REPORT ON VERIFICATION OF FEASIBILITY OF NEW MATERIALS

RESULTS FROM C12.1 (VLACO/OVAM) - WP2

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TABLE OF CONTENT

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1 RESULTS

In the initial phase of Cmartlife C12.1, a detailed overview – a ‘matrix’ of cultivation method, cultivation materials, prices, processing, and processing cost – was recorded for five different fruit vegetables, in particular of both the current and potential alternative scenarios. Vlaco synthesised the different conventional and alternative scenarios in this table, taking into account the difficulties encountered throughout the project regarding separation techniques (foliage versus rope & clips).

In work package 2 both composting trials (2021-2023) and cultivation trials (2022-2023) were held at several locations and with several materials which were deemed valuable (in conformity with the matrix of WP1). These tests and results are the topic of the following sections.

1.1 GREENHOUSE CULTIVATION TESTS

Cultivation trials were started (2022-2023) in the greenhouses of Proefcentrum Hoogstraten (PCH) and Proefstation Groenteelt at Sint-Katelijne-Waver (PSKW).

1.1.1 PSKW

The PSKW compared the use of cordenka (viscose) with PLA rope in combination with metal clips (Tom system) versus twisting in (clipless cultivation) in a pepper cultivation trial (Red block pepper Mavera, planting date December 2021).

Object 1: bio ropes viscose + metal clips
Object 2: bio ropes PLA + metal clips
Object 3: bio ropes viscose + twisting (clipless)
Object 4: bio ropes PLA + twisting (clipless)

Clipping in sweet pepper could be time-saving. It may also be desirable early in the crop to keep the plants more vegetative. In doing so, PSKW looked at parameters such as breakage, elasticity, firmness in knots and compatibility of thickness with clips for the ropes. The tying methods were evaluated for labour efficiency, crop damage and durability. At the completion of the trial (12/2022), conclusions included: the viscose twine appeared more elastic, causing pepper plants to sag. The viscose twine is also smoother, meaning more winding is required when twisting the plant around the rope to achieve the same degree of strength, which means greater labour effort.

The increased labour aside, the viscose rope does satisfy: there were no significant defects (wear, breakage, uncorrectable unloading). Attaching the clips (Tom system) to the plants requires more time than twisting in by a seasoned employee (...). In contrast, because of the complexity of twisting in and the higher risk of plant damage with inexperienced workers, 'clipping' with metal rings is more efficient when temporary/inexperienced workers have to tie up the plants: less risk of plant damage and presumably faster. The metal clips were compatible with both types of rope. Breaking of ropes by the metal clips did not occur. This had been an issue in the past but due to adjustment of the pinch force (: reducing pinch force), that problem was solved[1] in the various types of twines (PP, PLA, cotton viscose, viscose).

[1] PSKW – also partner in the LA Zero-Waste project – stated that there were similarly no rope breakage problems experienced with metal clip tests in the Zero-waste project (WP1 (2021-2023))

1.1.2 PCH

The PCH focuses on comparing growing vine tomato Marinice (planted 9/2022) with standard nylon versus viscose ropes and with metal versus plastic clips. In other words 4 objects:

Object 1: standard PP[2] ropes (reference)+ plastic clips[3]
Object 2: bio ropes viscose[4] + plastic clips
Object 3: bio ropes viscose + metal clips[5]
Object 4: standard PP ropes + metal clips

During the test several parameters are observed: production (weight of tomatoes, number of trusses), required time for applying clips (labour efficiency) and broken ropes (+ causes).

In a first evaluation, PCH already indicated that applying metal clips (Tom system) went smoother (faster) than manually applying plastic clips. During cultivation though, rope breaks were observed in object 3 and object 4: see table below.

