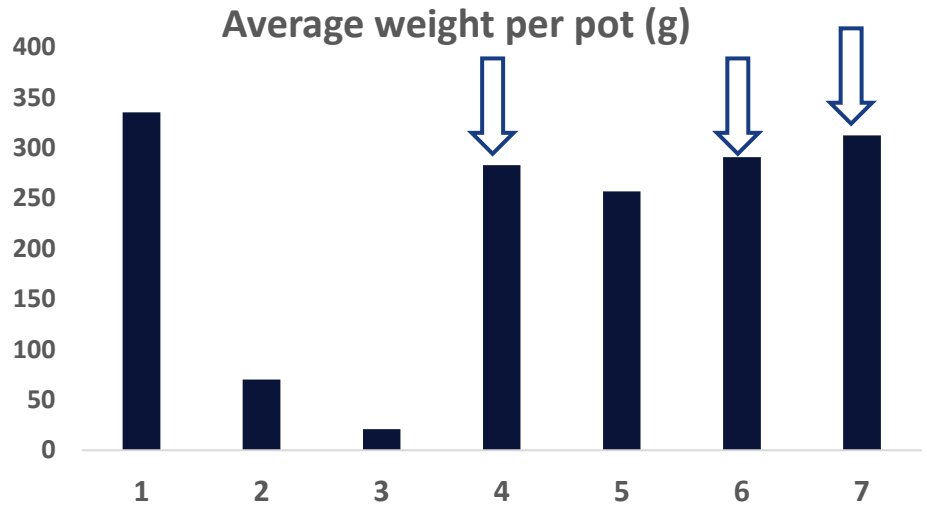
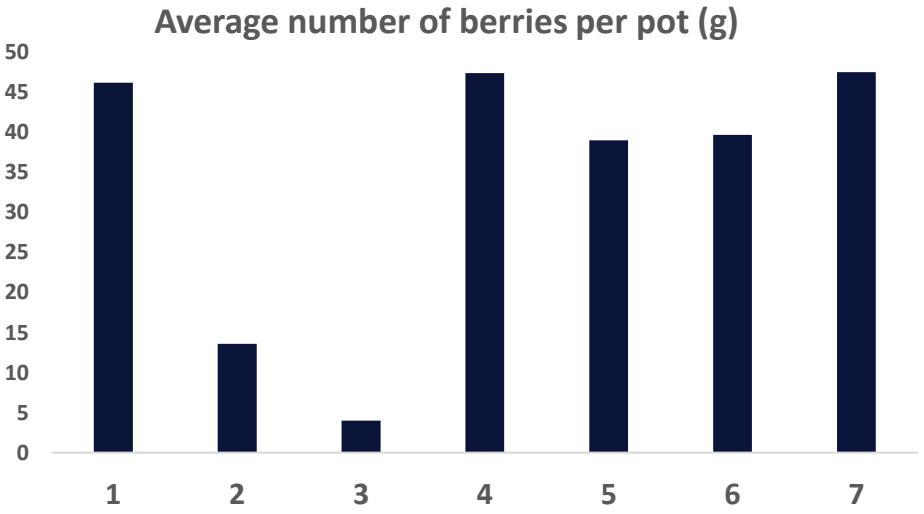
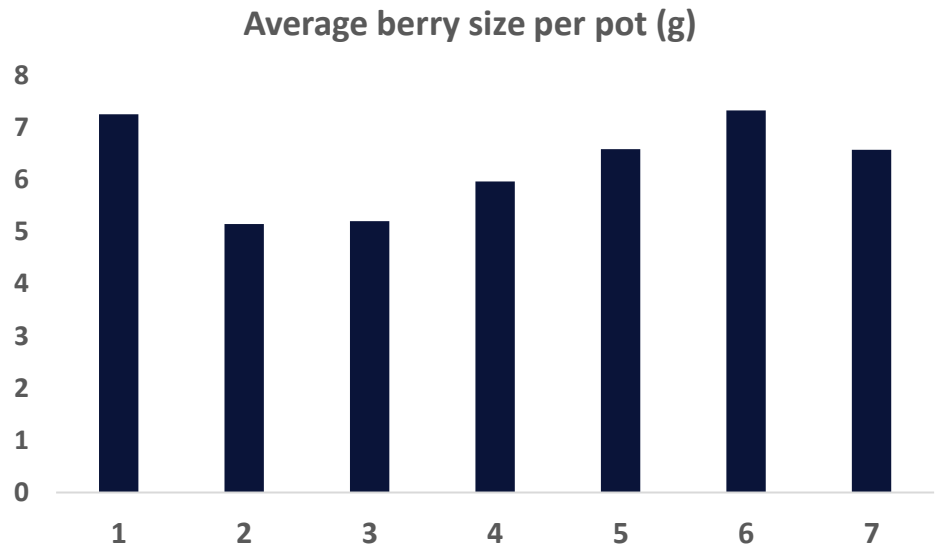
HARVEST (2020)

