Off the peat path - Online workshops, 4 April 2023

EDIBLE AND MEDICINAL MUSHROOM PRODUCTION IN AN INTEGRATED FOOD TO WASTE TO FOOD BIOSYSTEM

Agnieszka Jasinska

VegWaMus-CirCrop

Marie Sklodowska – Curie actions individual fellowship

2017-2022 MSCA-IF

Marie Skłodowska-Curie Actions Individual Fellowships (MSCA-IF)

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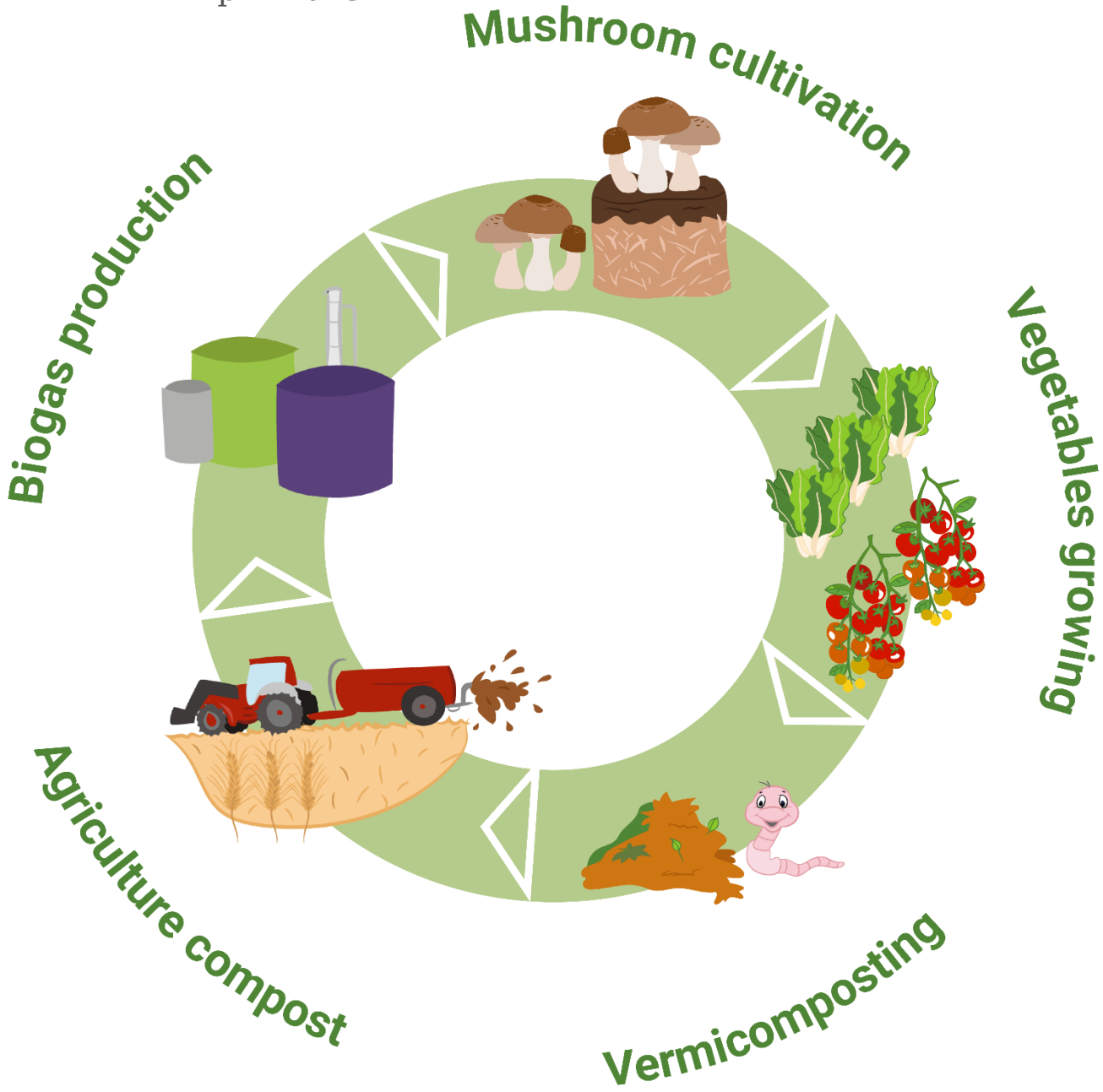
Lindum