Table 1. broken ropes in objects with metal clips and standard PP rope (obj 4) vs bio rope viscose (obj 3)

Weeknr	Aantal breuken in object 4	Aantal breuken in object 3	Mogelijke reden van uitval
8	0	3	Extra stengel
15	2	2	Plantbelasting/Teelthandeling
18	1	2	Plantbelasting/Teelthandeling
21	1	1	Plantbelasting/Teelthandeling
23	1	1	Plantbelasting/Teelthandeling
26	0	1	Plantbelasting/Teelthandeling

At the time of the second evaluation in 7/2023, some further rope breaks were observed in objects 3 and 4 when the leaves were cut & plants were sunk at the hook.
Rope breaks seemed also to be linked with the pinch position of the pincers (for applying metal clips): at the beginning of cultivation when pincers were still at position 3, it was observed that during leaf cutting, sliding of the metal rings could also cause the plants to fall down. Since then, the pinch position was increased to position 4, but other problems occurred: with metal clips it seems there is a higher percentage of ropes broken (thus loss of produce), especially with the viscose rope. It was also observed that the strength of pincers at position 5 cut the bio ropes. Consequently, the pincers were never used at position 5.

The times during cultivation when the highest probability of breakage was expected were (1) the time when the plants are sunk at the hook/leaf cutting, (2) the time when an extra stem is retained (3) periods with the greatest fruit hanging on the plants (up to 45 tomatoes per stem).

The average yield of tomatoes was similar in all 4 objects. However, the number of stems that fell out (broken rope) due to the use of the metal rings was ten in the bio ropes (viscose) and five in the standard ropes (PP). Thus, this is a loss of 10% and 5% production, respectively. In objects with plastic clips (objects 1 & 2) no rope breakage was observed.

Over almost 1 year of observations the Tom system for metal clip-application increases clamping speed by 18%. This savings in labor allows associated costs to be reduced significantly. However,

[2] PP touw (Haak 18 cm) (HESCO)
[3] 6CL22-TC Clip 22 (Polypropyleen) (Bato Plastics)
[4] Viscose touw (Ecotwine 300N)
[5] Agrifast V46 met Tom-system knijptang

this increase in labor efficiency does come with a cost of production losses between 5 (standard rope) and 10% (viscose rope).
This seems to indicate that viscose rope, in combination with metal rings, exhibits a rate of failure and consequently production loss that is (probably) too great to tolerate, even with the higher rates (gate fees) of disposing foliage with plastic clips taken into consideration. It should be noted though that no rope (viscose, PLA) breakages due to metal clips were detected in the PSKW trial (1.1.1)[6]

1.1.3 Conclusion

Applying metal clips (Tom system) may – particularly with relatively inexperienced workers – be significantly less time-consuming compared to twisting plants around the rope and compared to using plastic clips. Although applying metal clips may occasionally lead to rope breakages (standard and bio ropes) adjustments can be made amongst others to the pinch force of the pincer. Viscose rope may – because of flexibility, temperature sensitivity and smoothness – not be the ideal biodegradable rope for peppers. To move away from plastic clips – and increase composting or other recuperation options of greenhouse foliage – it is important to grow with types of rope (PLA, cotton/viscose or jute) and in such a manner that income is not negatively impacted (efficiency gains of clipping/twisting versus production loss through e.g. rope breakage).

1.2 COMPOSTING TESTS 2021-2022

3 trials were set up, each time with different types of greenhouse vegetables and biodegradable ropes (no clips). These trials were set up at 3 composting sites – 3 candidates from the group of Vlaco-member composters approached – according to the protocol written by Vlaco to conduct and monitor the tests in a similar, uniform and reproducible manner. These composting sites were IGEAN, De Kruisberg and Sabgro (see Table 1).

The tests with cucumber and aubergine foliage at composters sites De Kruisberg and Sabgro were completed in mid-April 2022. The most important conclusion was that, with the addition of 10 to 30% greenhouse foliage, the compost batch easily reached the required hygienisation temperatures over X days and weeks, and could therefore deal with potential plant pathogens. The test rills in the open air were smaller than normal compost batches, which made them more sensitive to excessive rainfall. This had a negative impact on the temperature development, the decomposition process and the sieving capacity of the compost at the end of composting – without nevertheless jeopardizing the final compost quality. In both tests there were no odour issues at the composting sites let alone in the wider area around them.