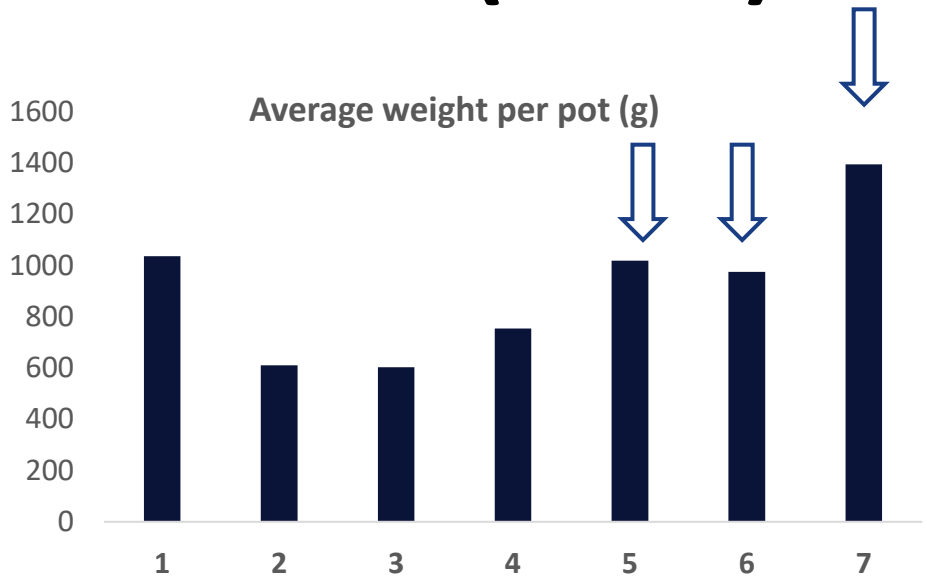


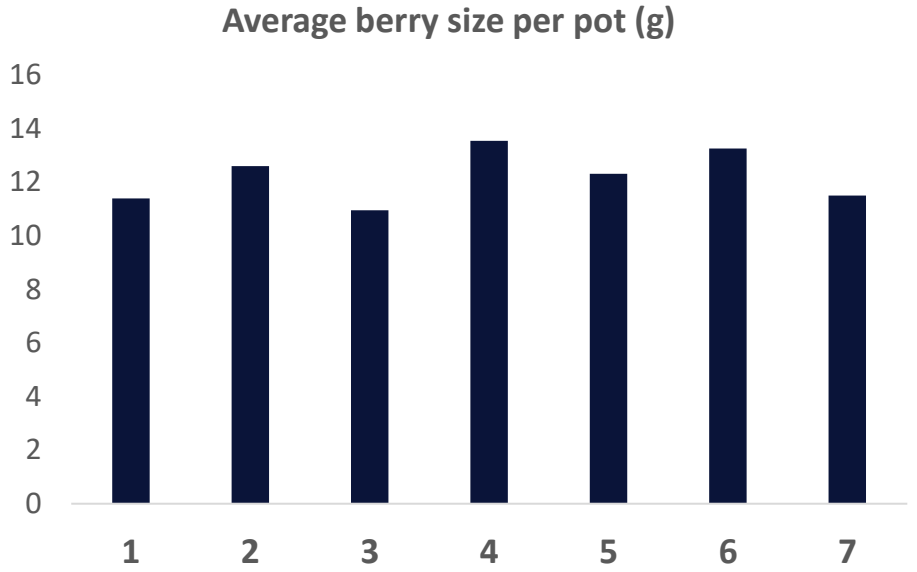


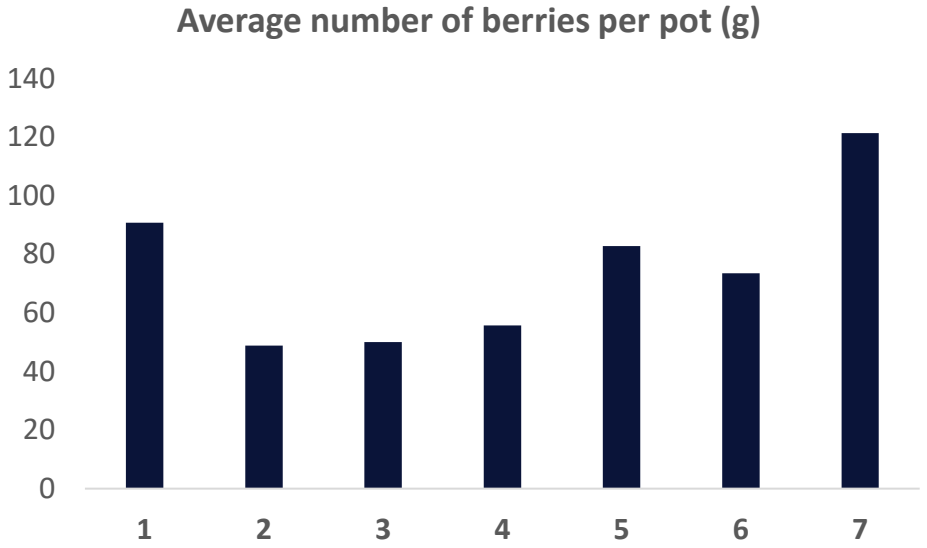


1	100% Strawberry substrate from Claus (Control)
2	100% Willow+Chickenpills(20%)
3	100% Willow+Grass
4	50% Willow+chickenpills and 50% Control substrate
5	50% Willow+Grass and 50% Control substrate
6	Improved substrates from Pindstrup (50% Komposteret Pileflis ØKO + 50% peat)
7	Improved substrates with fiber from Pindstrup (50% Træfibre Hobby + 50% peat)

