Workshop online, 8 luglio 2021
LIFE SUBSED: Sustainable substrates for agriculture
from dredged remediated marine sediments: from ports to pot

LIFE 17 ENV/IT/000347

VALUTAZIONE DI PARAMETRI MORFOLOGICI E BIOCHIMICI IN COLTIVAZIONI DI SPECIE ORNAMENTALI E ORTICOLE SU SUBSTRATI A DIVERSA PERCENTUALE DI SEDIMENTO FITORIMEDIATO

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SUBSED

MODEL PLANT SPECIES FOR VALIDATION OF SEDIMENT-BASED SUBSTRATES

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Life

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Evergreen ornamental

Typical and widely used evergreen ornamental and barrier plant (hedge), with a very fast growing and plant development.
Nowadays, *P. laurocerasus* is recognised as one of the most commercially important ornamental plant species for the Italian nursery sector.

***Prunus laurocerasus* (laurel) cv Novìta**

Woody perennial. Grows well in the Mediterranean climates and adapts to all types of soil, tolerating light, medium and heavy clay soil. Easy to care, finds the optimum in moderately fertile, neutral or alkaline, fresh and drained ones.

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Flower potted plant

National Flower of South Africa, is commercially relevant for the flower industry, and it was imported in Italy by Flora Toscana in the 2000 to be used as ornamental plant and currently, in Italy, only Flora Toscana is cultivating and exporting this plant species all over the world.

***Protea cynaroides* (King Protea), cv 'Little Prince'**

Perennial flowering plants, native from Southern Africa. Is adapted to nutrient-poor soils, with a pH 4-6, and a clay content of less than 20% with low levels of P, K and Na. Water requirements are high when grown under soilless conditions. Hot, humid conditions are not well tolerated by protea and sufficient air movement is required for healthy growth.

Cut flower

Calla is grown as outdoor garden and potted plants, but also largely raised for cut flower production. Thanks to its magnificent beauty, calla is a flowering plant of major economic importance worldwide.

***Zantedeschia aethiopica* (Calla lily)**

Perennial rhizomatous species, native to Africa. In Italy, the cultivation is performed indoor, under greenhouse, in order to preserve the vegetative part of the plants in winter. It prefers well-drained soil with pH 6-6.5 and constant irrigation. Is susceptible to salt stress but has been widely used for the treatment of wastewater or contaminated wetland as it is considered moderately tolerant to heavy metals.

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Aromatic leaf species

Basil is undoubtedly the most loved and popular herb in Italy. Has a very short spring-summer cycle and is cultivated by seed. It is prone to downy mildew, a relatively recent disease in Italy that under favorable conditions develops very quickly and is difficult to control.

***Ocimum basilicum* (basil) cvs 'Genova' and 'Valentino'**

Annual herb, suitable for the Mediterranean climate. It grows well in all types of soils, but does its best in well-drained, moist - nutrient rich soil with a neutral pH.

ALL EXPERIMENTS WERE PERFORMED UNDER GREENHOUSE CONDITIONS

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SUBSTRATE MIXTURES: totally 15

PBS - Peat-Based Substrate

CFBS - Coconut Fiber-Based Substrate

WFBS - Wood Fiber-Based Substrate

TS - Treated Sediment (0-25-50-100%)