Sieving after composting proved to be useful for sieving out residues of the bio twine: especially the jute twine (after about twelve weeks) and cotton-viscose twine (after about sixteen weeks). The sieved-out end result, the compost, of the test batches at De Kruisberg and Sabgro scored very well in terms of impurities (< 0,5% dm standard).
In the Sabgro trial, not only was a mixture made with 30% greenhouse foliage, but a batch of approximately 30 tonnes of pure greenhouse foliage (100%) was also composted. This batch was not successful because the decomposition and temperature build-up soon stopped. The temperatures did not exceed 30°C. This would seem to indicate that ‘composting’ of solely greenhouse foliage performed by growers themselves may not be a guarantee for a good composting process and resulting end product.

[6] Neither in trials performed during the LA-project Zero-Waste

By end of may (after 6 months) also the third composting trial at IGEAN (27% sweet pepper foliage in total test batch) was completed resulting in no odour nuisance and a good compost with completely degraded PLA ropes. More specifically, and notwithstanding fairly heavy rainfall in previous months, the temperature/time requirements for hygienisation of the compost were met and IGEAN observed the gradual 'breakdown of the strings week after week'. IGEAN further stated they had noticed in the first weeks the smell of peppers in the area of the test batch, but after a few weeks it had disappeared'. In the compost (0-20mm) no PLA traces were observed by IGEAN and in the overflow fraction (20-80mm) IGEAN detected 'no impurities'. They concluded there was 'no difference noticeable compared to our standard end product'.

Table 2. C12.1 composting trials – full overview (2021-2023)

Type of foliage	Tons	Date initiated	Composter
Shredded pepper foliage (twisted in bio-rope PLA – without clips)	12,5	11/2021	IGEAN
Unshredded cucumber foliage (twisted in bio-rope jute – without clips)	30	11/2021	De Kruisberg
Shredded aubergine foliage (twisted in bio-rope cotton-viscose– without clips)	90 ton in 2 heaps (with different %)	11/2021	Sabgro
Mix of pepper foliage (with galvanized metal clips in bio-rope PLA) + tomato foliage (twisted in bio-rope PLA without clips)	40	12/2022	Sabgro
Shredde pepper foliage (with bio-rope PLA) + 60.000 biodegradable 'OK compost' clips & truss brackets (PASKAL) + tomato foliage	30	12/2022	Loonwerken Renders

Bron: cijfers VLACO

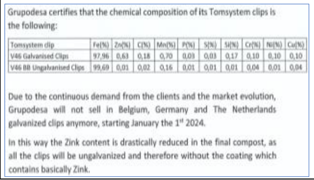
1.3 COMPOSTING TESTS 2022-2023

In late 2022, the Cmartlife C12.1 consortium launched 2 additional composting trials. This time with a focus on testing the compostability of bioplastics and metal rings. As no foliage stream with such clips could be sourced, unused bioclips from Paskal (see photo) were mixed into the trial batch with foliage. A batch of greenhouse foliage with metal clips, currently emerging (Hortiware - Tom System), was also included in a composting trial.


Source: PASKAL

A full description of the tests performed at both composter Sabgro and Loonwerken Renders is described in the table below.