HARVEST (2021)







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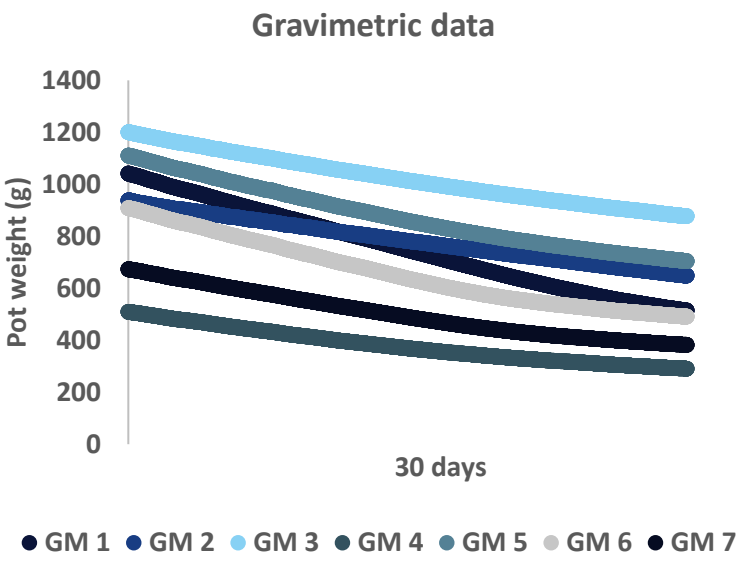
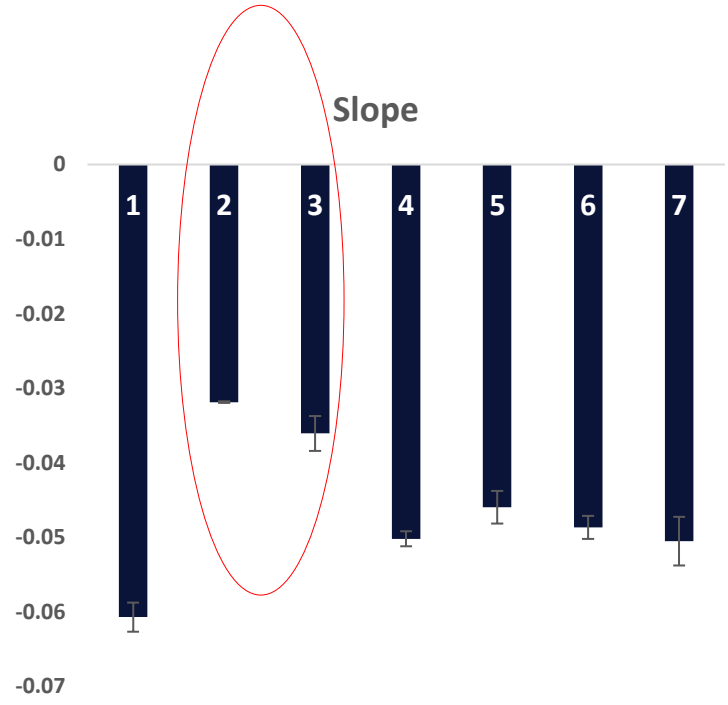
6	Improved substrates from Pindstrup (50% Komposteret Pileflis ØKO + 50% peat)
7	Improved substrates with fiber from Pindstrup (50% Træfibre Hobby + 50% peat)

GRAVIMETRIC DATA



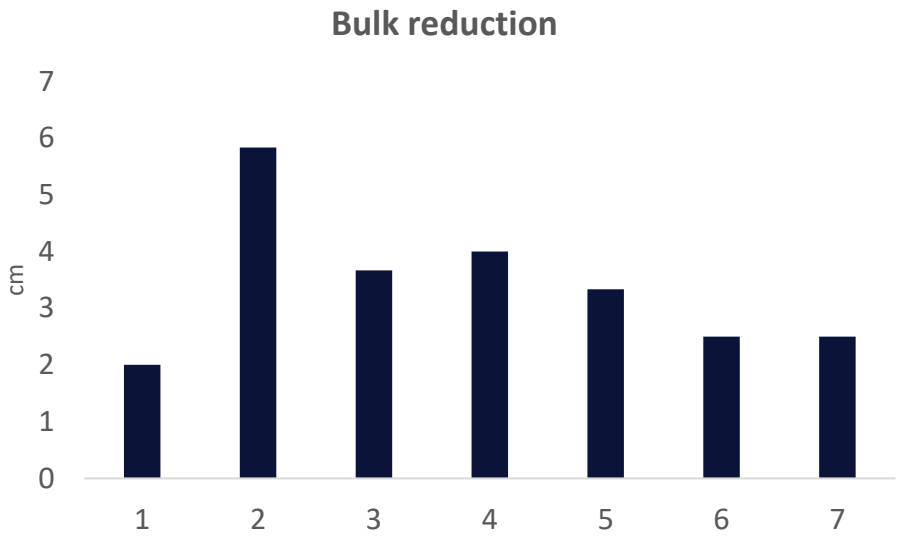


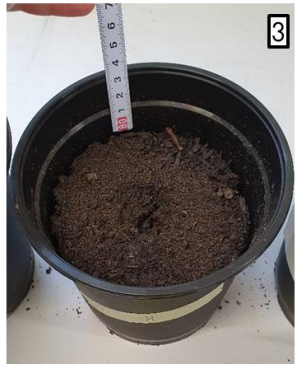
- Gravimetric platform
- Fully saturated pots
- 30 days at 32˚C
- 3 repetitions 1l pots