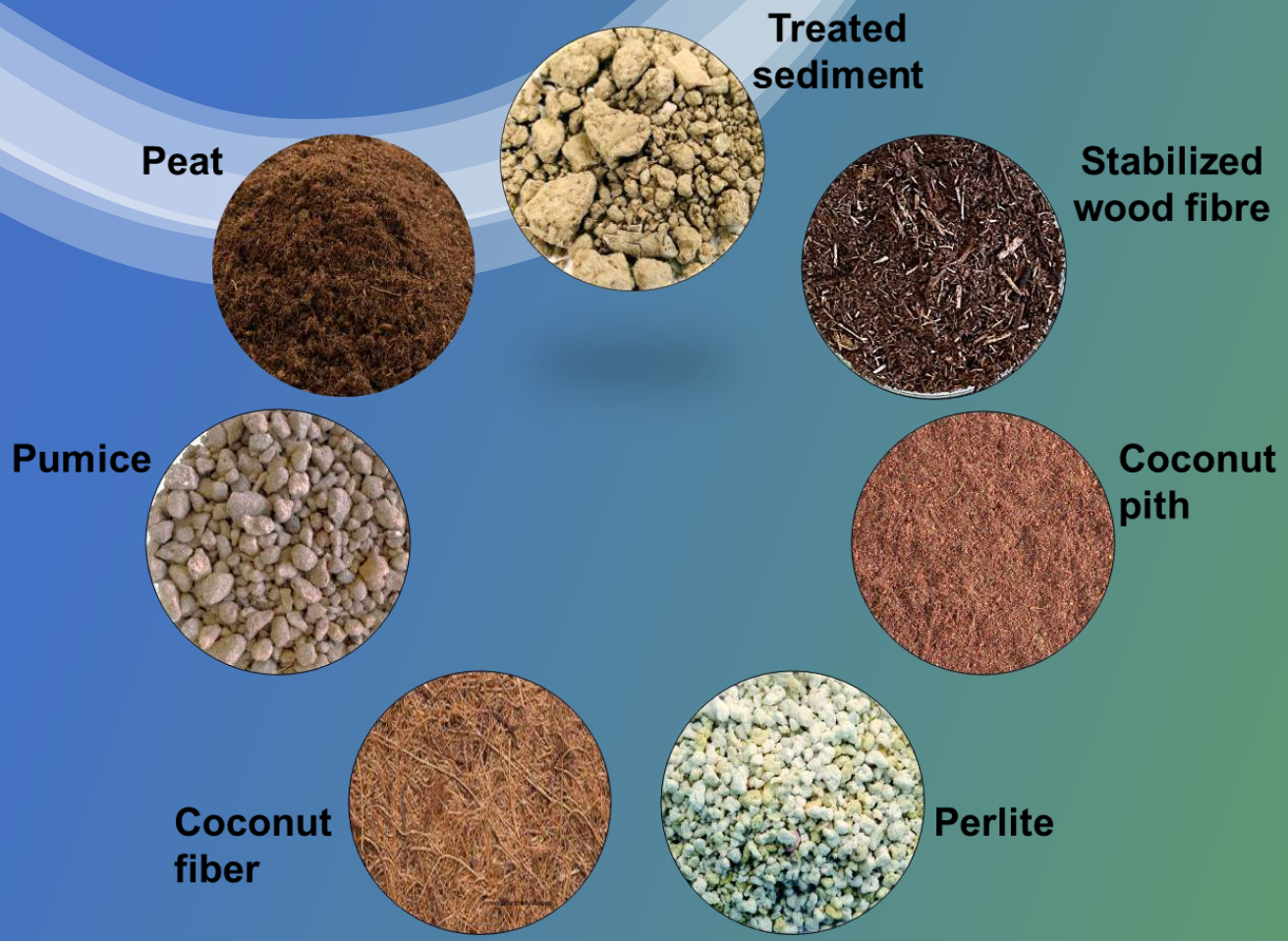
WATER REGIMES:

WR1: normal

WR2: low (reduced 30%)

WR3: very low (reduced by 50%)

USED MATRIXES



Legend:
PBS = Peat-based substrate (control); CFBS = Coconut fiber-based substrate; WFBS = Wood fibre-based substrate; TS = Treated sediment

USED Mixtures and matrixes (v/v)

Substrate	Peat	Pumice	Coir fiber	Coir dust	Wood fiber	Perlite
PBS_1	60	40				
PBS_2	79	12.4				8.5
CFBS_1		40	60			
CFBS_2		24	45.6	30.4		
CFBS_3		24	53.2	22.8		
WFBS		40			60	

Mixtures	PBS_1	CFBS_1	WFBS	PBS_2	CFBS_2	CFBS_3	TS
1	100						0
2	75						25
3	50						50
4		75					25
5		50					50
6			75				25
7			50				50
8				100			0
9				75			25
10				50			25
11					75		25
12					50		25
13						75	25
14						50	50
15	0						100

DATA COLLECTION

Non-destructive analysis

- Plant mortality (number; percentage)
- Base stem diameter
- Maximum plant height
- Number of vegetative sprouts
- Length of primary vegetative shoot
- Number of fully expanded leaves on primary vegetative shoot
- Leaf blade colour (L. a. b coordinates) and Chroma index $(a^2 + b^2)^{1/2}$
- Photosynthetic activity by CIRAS-2

Destructive analysis

- Leaf area
- Chlorophyll content
- Fresh and dry weight of the whole plant
- Fresh and dry weight of stem (aerial part)
- Fresh and dry weight of root system
- Malondialdehyde (MDA) analysis for oxidative stress
- Heavy metal analysis

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DATA COLLECTION FOR BASIL

Plants and leaves

Germination test

- Seed germination (number; percentage)
- Mean germination time (number; percentage)
- Time taken to 50% germination
- Plant mortality

Data collection at growth stage of 2-4 couple of true leaves (end of demonstration)

- Number of leaves
- Leaf area
- Chlorophyll content
- Fresh weight of the whole seedling

Chemical parameters

- Total polyphenols content
- Antioxidant activity (FRAP, ABTS and DPPH)
- Organic acids and sugars
- Analysis of organic and inorganic contaminants