Food to Waste to Food

F2W2F cycle

Integrated Biogas Plant and BBBLS Greenhouse


Mushroom cultivation
Vegetables growing
Vermicomposting
Agriculture compost
Biogas production

Mushroom cultivation substrate

Original combined foodwaste –diary manure digestate based mushroom cultivation substrate – at make up and during phase I

Composition of the experimental mushroom compost (EMC) – at make-up and during phase I after Phase II (at inoculation)

Make-up							Phase I				Phase II	
EMC	Wheat Straw (% DM)	Oat Straw (% DM)	Barley Straw (% DM)	Digestate (% DM)	Other substrate components (% DM)	Digestate Water (g kg^{-1})	RH (%)	Max. Temperature (°C)	DM (%) in Phase I	C/N ratio	DM (%)	RH (%)
Experiment 1												
WD1	82	-	-	10	8	644	67	80	33	26	36	64
WD2	84	-	-	7	9	556	60	74	40	30	29	71
WD3	80	-	-	14	6	700	71	72	29	23	22	78
WD4	81	-	-	13	6	705	72	72	28	22	25	75
Experiment 2a												
WD	80	-	-	13	7	695	71	64	29	22	25	75
O4WD	40	40	-	12	8	675	71	81	29	22	23	77
B4WD	40	-	40	12	8	675	71	81	29	22	26	74
Experiment 2b												
O25WD	60	25	-	10	5	572	72	70	28	25	27	73
B25WD	60	-	25	10	5	590	73	73	27	24	25	75
BOWD	35	15	35	10	5	595	72	71	28	24	26	74
B6WD	25	-	60	10	5	593	72	77	28	24	24	76

(EMC): WD—wheat straw–digestate (1,2,3,4-consecutive numbers of EMC); OWD—oat–wheat straw–digestate; BWD—barley–wheat straw–digestate; BOWD—oat–barley–wheat straw digestate; the numbers in exp 2a and 2b means the % of oat or barley straw in substrate). DM—dry matter, RH—relative humidity of experimental mushroom composts

Using original digestate:

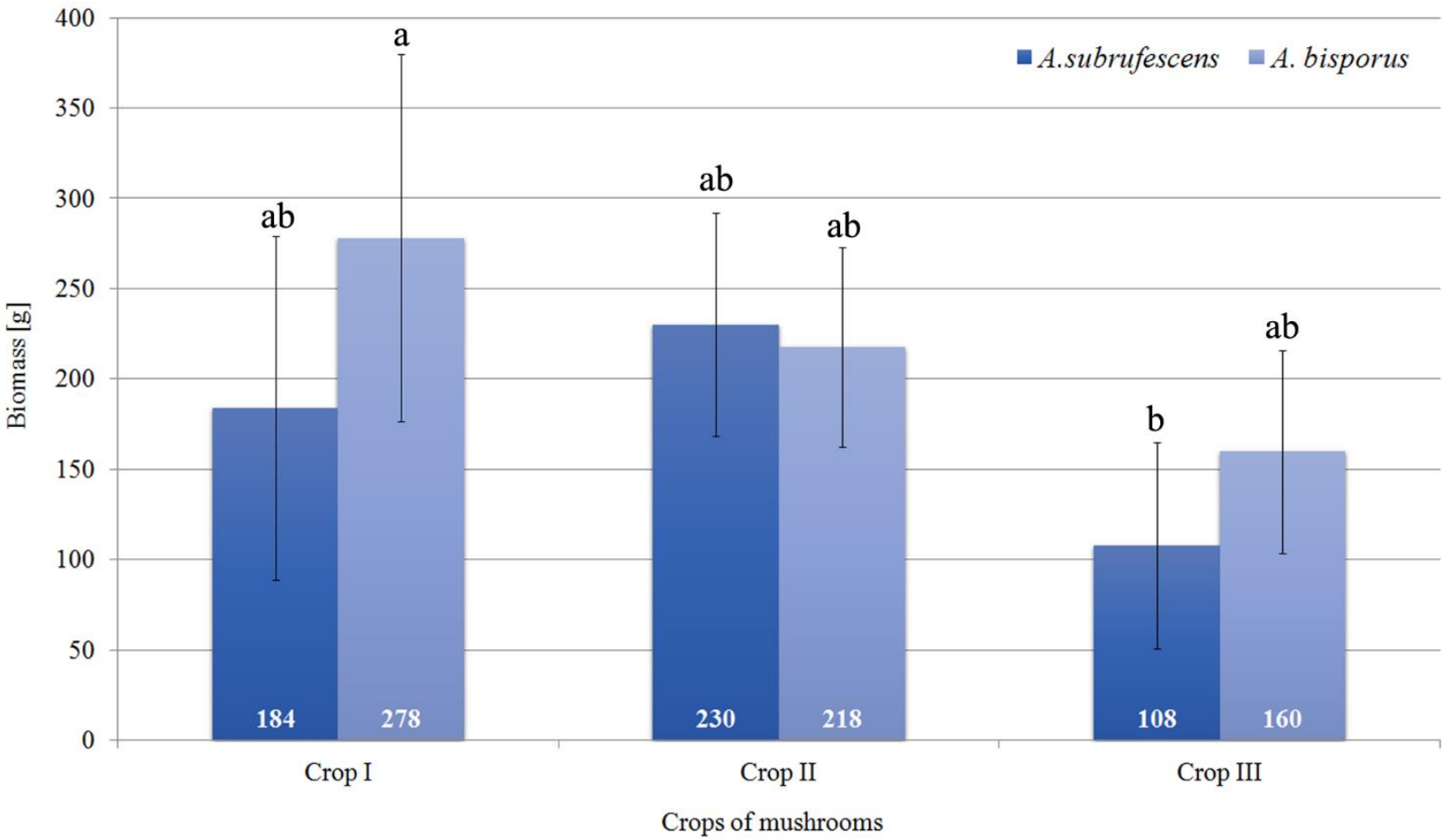
a. Mixes well with investigated native corn straws of barley, oat, and wheat;
b. Has appropriate moisture of experimental mushroom compost, 64% to 78% at the point of inoculation was achieved without additional watering during composting process;
c. Presents good composting process supported substrate colonization and mushroom formation;
d. Has appropriate final C/N ratios of experimental mushroom composts, ranging from 22 up to 30

Mushroom cultivation

Controled temeparute, RH air humidity, CO_2 concentration and LED growing light

Almond mushroom (*Agaricus subrufescens*)
Brown button mushroom (*Agaricus bisporus*)