BULK REDUCTION

-

1	100% Strawberry substrate from Claus (Control)
2	100% Willow+Chickenpills(20%)
3	100% Willow+Grass
4	50% Willow+chickenpills and 50% Control substrate
5	50% Willow+Grass and 50% Control substrate
6	Improved substrates from Pindstrup (50% Komposteret Pileflis ØKO + 50% peat)
7	Improved substrates with fiber from Pindstrup (50% Træfibre Hobby + 50% peat)





SCREENING HERBS AND CUTTINGS

Plant materials

- Organic -Herbs (Basil)
- Conventional -Cuttings of Salvie, Geranium and Kalanchoe

Methods

6-9 new mixes

- Leaf area
- Fresh and dry weight
- pH and EC
- Root evaluation

SCREENING HERBS AND CUTTINGS

Aim to replace 70% of Peat in the mix

Organic Basilikum

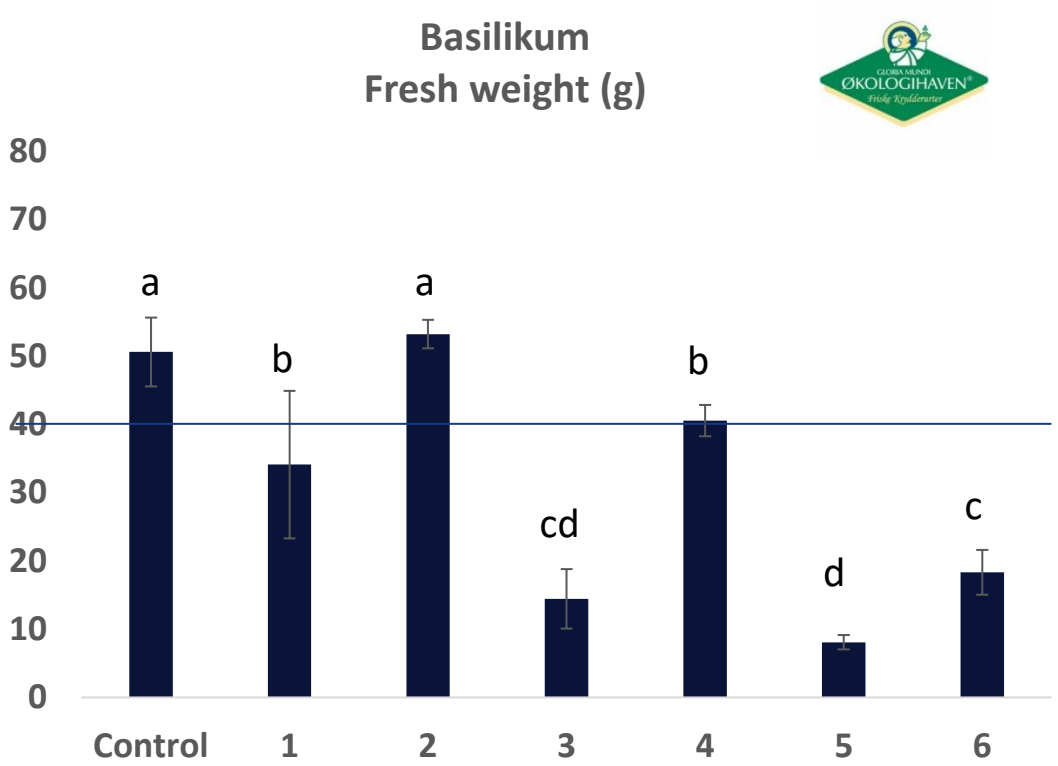
GM	Name
0	Control
1	100% willow composted with grass 50/50
2	70% willow composted with grass 50/50 + **30% Raw peat**
3	100%(70% willow composted with grass and 30% mixed with extruded willow)
4	70%(70% willow composted with grass and 30% mixed with extruded willow) + **30%raw peat**
5	100% Willow compost
6	100% Willow compost + **30% Raw peat**