CHARACTERISTICS OF GROWING MEDIA

Physicochemical characteristics	TS0	TS50	TS100	L.D. 75/2010	L.D. 152/2006
Dry bulk density (g cm^{-3})	0.31	0.58	0.67	≤ 0.95	n.a
Porosity (%)	90.1	75.1	74.3	n.a	n.a
Air capacity (%)	25.6	19.5	6.0	n.a	n.a
Water capacity (%)	64.5	55.62	73.7	n.a	n.a
Easy available water (%)	21.4	11.2	21.5	n.a	n.a
EC (dS m^{-1})	0.40	0.28	0.20	≤ 1.0	n.a
pH	6.4	7.3	7.8	4.5-8.5	n.a
$N\text{-}NH_3$ (mg Kg^{-1})	277.0	29.2	2.2	n.a	n.a
$N\text{-}NO_3$ (mg Kg^{-1})	271.7	118.8	59.4	n.a	n.a
Humidity (%)	14.9	4.8	2.1	n.a	n.a
Total nitrogen (%)	1.3	0.3	0.1	n.a	n.a
Total organic carbon (%)	27.7	8.7	0.7	≥ 4	n.a
Phosphorus (g Kg^{-1})	518.0	715.0	662.0	n.a	n.a
Metals				n.a	n.a
Cu (mg Kg^{-1})	12.1	35.5	37.1	≤ 230	≤ 120
Zn (mg Kg^{-1})	18.1	167.4	188.5	≤500	≤150
Ni (mg Kg^{-1})	6.5	50.0	50.3	≤ 100	≤ 120
Cr (mg Kg^{-1})	5.2	64.1	59.4	n.a	≤ 150
Cr (VI) (mg Kg^{-1})	-	-	-	≤ 0.5	≤ 2
Pb (mg Kg^{-1})	20.6	35.9	49.5	≤ 140	≤ 100

- Physico-chemical properties in compliance with Legislative Decree 75/2010 regarding fertilizers
- Contamination limits set by Legislative Decree 152/2006 regarding soil requirements

Substrates:
TS0 (BMix 1): 100% PBS (control)
TS50 (BMix 2): 50% PBS, 50% TS (v/v)
TS100 (BMix 3): 100% TS

Physicochemical characteristics	LMix 1	Lmix 2	LMix 3	LMix 4	LMix 5	LMix 6	LMix 7	L.D. 75/2010	L.D. 152/2006
Dry bulk density (g cm^{-3})	0.31	0.54	0.61	0.49	0.63	0.45	0.68	≤ 0.95	n.a
Porosity (%)	87	78	76	80	75	81	72	n.a	n.a
Air capacity (%)	50	28	27	17	17	38	21	n.a	n.a
Water capacity (%)	36	50	48	63	58	44	51	n.a	n.a
Easy available water (%)	4.1	8.0	9.5	11.9	11.3	9.8	8.8	n.a	n.a
Electrical conductivity (dS m^{-1})	0.15	0.41	0.36	0.40	0.40	0.20	0.19	≤ 1.0	n.a
pH	4.6	6.5	6.7	7.4	7.7	7.9	8.0	4.5-8.5	n.a
N-NH3 (mg Kg^{-1})	11.4	8.5	6.7	4.9	1.5	1.3	0.7	n.a	n.a
N-NO3(mg Kg^{-1})	42.9	36.3	28.5	49.6	38.7	85.5	73.1	n.a	n.a
Humidity	5.45	3.63	2.93	4.30	3.33	2.95	2.55	n.a	n.a
Total nitrogen (%)	0.63	0.18	0.14	0.21	0.17	0.33	0.18	n.a	n.a
Total organic carbon (%)	7.96	5.41	**3.52**	7.41	5.68	10.85	4.86	≥ 4	n.a
Phosphorus (g Kg^{-1})	302	354	389	379	388	434	415	n.a	n.a
Metals									
Ca (g Kg^{-1})	4.8	22.5	25.7	18.0	21.6	22.1	25.0	n.a	n.a
Mg (g Kg^{-1})	2.0	5.0	5.1	4.3	5.0	4.9	5.2	n.a	n.a
K (g Kg^{-1})	5.7	3.6	3.0	3.9	3.0	3.4	2.6	n.a	n.a
Fe (g Kg^{-1})	5.0	13.9	15.1	12.3	14.9	13.9	15.7	n.a	n.a
Cu (mg Kg^{-1})	12.1	37.6	40.8	33.3	39.4	38.1	45.2	≤ 230	≤ 120
Zn (mg Kg^{-1})	18.1	136.7	**150.4**	114.6	**143.0**	133.6	**181.3**	≤500	≤ 150
Mn (mg Kg^{-1})	176.6	248.8	278.2	221.9	264.0	253.1	276.5	n.a	n.a
Ni (mg Kg^{-1})	6.5	36.1	37.6	30.0	37.0	34.2	38.6	≤ 100	≤ 120
Cr (mg Kg^{-1})	5.2	44.7	40.7	32.3	42.9	41.4	41.2	n.a	≤ 150
Pb (mg Kg^{-1})	20.6	40.1	43.1	33.0	43.1	38.1	47.4	≤ 140	≤ 100
Cd (mg Kg^{-1})	-	-	-	-	-	-	-	≤ 1.5	≤ 2
Germination index (%)	98.3	83.5	103.6	94.5	70.7	74.5	86.9	n.a	n.a

Substrates:
LMix 1: 100% PBS (control) **LMix 2**: 75% PBS, 25% TS (v/v)
LMix 3: 50% PBS, 50% TS (v/v) **LMix 4**: 75% CFBS, 25% TS (v/v)
LMix 5: 50% CFBS, 50% TS (v/v) **LMix 6**: 75% WFBS, 25% TS (v/v)
LMix 7: 50% WFBS, 50% TS (v/v)

(UNI EN ISO 3696)