Biomass comparison of two *Agaricus* species cultivated on original digestate



Summary of *A. subrufescens* productivity and cultivation parameters

EMC	Fresh weight of mushrooms from whole cropping period	Yield (g kg^{-1})	BE (%)	% DM of Mushrooms	Number of Mushrooms (Bag of Substrate)	E (Days)	P (%)
Wheat based substrates							
WD1	944	44.9 c	15 c	13.5 a	3.6 b	31.4 a	68.9 a
WD2	2219	105.7 b	36 b	12.7 a	8.0 a	29.5 ab	50.6 ab
WD3	4832	115.0 b	53 ab	12.5 a	9.1 a	32.5 a	53.6 ab
WD4	4705	156.8 a	64 a	11.8 a	10.2 a	25.5 b	49.5 b
Oat based substrates							
O25WD	1434	95.6 bc	36 c	10.0 a	6.6 ab	34.4 a	68.9 a
O40WD	1596	88.6 c	38 bc	9.5 a	5.8 b	36.0 a	57.8 b
Barley based substrate							
B25WD	2369	157.9 a	64 a	8.9 a	10.1 a	32.2 a	52.8 ab
B40WD	1885	123.2 abc	48 abc	11.7 a	9.0 ab	26.4 a	47.7 ab
B60WD	3605	133.5 ab	55 ab	10.3 a	10.5 a	26.1 a	52.1 ab
Mixed straw substrate							
BOWD	3915	145.0 a	56 a	10.5 a	10.3 a	29.8 a	43.3 ab

Conclusions

- Both investigated Agaricu species performed well on OD: combined mushroom yield from all three flushes was 172 g kg−1 for *A. subrufescens* and for *A. bisporus* brown variety was 218 g kg−1.
- The highest yield obtained for wheat based substrates was 156.8 g kg−1 , with the lowest C/N ratio 22:1 of the substrate. Therefore, much more original digestate can be used for *A. subrufescens* cultivation.
- Experimental mushroom compost mixes with barley straw were performing better than with oat straw. Barley enriched substrates showed productivity of 123.2 up to 157.9 g kg−1 and BE from48 up to 64%, while oat straw gave lower yield, 88.6 to 95.6 g kg−1 and BE of 36% to 38%.
- The optimal digestate mushroom compost for *A. subrufescens* cultivation is a mixture of all three types of native Norwegian straws: **barley, oat, and wheat in a 3:1.5:3** ratio with high yield and BE (145 g kg−1 and 56% respectively), earliness of 29.8 days, and the lowest precociousness of 43.3%.

The findings above support the assumption that original digestate can be a used directly into mushroom cultivation and thus the additional cost of separation could be omitted.

If the mushroom farm could be situated close to the anaerobic digestion plant, sustainable use of assets could be achieved.