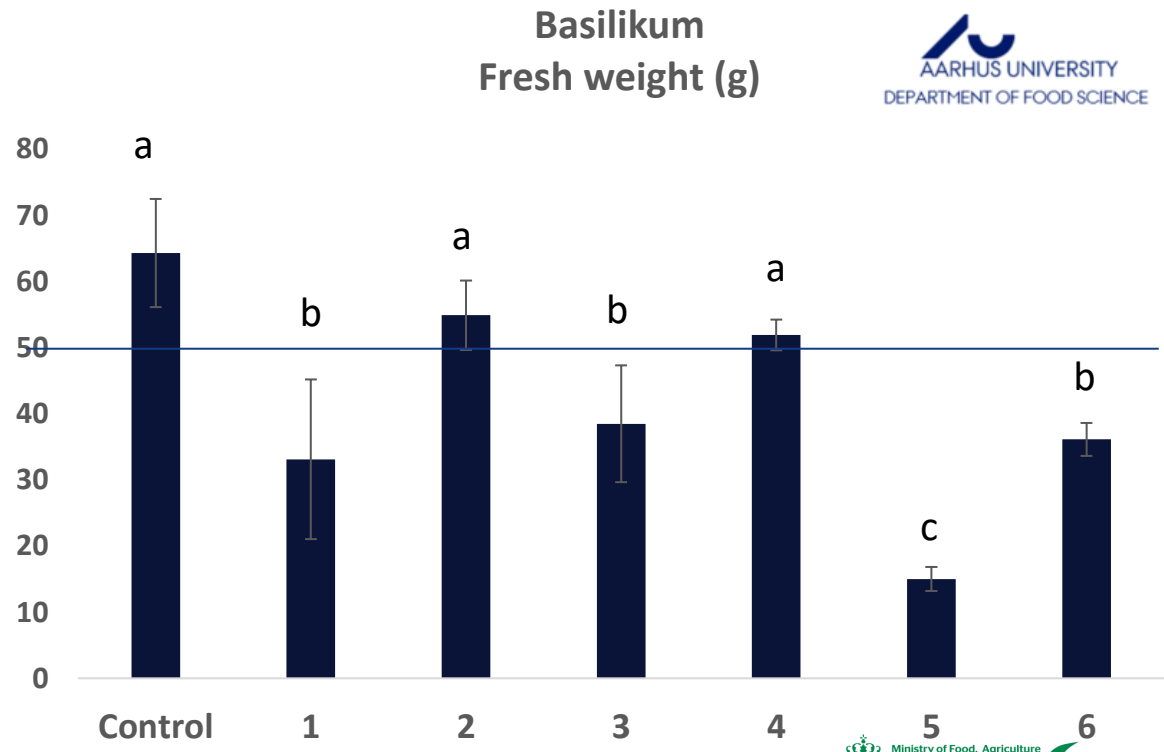
Ornamental cuttings

GM	Name
0	Control
1	100% willow composted with grass 50/50
2	70% willow composted with grass 50/50 + **30% Raw peat**
3	100%(70% willow composted with grass and 30% mixed with extruded willow)
4	70%(70% willow composted with grass and 30% mixed with extruded willow) + **30%raw peat**
5	100% Willow compost
6	70% Willow compost + **30% Raw peat**
7	55% Willow composted with grass + 15% Wood fibre + **30% Raw Peat**

HERBS - BASILIKUM

Økologihaven





HERBS - BASILIKUM

GM	Name
0	Control
1	100% willow composted with grass 50/50
2	**70% willow composted with grass 50/50 + 30% Raw peat**
3	100%(70% willow composted with grass and 30% mixed with extruded willow)
4	**70%(70% willow composted with grass and 30% mixed with extruded willow) + 30%raw peat**
5	100% Willow compost
6	100% Willow compost **+ 30% Raw peat**

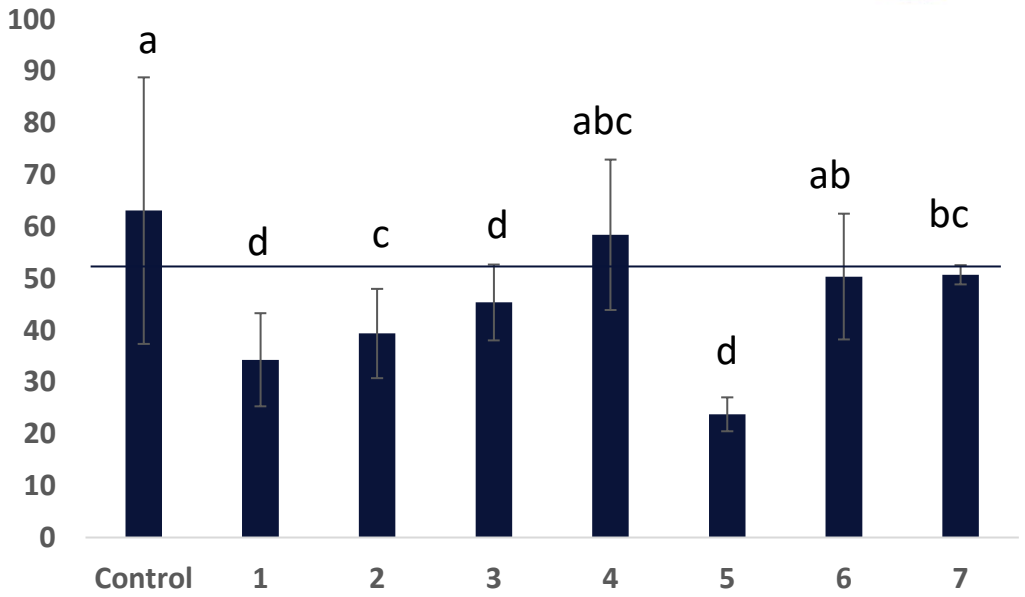
AUFOOD

Control | 100% GM 1 | 70% GM 1 30%Peat | 100% GM 3 | 70% GM 3 30%Peat | 100% GM 5 | 70% GM 5 30%Peat