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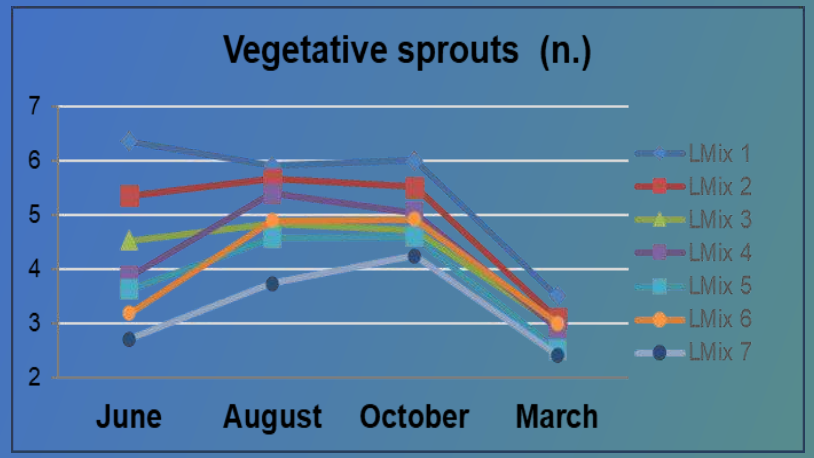
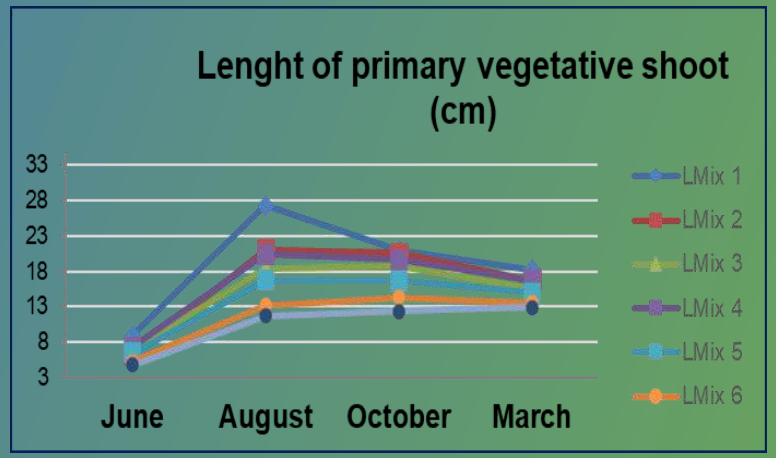
RESULTS: LAUREL

Factor/Parameter Substrate	MPH	NVS	LVS	NEL
LMix 1	38.5 a	6.2 a	20.8 a	14.2 a
LMix 2	36.1 ab	5.3 b	17.2 b	13.7 ab
LMix 3	33.5 b	4.6 c	15.7 bc	12.7 ab
LMix 4	36.3 ab	4.7 bc	16.9 b	13.4 ab
LMix 5	31.1 c	4.3 c	14.4 c	12.0 bc
LMix 6	26.8 d	4.6 c	11.5 d	10.8 c
LMix 7	25,6 d	3.6 d	10.9 d	10.4 c

Legend: BSD = Base stem diameter; MPH = Maximum plant height; NVS = Number of vegetative sprouts; LVS = Length of vegetative sprouts; NEL = Number of fully expanded leaves on vegetative sprouts





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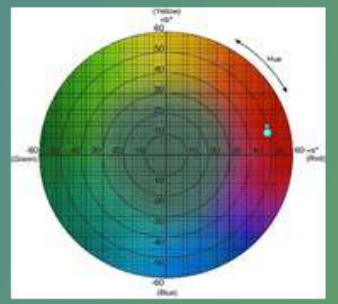
LAUREL LEAF BLADE COLOUR AND CHROMA INDEX

August 2020

Substrate	L brightness	a redness	b yellowness	Chroma index
LMix 1	34.1 a	-6,6 e	11,8 a	13,6 a
LMix 2	34.9 a	-7.1 d	13,1 a	14,8 a
LMix 3	36.1 b	-7.6 c	15,0 b	16,8 b
LMix 4	35,9 b	-7.9 b	15,2 b	17,1 b
LMix 5	36.6 b	-8.0 b	16,2 b	18,1 b
LMix 6	45,3 d	-10.1 a	30,1 d	31,7 d
LMix 7	45.4 c	-9.9 a	27,0 c	28,8 c

Water regime	L brightness	a redness	b yellowness	Chroma Index
WR1	38,3 ns	-8,2 ns	18,7 ns	20,6 ns
WR2	37.8 ns	-8,1 ns	17,9 ns	19,8 ns



CIELab coordinates

October 2020

Substrate	Chroma index
LMix 1	14.1 ab
LMix 2	13.4 a
LMix 3	14.1 ab
LMix 4	14.7 bc
LMix 5	14.3 bc
LMix 6	16.5 d
LMix 7	14.9 c

LAUREL DESTRUCTIVE ANALYSIS

MDA: 0.3 - 0.4 mM/g DW
Chl_a : 1.6 - 2.2 µg/mg FW
Chl_b : 0.8 - 1.0 µg/mg FW
Chl_{Tot} : 2.4 - 3.1 µg/mg FW
Carotenoids: 0.3 - 0.6 µg/mg FW