Exotic oyster mushrooms growth on original digestate based substrate

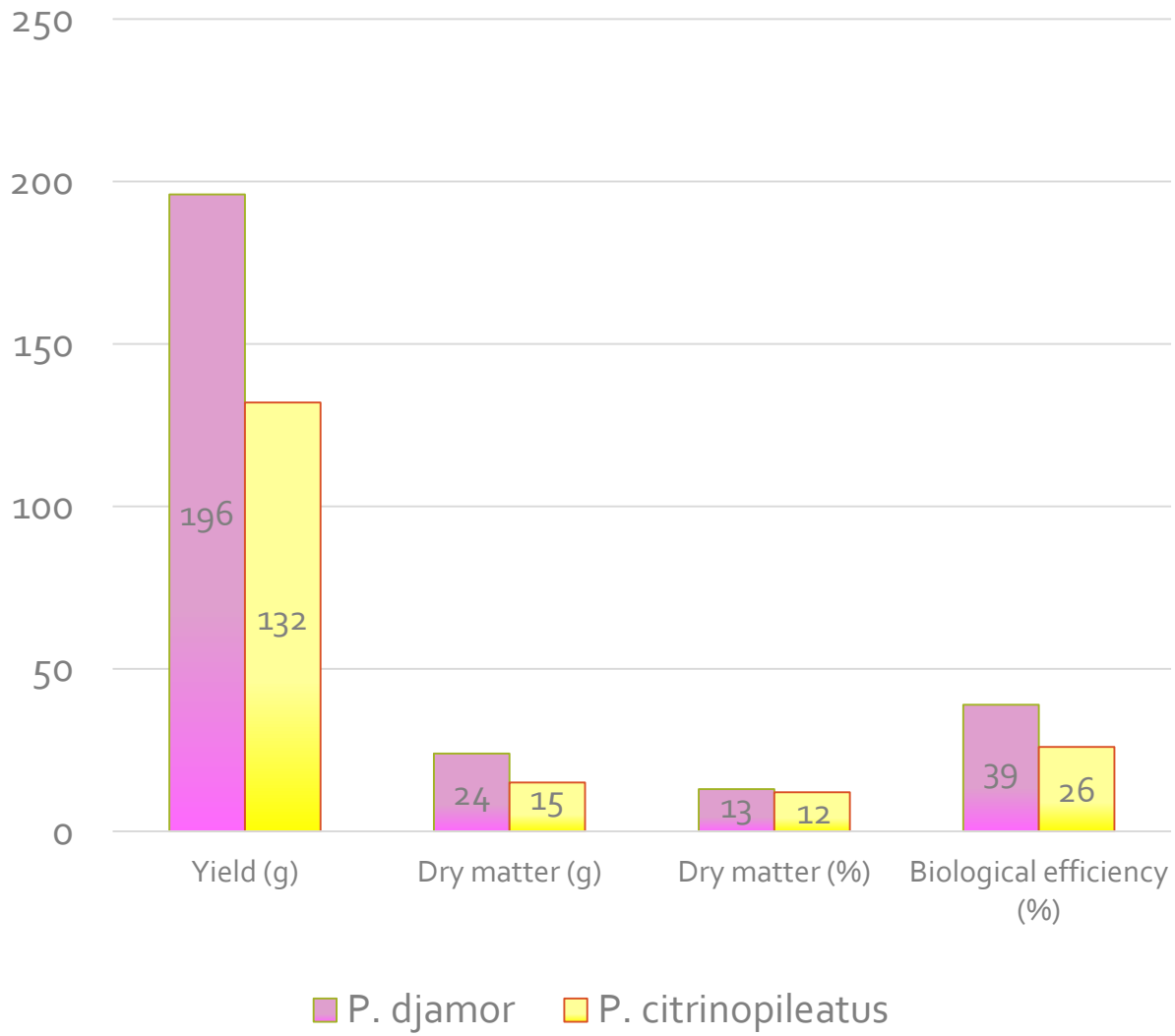
Pink and yellow oyster mushroom

Original combined foodwaste –diary manure digestate based mushroom cultivation compost – short composting in *Pleurotus* cultivation

Composition of the experimental mushroom compost (EMC) – at make-up, during short composting and at inoculation

	Make Up				Short composting		At innoculation	
EMC	Wheat Straw (% DM)	Digestate (% DM)	Other substrate components (% DM)	RH (%)	DM (%)	C/N ratio	DM (%)	RH (%)
WD1	84	11	5	77	33	28	30	70
WD2	84	12	4	79	31	26	27	73

Productivity parameters of two *Pleurotus* species cultivated on original digestate