CUTTINGS - PELARGONIE

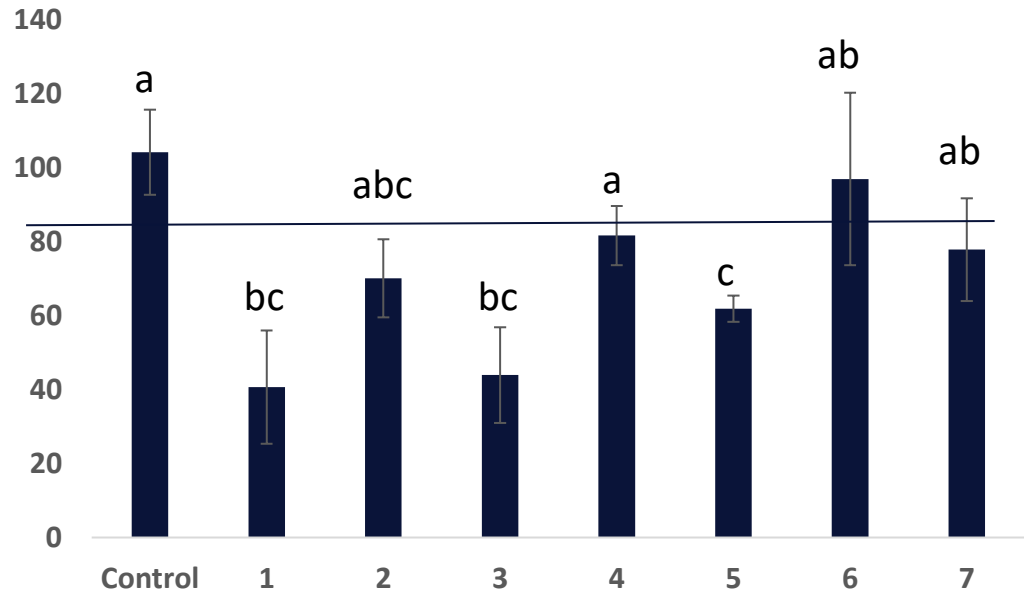
Kjærgårdsminde

Pelargonie
Fresh weight (g)



AUFOOD

Pelargonie
Fresh weight (g)



CUTTINGS - PELARGONIE

GM	Name
0	Control
1	100% willow composted with grass 50/50
2	70% willow composted with grass 50/50 + **30% Raw peat**
3	100%(70% willow composted with grass and 30% mixed with extruded willow)
4	70%(70% willow composted with grass and 30% mixed with extruded willow) + **30%raw peat**
5	100% Willow compost
6	70% Willow compost + **30% Raw peat**
7	55% Willow composted with grass + 15% Wood fibre + **30% Raw Peat**

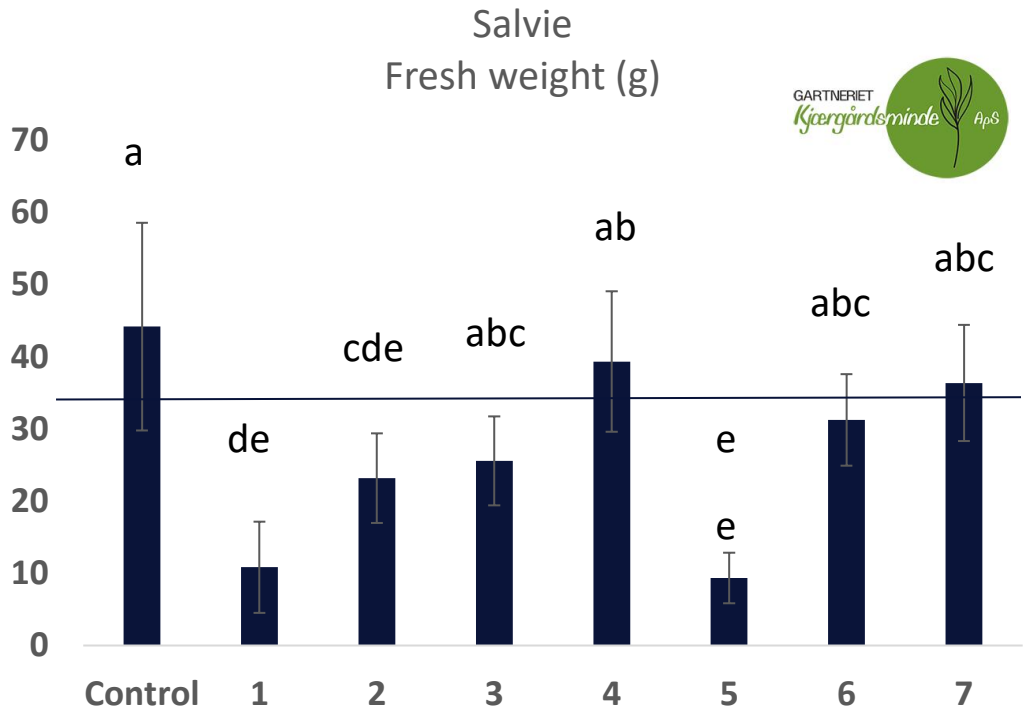
100% GM 1 | 70% GM 1 30%Peat | 100% GM 2 | 70% GM 2 30%Peat | 100% GM 3 | 70% GM 3 30%Peat | 55% GM 1 + 15% Wood fibre + 30%Peat | Control