Range of lipid peroxidation by measuring malondialdehyde (MDA) concentration and of chlorophylls (a = Chl_a, b = Chl_b, Total = Chl_{Tot}) and carotenoids content by spectrophotometer

Factor	Stem DW (g)	Leaf DW (g)	Root DW (g)	Total DW (g)	Total leaf area (cm^2)
Substrate					
LMix 1	42.6 a	116.7 ab	134.8 bc	294.1 bc	9.764.2 a
LMix 2	42.8 a	126.0 a	197.7 a	366.4 a	8.632.6 ab
LMix 3	31.6 b	89.3 c	126.7 bcd	247.6 cd	7.282.6 bc
LMix 4	42.3 a	119.4 a	155.5 ab	317.2 ab	8.442.8 ab
LMix 5	31.6 b	93.0 bc	93.3 cd	218.0 de	6.621.3 c
LMix 6	18.4 c	55.4 d	91.7 cd	165.5 e	4.885.4 d
LMix 7	18.2 c	56.6 d	82.5 d	157.3 e	4.357.3 d
Water regime					
WR1	29.6 b	ns	ns	ns	6.677.6 b
WR2	35.3 a	ns	ns	ns	7.604.2 a

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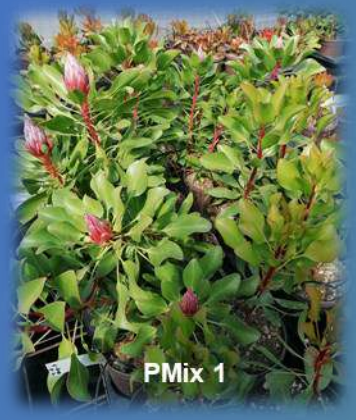
RESULTS: PROTEA

2020

Factor	Shoot (n.)		Shoot lenght (cm)	
	August	October	August	October
Substrate				
PMix 1	2,7 a	2,6 a	3,9 a	8,8 a
PMix 2	1,9 b	1,8 bc	2,2 b	4,2 b
PMix 3	1,2 c	1,5 c	1,6 bc	2,4 d
PMix 4	1,6 bc	1,8 bc	1,3 c	3,5 bc
PMix 5	1,7 b	1,7 bc	1,7 bc	2,3 d
PMix 6	1,9 b	2,1 b	1,7 bc	3,3 bcd
PMix 7	1,9 b	2,1 b	1,8 bc	2,9 cd
Water regime				
WR1	2,0 a	2,1 a	2,2 ns	3,9 ns
WR2	2,0 a	2,0 a	2,0 ns	4,1 ns
WR3	1,5 b	1,7 b	1,9 ns	4,0 ns



April 2021

Protea mortality (%)
October 2020

	WR1	WR2	WR3
Mix1	0	0	10
Mix2	0	0	17
Mix3	0	0	13
Mix4	0	0	13
Mix5	3	17	37
Mix6	7	0	53
Mix7	3	3	57

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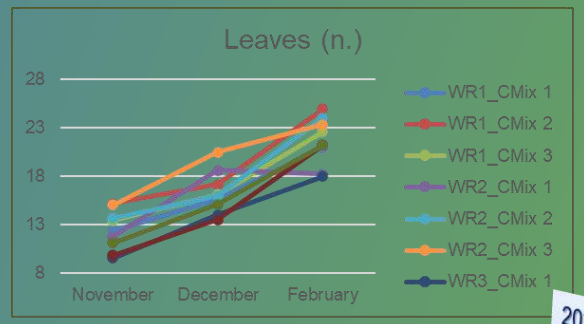
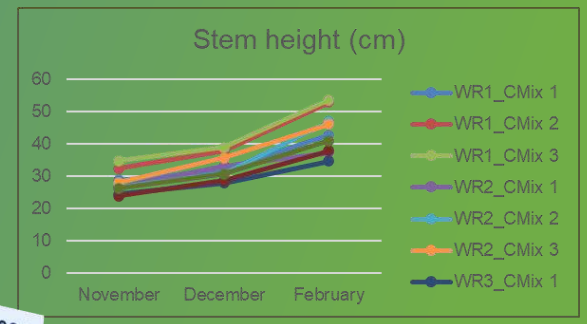
RESULTS: CALLA

Factor/Parameter	NL	MSH	LA
Substrate			
LMix 1	15.5 b	31.9 c	477.0 c
LMix 2	17.4 a	35.6 b	558.6 b
LMix 3	17.6 a	37.3 a	612.4 a
Water regime			
WR 1 - high	17.7 a	39.5 a	621.6 a
WR 2 - medium	17.9 a	34.6 b	540.3 b
WR 3 - low	14.9 b	30.7 c	486.9 c

Legend: NL = Number of leaves (stems); MSH = Maximum stem height; LL= Leaf length; LW = Leaf width; LA = Leaf area





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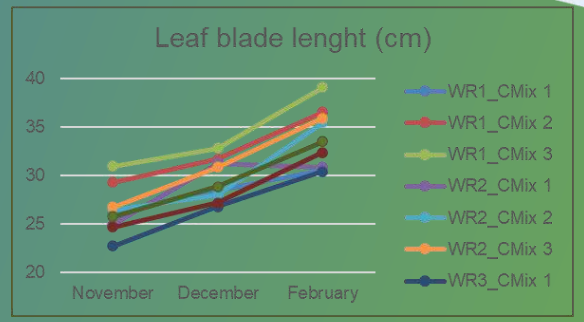