Spent Cultivation Substrate Management

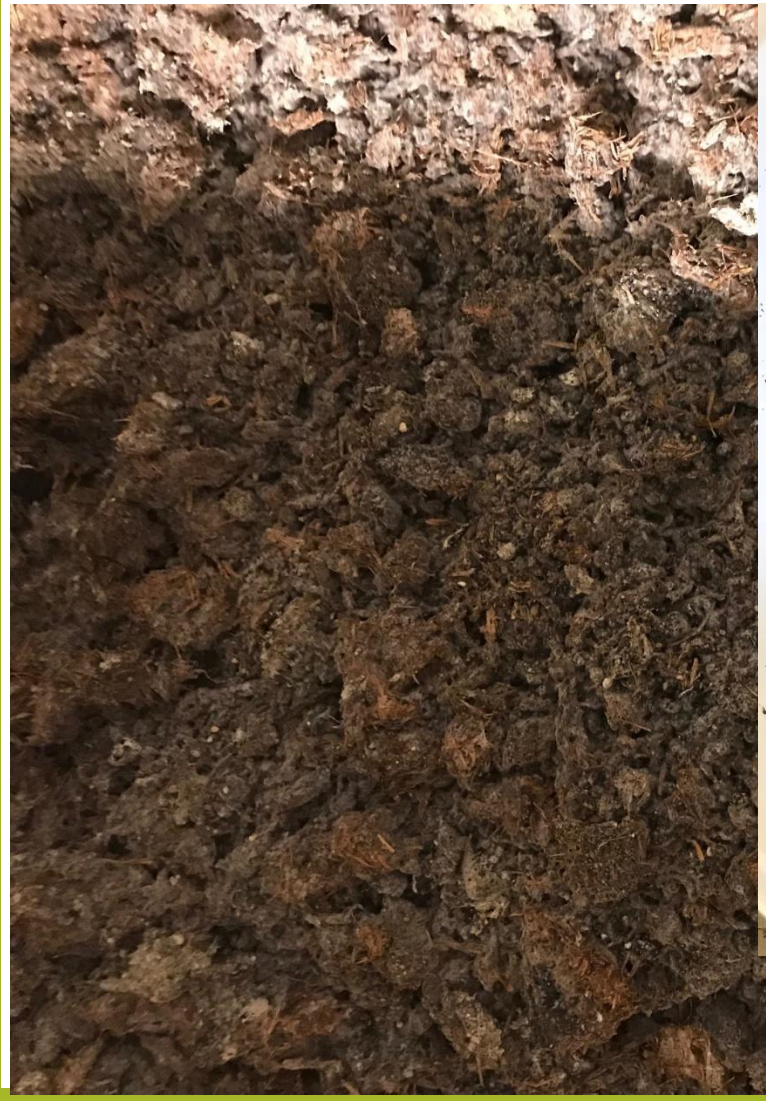
USE OF SCS

- HORTICULTURE
  - Combined mushroom-plant cultivation
  - Organic fertiliser
  - Substrate component

Characteristic of SMS/SMC

- High organic matter
- Low bulk dencity
- Source of nutrients
- High moisture content
- No pests and weed seeds
- High pH and solulable salts

Spent Cultivation Substrate



Substrate composition before and after mushroom cultivation — summary of changes

	Before Use	After Use
	Mushroom Compost	SMC
OM%	87.6	83.2
DM%	30.2	35.5
pH	8.8	5.5
EC (dS/m)	4.3	3.6
Ash%	12.4	16.8
K (mg/kg)	10,968	14,334
P (mg/kg)	3100	3900
Na (mg/kg)	1955	3123
Mg (mg/kg)	1275	2410
Ca (mg/kg)	1420	1660
Mn (mg/kg)	51.6	96.6
Fe (mg/kg)	28.8	57.9
Si (mg/kg)	45.9	40.6
Se (mg/kg)	1.1	2.9
Mo (mg/kg)	0.5	1.6

SMC is almost ideal as a plant fertilizer or growing substrate additive:

- The advantage over chemical fertilizer is that SMS deliver a slow release of nutrients, which does not cause nutrient burn of the crops
- However, excessive application can increase the salinity of soils and substrates

If the digestate in the circular food-loop were to be used for mushroom cultivation, it would be very useful if the SMC could be used as a plant-stimulating growth medium.

This would also be of interest for existing greenhouse vegetable growers seeking more sustainable solutions.