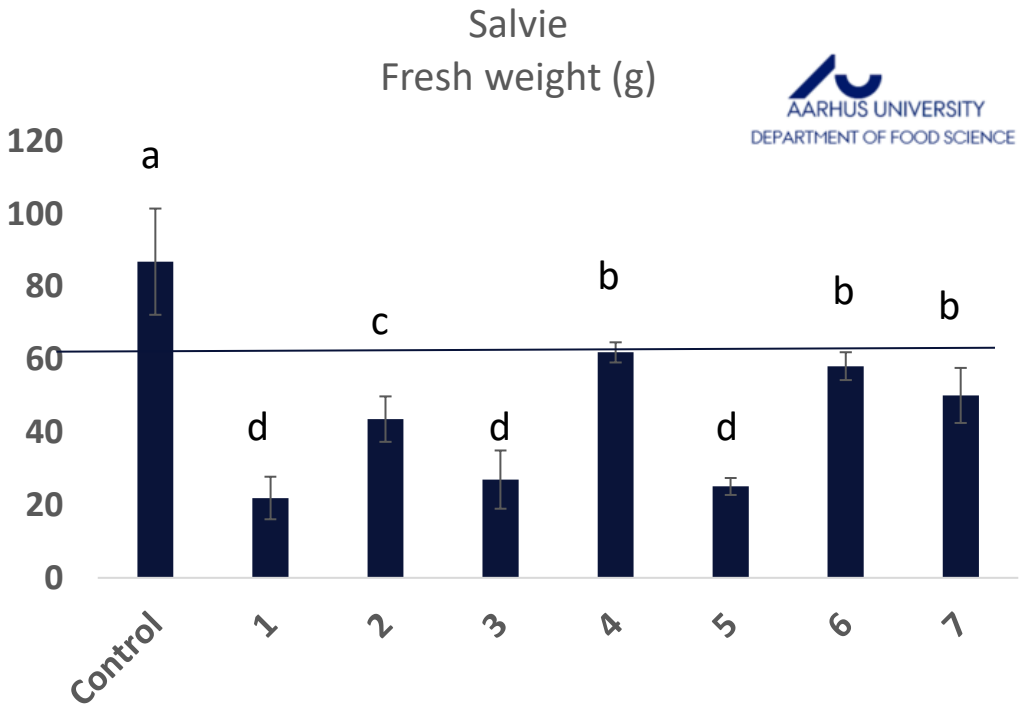
Control | 100% GM 1 | 70% GM 1 30%Peat | 100% GM 2 | 70% GM 2 30%Peat | 100% GM 3 | 70% GM 3 30%Peat | 55% GM 1 + 15% Wood fibre + 30%Peat

CUTTINGS - SALVIE

Kjærgårdsminde

-





CUTTINGS - SALVIE

GM	Name
0	Control
1	100% willow composted with grass 50/50
2	70% willow composted with grass 50/50 + **30% Raw peat**
3	100%(70% willow composted with grass and 30% mixed with extruded willow)
4	70%(70% willow composted with grass and 30% mixed with extruded willow) + **30%raw peat**
5	100% Willow microorganism (cold compost)
6	70% Willow microorganism (cold compost) + **30% Raw peat**
7	55% Willow composted with grass + 15% Wood fibre + **30% Raw Peat**

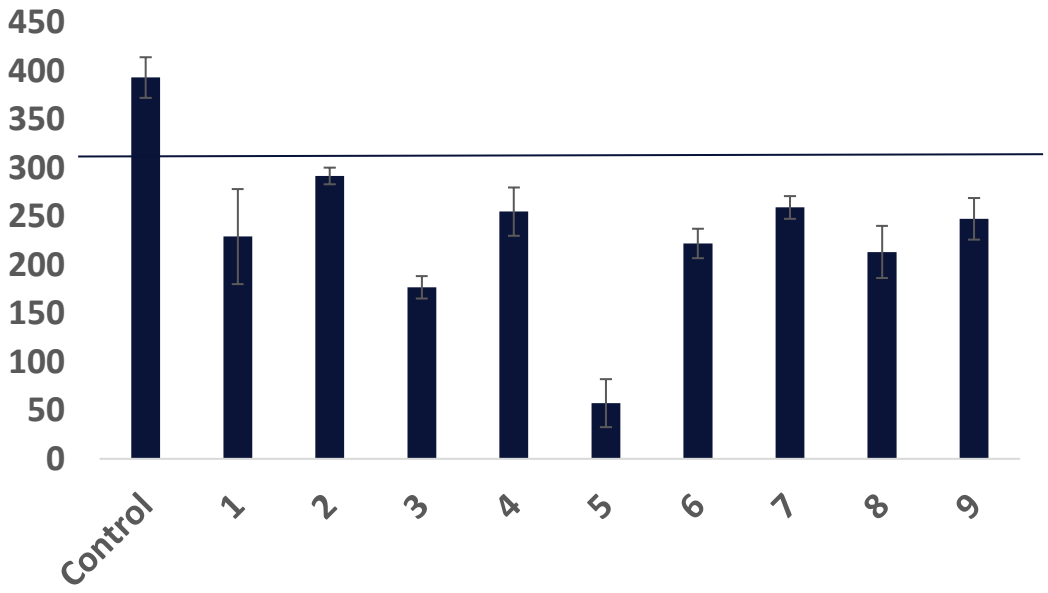
100% GM 1 | 70% GM 1 30%Peat | 100% GM 2 | 70% GM 2 30%Peat | 100% GM 3 | 70% GM 3 30%Peat | 55% GM 1 + 15% Wood fibre + 30%Peat | Control