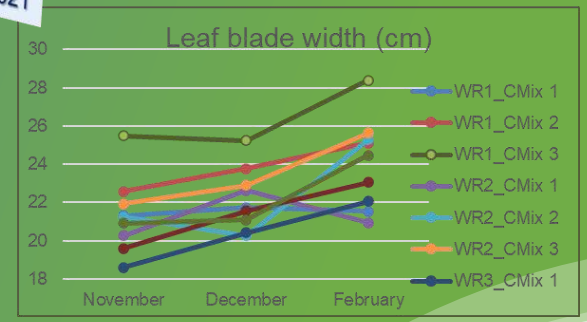

CALLA LEAF BLADE COLOUR AND CHROMA INDEX

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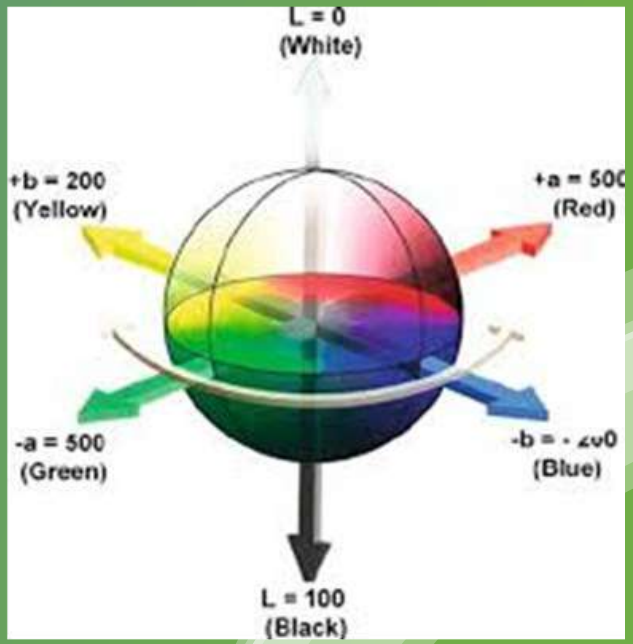
February 2021

Factor	L brightness	a redness	b yellowness	Chroma index
Substrate				
CMix 1	47,29 a	-10,25 a	30,15 a	32,01 a
CMix 2	38,15 b	-6,87 b	21,18 b	22,30 b
CMix 3	37,92 b	-8,33 b	20,09 b	21,81 b
Water regime				
WR1	41,03	-8,50	21,18	22,90
WR2	40,86	-8,99	25,81	27,35
WR3	41,57	-7,97	24,42	25,86

Mean separation within columns by Duncan's multiple range test ($p < 0.01$)



CALLA: NUMBER OF FLOWERS and POST HARVEST

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Substrate * WR	Flowers (n)	Flower commercial senescence (days)
CMix1_WR1	150	11.8 ab
CMix2_WR1	197	13.2 a
CMix3_WR1	182	13.4 a
CMix1_WR2	148	14.8 a
CMix2_WR2	176	13.8 a
CMix3_WR2	165	13.8 a
CMix1_WR3	129	8.2 bc
CMix2_WR3	113	7.6 c
CMix3_WR3	165	12.0 ab

RESULTS: BASIL

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October 2020

Factor/Parameter	Germination %
Cultivar	
Genova	60.2 ns
Valentino	57.2 ns
Substrate	
LMix 1	61.8 a
LMix 2	65.6 a
LMix 3	48.8 b
Water regime	
WR 1 - high	60.4 ns
WR 2 - medium	59.2 ns
WR 3 - low	56.4 ns

Substrate	Water regime	Total fresh weight (g)		Total leaf area (cm²)	
		Genova	Valentino	Genova	Valentino
TS0	WR1	71	114	2041	3074
TS50	WR1	48	91	1448	2445
TS100	WR1	22	43	714	1082
TS0	WR2	77	109	2271	2850
TS50	WR2	57	89	1801	2402
TS100	WR2	20	36	700	1011
TS0	WR3	37	54	1369	1598
TS50	WR3	24	41	755	1268
TS100	WR3	13	21	487	611

TS0 - WR2 TS50 - WR2 TS100 - WR2

ESTIMATION OF HEAVY METALS IN LAUREL LEAVES (mg kg $^{-1}$ dw)