VegWaMusCirCrop Team

Dr Ketil Stoknes

Dr Agnieszka Jasinska

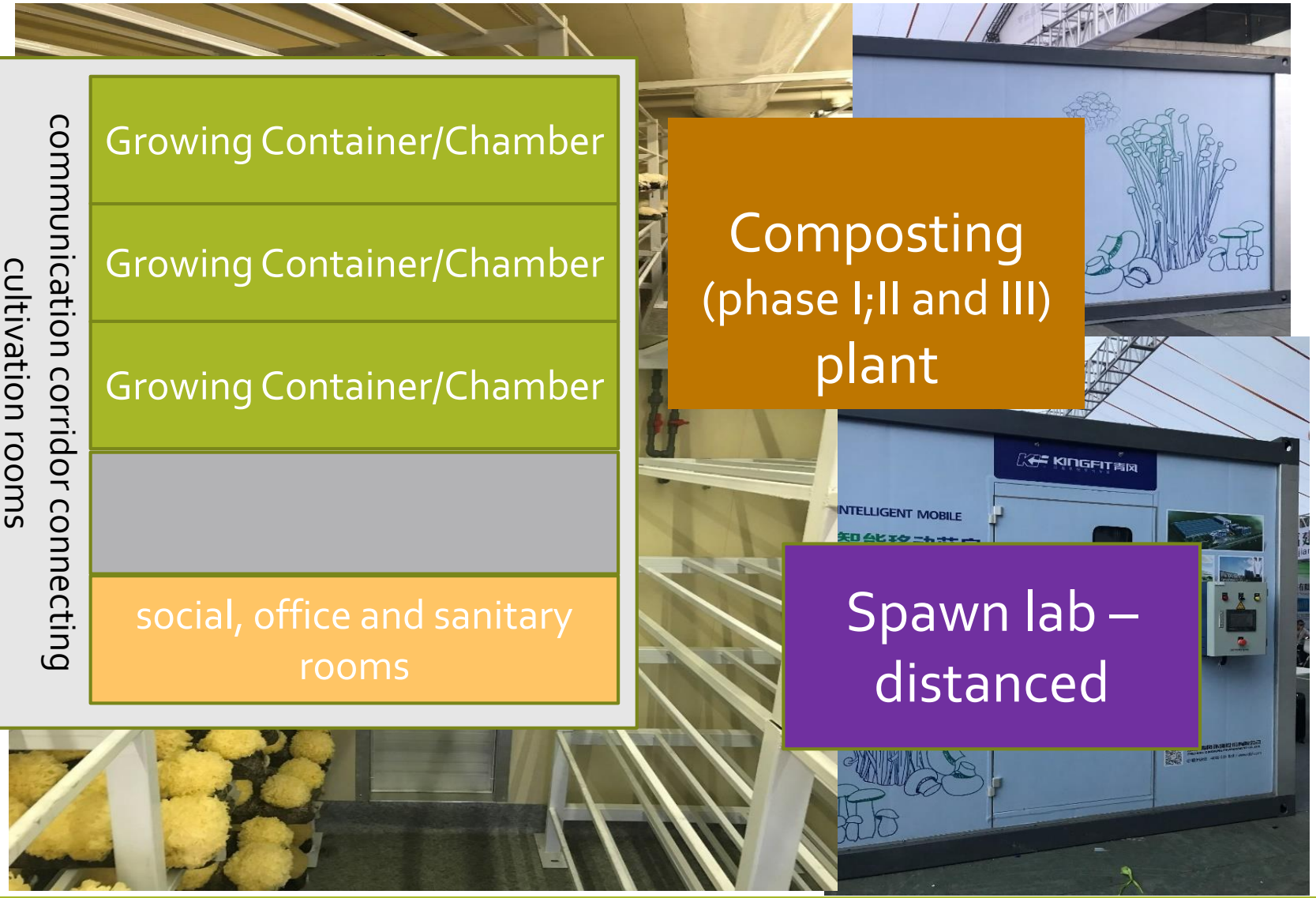
Msc Michał Roszak

SOPPAS

100 ton small scale farm

Container based («plug and play» ready to use divices) small scale farm:

Growing Container/Chamber	communication corridor connecting cultivation rooms	Growing Container/Chamber
Growing Container/Chamber		Growing Container/Chamber
Growing Container/Chamber		Growing Container/Chamber
cold storage		
		social, office and sanitary rooms



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