Table 3. C12.1 composting trials 2022-2023

locatie	type compostering	inputs		tonnage	start	keren	water	tussentijdse bemerkingen composteerder		temp.metingen/ hygiënisatie	afzeving	zeefmaat	eindtonnage	finale bemerkinge composteerder	Analyseresultaten
RENDERS Hoog-straten	oba-compostering tafel - buiten/onbedekt	paprikaloof (°10/11/2022- Maropa) + loof van pepertjes met bioafbreek touw (type ?)		85,5 ton	11/11/2022: bijmenging clips bij reeds verkleinde (Renders) (?) paprika- en peperloof ../../….: extra verkleining (?) 10/1/2023: opzet composthoop	opzet + 5x keren tss 10/1/2022-19/5/2023	geen water toevoeging (nodig) geweest	- De aanwezigheid van het bio afbreekbaar touw is merkbaar afgenomen. De bio clips zijn ook gestart met verwerking, ze zijn meer poreus dan bij het opzetten. - qua geur en visueel geen bemerkingen/normaal - 30/3/2023: temperaturen nog steeds problematisch (materiaal van tuinder is niet vers/te droog toegekomen waardoor temperatuur te weinig wordt gehaald ook na opmenging. In pockets van de (proef)batch waar temperaturen wel worden gehaald is afbraak (touw en) bioclips OK. Composteringsduur zal iets langer doorlopen dan initieel gepland. Zien het potentieel van de clips wel in/vertrouwen dat dit correct composteert finaal. - Herhaalt tot slot dat risico wel is dat tuinders toch (ook) gewone clips gebruiken en via serreloof afvoeren naar een composteerder ...!	 	11 metingen (manueel)/ wellicht gehygiëniseerd	12/7/2023	35mm	40 ton compost	We merken nog wel aanwezige koord op (in zeefoverloop), Blijkbaar toch weer enkele niet biologische afbreekbare koorden gebruikt Nog niet alle bioclips volledig verkruimeld	Relatief vochtig, relatief hoog (doch conform) gehalte onzuiverheden, hoge Cl- en EC-gehalten - in lijn met gebruikelijke OBA-compost-parameterwaarden Gehalte aan steentjes > 5 mm < 0.05 Gehalte aan steentjes > 5 mm (in DS) < 0.05 Gehalte aan glas 0.00 Gehalte aan glas op DS < 0.05 Gehalte aan onzuiverheden > 2mm 0.12 Gehalte aan onzuiverheden > 2mm (op droge stof) 0.34 Gehalte aan metaal 0.00 Gehalte aan overige fractie 0.00 Gehalte aan plastiek 0.12 Gehalte aan metaal op DS < 0.05 Gehalte aan plastiek op DS 0.34 Gehalte aan overige fractie op DS < 0.05
		Clips (PASKAL): 1 doos (tot: 23.000 stuks) top arch (6mm) biodegradable (561ac-bio) & 2 dozen (tot: 24.000 stuks) komkommer oval clip 16 mm biodegradable (554-kc-bio) & 2 dozen (tot: 16.000 stuks) Optima clip23 mm (550kcbio-8)	  												
		tomatenloof		6 ton (later bijgevoegd 26/1/2023) wegens te weinig structuurmateriaal (lees: temperatuurtoename)											
SABGRO Nossegem	Groencompostering ril - onbedekt/buiten	- Onverhakseld loof (Vitaetom) m.n. * 1 (drie kwart gevulde) container paprikaloof (biotwine met NIET GEGALVANISEERDE (dixit Hortiware 10/2/2023) metalen clips ('V46b')) 2de helft november * 1 (half gevulde) container tomatenloof (biotwine zonder clips) 2de helft november ("Beste Koen, We noteren de aanlevering door jullie transporteur van de 2 containers paprika- en tomatenloof met bio twine touw hetzij einde week 47 (20/11) hetzij begin week 48 (27/11)."). Dit betrof dixit Hortiware anderzijds wel degelijk nog GEGALVANISEERDE clips (V46) Hier en daar nog groen plastic lint, plastic beugels, Biobest zakjes (gewasbescherming) en ijzer (serrehaak) - Groenafval - zeefoverloop		- serreloof: 30 ton - groenafval: 80 ton -zeefoverloop: 10 ton (geschat structuurmateriaal: 30%)	30/11/2022: verkleinen met sneldraaier JENZ - Opmengen samen met ander groenafval en gedoseerd invoeren en de Sneldraaier in balans houden zodat hij zich niet " verslikt" (rekenen op 20% meer tijd benodigd voor deze voorbewerking/opzet & 10 a 12 euro / ton)	4x keren tussen 21/12/2022 en 6/4/2023	geen water toevoeging (nodig) geweest	- typisch groenafval/compost geur - geen praktische moeilijkheden - nat voorjaar		wekelijks metingen/hygiënisatie OK	16/5/2023 en narijping tot 20/6/2023	20mm	- 0-20mm: 90 ton (?) - >20mm: 30 ton (?)	- mooie afgerijpte compost vochtig genoeg mooie typische donker zwarte kleur vs zeefoverloop (niets aan te merken) - verloop compostering proefbatch was gelijkaardig aan klassieke ril. De metalen clipsen waren zo snel "verteerd" dat we na 2 maand deze niet meer konden waarnemen. - clipsen worden perfect afgebroken en vormen geen obstakel in het composteerproces. Opmerkelijk ze breken veel sneller en makkelijker dan verwacht.	Goede kwaliteit compost (OS, DS, rijpheid,..) Volledig conform incl onzuiverheden en Vlarema m.n. zware metalen Gehalte steentjes >5mm 0.8 Gehalte onzuiverheden >2mm <0.1 Gehalte onzuiverheden >2mm <0.05 Gehalte metaal >2mm <0.05 Gehalte glas >2mm <0.05 Gehalte kunststof >2mm <0.05 Gehalte overige onzuiverheden >2mm <0.05 Kiemkrachtige zaden afwezig Zuurstofconsumptie (Oxitop) 2.8 Rijpheidsgraad (klasse) 5 Rijpheidsgraad (temp) 25.7 Vochtgehalte na knijptest 51
		inputs			**start**	**keren**		**tussentijdse bemerkingen composteerder**		**temp.metingen/ hygiënisatie**	**Einde proef**			**finale bemerkinge composteerder**	
		- Gegalvaniseerde (V46) vs ongegalvaniseerde (V46BB) ONGEBRUIKTE clips van Agrifast (ES) - verdeeld via Hortiware (NL) - cartouches werden - deels uit elkaar getrokken deels integraal - ingebracht in 2 open rillen met bordjes erbij - nadien werd ongeveer 2-wekelijks aan de bordjes de clips terug opgediept (van diepte van +/- 60 cm) uit ril om visueel het (verschil in afbraak) te evalueren & fotograferen - en bij omzetting ril werden de niches met clips (V46 en V46BB) uitgegraven en na omzetting weer ingegraven + weer bordjes bijgeplaatst 			15/03/2023	cfr normale frekwentie groencompostering		- clips beginnen te corroderen na paar weken - niet gegalvaniseerde clips lijken sneller te gaan roesten - afbraak van clips die integraal in cartouche-vorm ingebracht werden verloopt - door massiever vorm - uiteraad moeilijker		- rillen werden met sensor gemeten - temperatuur aan de clips door relatief ondiepe positie en regelmatig uitgraven niet volledig conform aan temp.condities van gemiddelde groenafval in batch doorheen composteerverloop	30/06/2023			- finaal geen blijvend verschil tussen V46 en V46BB inzake afbraak (resultaat na 3,5 mnd) - na 3,5 maanden zijn metalen clips m.n. breekbaar geworden en zwaar geoxideerd maar nog niet volledig afgebroken - nog iets langere compostering en narijping kan finale afbraak ondersteunen 	/