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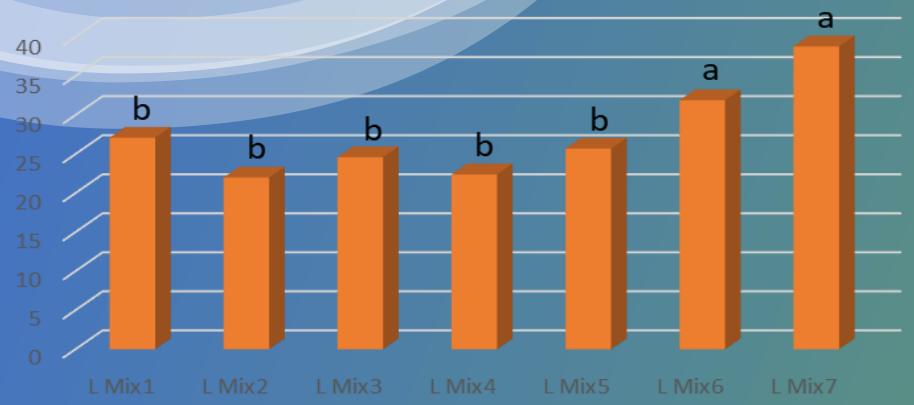
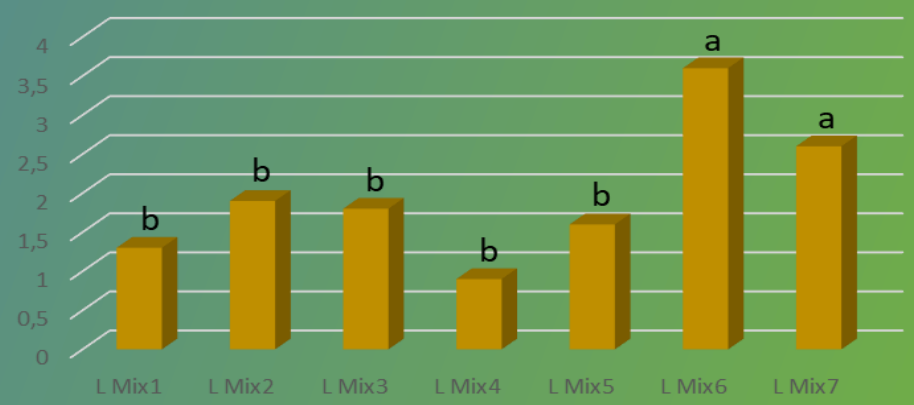
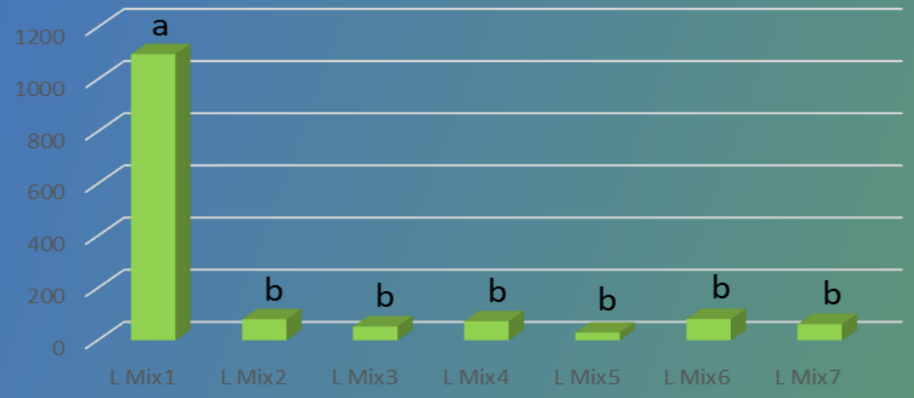
Fe



Cu



Mn



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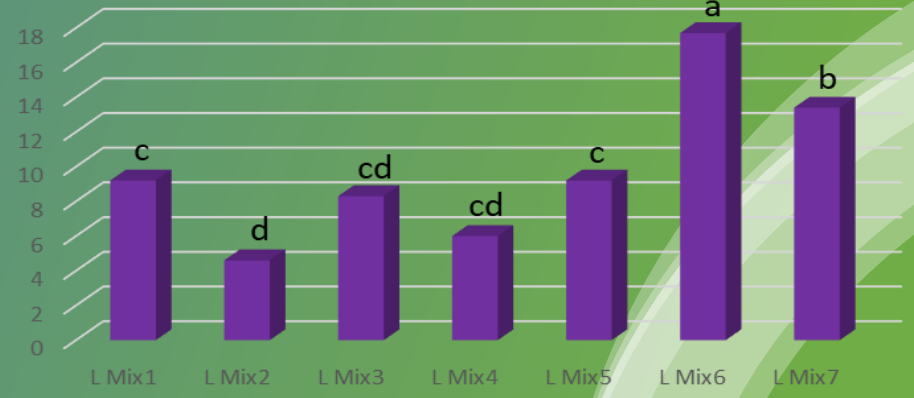

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ESTIMATION OF NUTRIENTS IN LAUREL LEAVES (g kg $^{-1}$ dw)