Control | 100% GM 1 | 70% GM 1 30%Peat | 100% GM 2 | 70% GM 2 30%Peat | 100% GM 3 | 70% GM 3 30%Peat | 55% GM 1 + 15% Wood fibre + 30%Peat

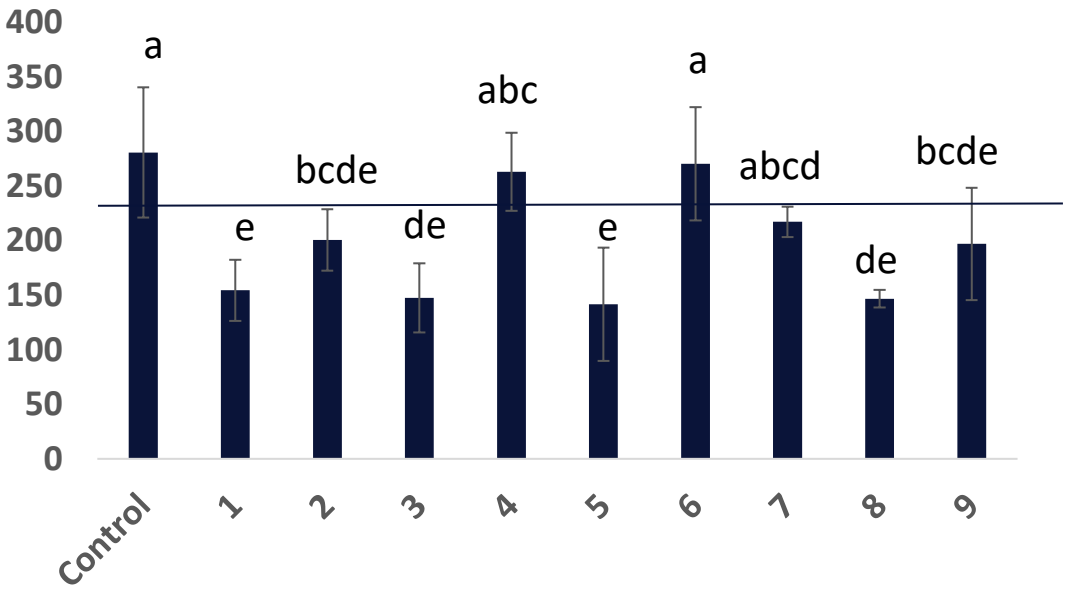
CUTTINGS - KALANCHOE

Not comparable

Kalanchoe
Fresh weight (g)



Kalanchoe
Fresh weight (g)



CUTTINGS - KALANCHOE

Queen®

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DEPARTMENT OF FOOD SCIENCE

100% GM 1
70% GM 1 30%Peat
100% GM 2
70% GM 2 30%Peat
100% GM 3
70% GM 3 30%Peat
55% GM 1 + 15% Wood fibre + 30%Peat
100% GM 4
70% GM 4 30%Peat
Control

GM	Name
1	100% willow composted with grass 50/50
2	70% willow composted with grass 50/50 + 30% Raw peat
3	100%(70% willow composted with grass and 30% mixed with extruded willow)
4	70%(70% willow composted with grass and 30% mixed with extruded willow) + 30%raw peat
5	100% Willow micoorganism
6	70% Willow micoorganism + 30% Raw peat
7	55% Willow and grass + 30% Peat + 15% Forest Gold
8	100% Willow and insect frass
9	70% Willow and insect frass + 30% Raw peat
10	Control

POINTS TO BE CONSIDERED

- Better bioassays/processing to screen the full potential of new materials
- Nutrient and watering optimization need to be taken in account
- Particle size and material uniformity/compaction of some materials
- Solve pH and high salt level without blending with peat
- Find the right mix of components

CONCLUSIONS

- The bioassays used during this project could screen a large variety of new materials
- Dilution of GM with peat increased germination and biomass accumulation
- Adding 30% of “raw peat” can reduce pH to a commercial range
- Wood fibers, willow composted and the mix of willow composted + wood fibers can replace between 50 to 70% of peat in substrate mixes (commercial demonstration)

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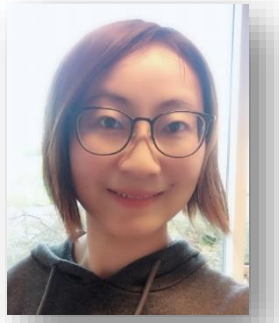

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Thank you
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