Grupodesa certifies that the chemical composition of its Tomsystem clips is the following:

Tomsystem clip	Fe(%)	Zn(%)	C(%)	Mn(%)	P(%)	S(%)	Si(%)	Cr(%)	Ni(%)	Cu(%)
V46 Galvanised Clips	97,96	0,63	0,18	0,70	0,03	0,03	0,17	0,10	0,10	0,10
V46 BB Ungalvanised Clips	99,69	0,01	0,02	0,16	0,01	0,01	0,01	0,04	0,01	0,04

Due to the continuous demand from the clients and the market evolution, Grupodesa will not sell in Belgium, Germany and The Netherlands galvanized clips anymore, starting January the 1st 2024.

In this way the Zink content is drastically reduced in the final compost, as all the clips will be ungalvanized and therefore without the coating which contains basically Zink.

During pilot composting (OBA-composting) at Renders, the bio-twine (assumed: PLA) and PASKAL bioclips and brackets systematically broke down. A balanced setup of fresh 'green' and 'brown' biowaste - basis for being able to reach high composting temperatures is all the more important to fully disintegrate and biodegradate[7] these binding materials. No odor issues or visual anomalities were reported. After about 6 months still some residue of twine and clips/brackets were noticed (albeit in a very far degraded state) within the composting heap and in the sieve overflow – stressing the importance of a sufficiently long composting period. The level of impurities (>2mm (% on dm)) of the resulting compost is in conformity with the Vlaco-threshold (< 0,5% on dm). Moisture, chlorides and EC content were slightly higher than an average green compost due to the presence of unharvested tomatoes/peppers in the foliage.

The first Sabgro composting test – with circa 25% greenhouse foliage (tomato and pepper including galvanized metal clips) – led to a smooth composting process (typical odor of green composting and normal temperatures) and a hygienised and matured compost. This compost was further characterized by a good moist level and dark color. The metal clips were broken down very quickly: after 2 months the composter could not detect any more metal clips (‘Clips break down perfectly and are not an obstacle in the composting process. … they break much faster and easier than expected.’). The sampled final compost was of a good quality: organic and dry matter levels, maturity, impurities, heavy metals, etc were fully compliant to the Vlaco quality standard.

An additional test was performed by Sabgro with both galvanized (V46) and ungalvanized (V46B) metal clips (produced by Grupodesa and distributed in Flanders and other regions by Hortiware). More particulary inserting unused (semi-crushed) stocks of clips into a newly started classical green composting rill at (only) about 60 cm depth. The temperature around the clips was continuously measured by sensors but was – due to the relatively shallow position (in the rill) and regular excavation – not fully representative to the average temperature conditions of a biowaste in a green waste composting batch. Both types of clips became brittle and heavily oxidized after 3,5 months of composting. Nevertheless – most likely due to the clustered presence in the composting batch of unused clips and atypical temperature conditions – the clips were not completely disintegrated after this period. The composter refrained from further testing. Also, a representative compost-sampling and heavy metals-analyses in this full scale test-setup would be very difficult and costly to conclusively effectuate. Therefore, looking at the clip composition (data Grupodesa), we found that ungalvanized clips consist of 99,7% iron (Fe) with very small presence of other metals such as 0,16% manganese (Mn), 0,04% chromium (Cr), and 0,04% cupper (Cu). With such a composition a hypothetical composting batch consisting entirely[8] of foliage of a fruit vegetable, e.g. tomatoes, cultivated with metal clips would still lead to a final compost comfortably in accordance with the Vlarema-thresholds of heavy metals.

[7] Cfr for example the ‘OK Compost Industrial’ label that requires at least 90% of the material to be disintegrated (< 2 mm) within 12 weeks and at least 90 of the material to be further degraded to CO_2, H_2O and biomass within 6 months

[8] In reality composting greenhouse foliage is done by adding several sources of green/bio-waste so the perfect mix of fresh, woody and more N-rich feedstocks is reached for initiating the composting process.

2 CONCLUSIONS

Tests at several pilot centres and composting facilities show the potential of

- on the one hand, fruit vegetable cultivation with biodegradable ropes and biodegradable or even no clips, and
- on the other hand, successful composting of the resulting foliage streams.

For tomato and pepper – the largest vegetable fruit cultivations in Flanders - particularly PLA twine and metal clips seem promising – particularly if no rope breakage arises and production numbers are similar to standard PP rope and plastic clip cultivation.

The legal framework – including which types of composting are allowed on greenhouse foliage – and an economical evaluation – a cost/benefit-analysis taking into account material and disposal costs as well as possible GMO subsidies – are further taken into account in work package 3 of C12.1 and discussed in the final deliverable (C12.1 D2).