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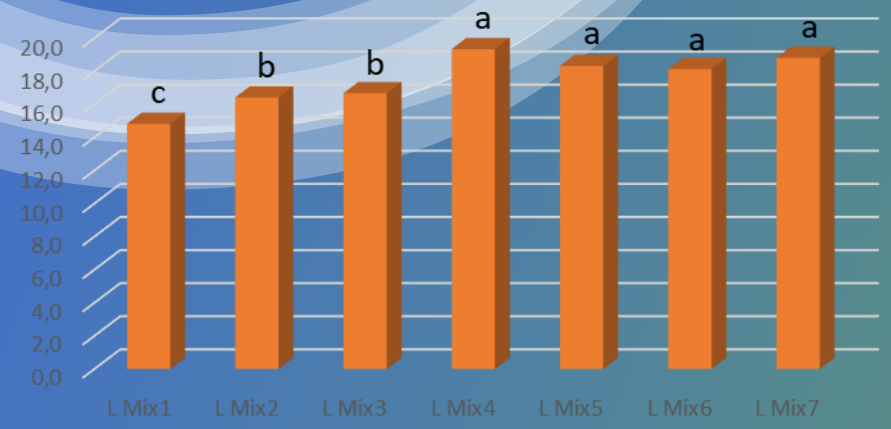
K



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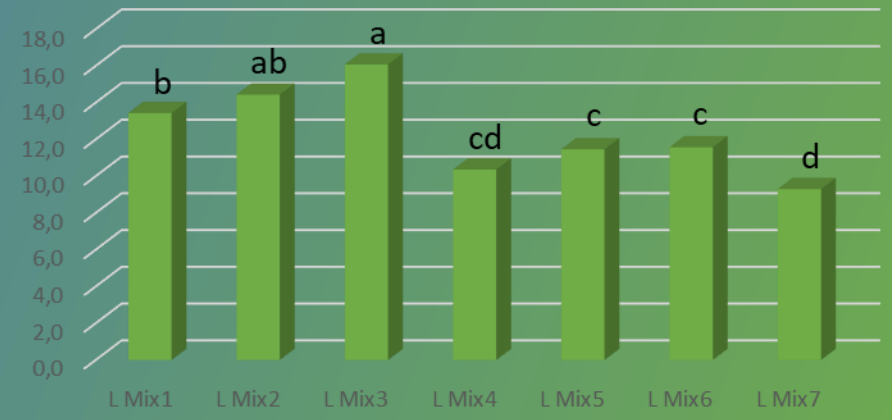

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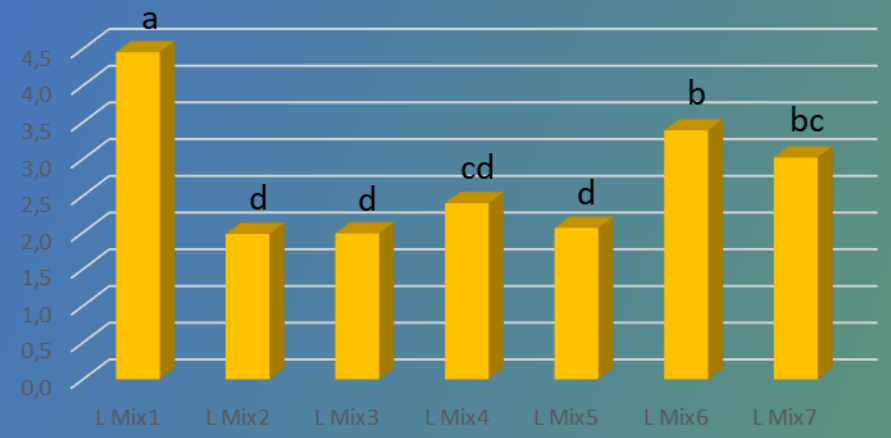

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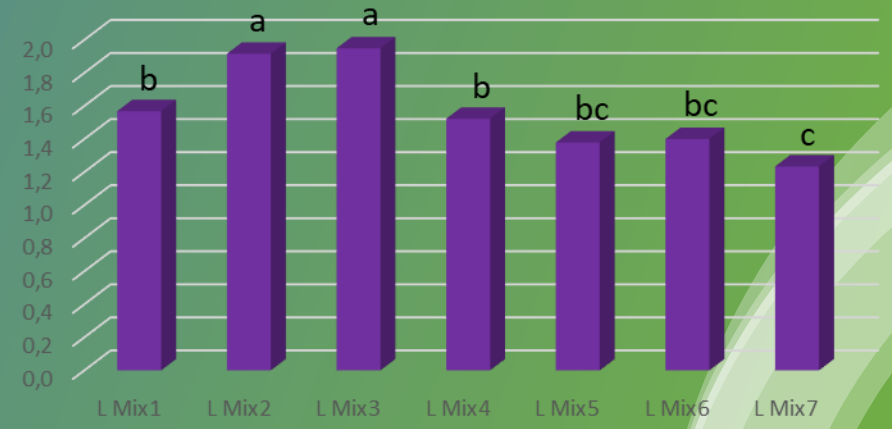

Workshop online, 8 July 2021

crea
Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria

SUBSED

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Workshop online, 8 luglio 2021
LIFE SUBSED: Sustainable substrates for agriculture from dredged remediated marine sediments: from ports to pot

SedNet

Life

Dredged sediments are one of the biggest potential waste flows, according to regulations.
Dredged sediments are mostly disposed of, at sea or on land.
Sediments are part of our potential mineral resources (but also of our environment).
⇒Sediments are eligible to circular economy thinking

The SedNet Working Group (WG) on Sediments in Circular Economy

Sediment as a resource

Sediment as an agronomic substrate

brgm
Geoscience for a sustainable Earth

BRGM
Bruno Lemière

Thank you for your attention!

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