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Industry Representative:	Dr John Collier
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AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

Signed on behalf of: East Malling Research

28 September 2012

Signature:……………………..……………………..…… Date: ……..……………………………...

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GROWER SUMMARY

Headline

- Several peat alternative materials were identified which increased mushroom yield from commercial peat + SBL casing.

Background and expected deliverables

To obtain casing for producing high yields of quality mushrooms, the industry is reliant on supplies of wet, deep-dug peat and sugar beet lime (SBL). However, these materials will no longer be locally available in Great Britain and Ireland respectively. Import of alternative sources of casing materials will increase costs.

Milled surface peat is widely available, cheaper, easier to transport, and under less environmental pressure than wet deep dug peat. However, increased use of milled peat and other materials in casing may have an impact on mushroom initiation, cropping and quality. Selection of the optimum materials and blends will therefore be essential.

Although the casing layer has certain known requirements in terms of physical, chemical, and microbial properties, the definition of an optimum casing material in terms of mushroom yield and quality remains elusive.

The commercial objectives of this project are to:

- Investigate new materials which can be beneficially added to casing to substitute wet deep-dug peat and SBL, and suppress diseases.
- Compare a range of existing commercial casings based on deep-dug peat and SBL with new casing materials and blends in terms of mushroom crop husbandry, yield, and quality.
- Explore the use of recycled casing, separated from the compost, as a component in new casing.
- Conduct physical, chemical and microbial analyses on new and existing casing ingredients and blended mixes which relate to subsequent performance in terms of mushroom initiation, yield and quality.

Summary of the project and main conclusions

A series of four cropping experiments were conducted in plastic trays to test the performance of commercial peat + SBL casings, when different materials were used to substitute 12.5 – 50% by volume of the peat + SBL. The materials used were: used granulated rockwool slabs, filter-cake clays from mining and quarrying, wood fibre, green waste compost, recycled cooked-out separated spent mushroom casing and aged spruce bark fines. This was followed by trials at two commercial mushroom farms to test the effect of substituting 25% of fresh casing with cooked-out, separated spent casing. The water and air holding characteristics, electrical conductivity, pH and bacterial populations of each of the casing materials were determined, and their influence on the cropping performance of the casing materials was examined.

- Several peat alternative materials were identified which increased mushroom yield from Everris peat + SBL casing when added to casing at 12.5% v/v in small tray experiments. These included multi-roll filter cake (MRF), filter-cake clay from sand quarrying, spent casing and bark. Used rockwool and MRF, when added together, each at 12.5% v/v, also increased mushroom yield from Everris and McDon peat + SBL casings.
- When used at 25% by volume in Everris casing, the effect of the above materials on mushroom yield was not significant, except spent casing which slightly reduced yield in small tray experiments.
- In two farm trials, addition of spent casing at 25% v/v in Harte casing did not affect mushroom yield.
- The effects of adding green waste compost to casing on mushroom yield were variable.
- Wood fibre reduced mushroom yield when added at more than 12.5% v/v to casing.
- Under the cropping conditions of the experiments, and without the addition of any alternative materials, mushroom yields were higher from the McArdle and McDon casings than from the CNC, Harte and Everris casings.
- A relationship was identified between the air-filled porosity (AFP) of casing materials and mushroom yield. The optimum casing AFP in terms of mushroom yield was 19 ±4% (Figure i).

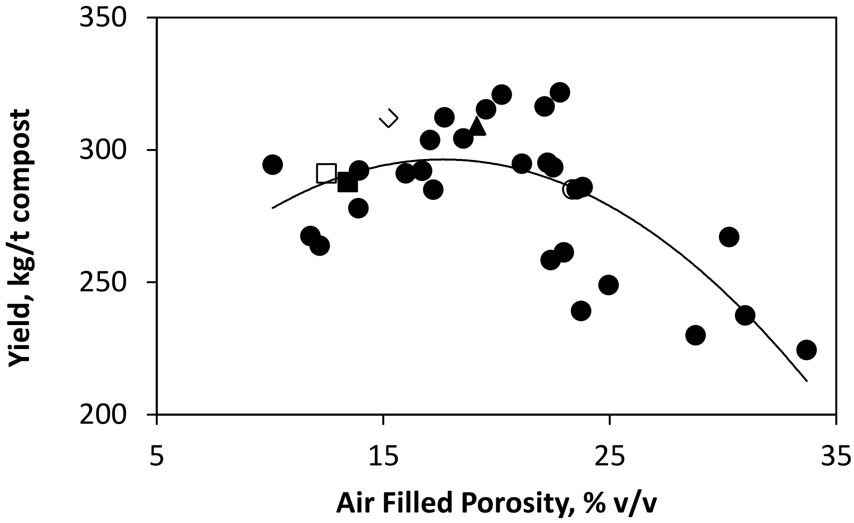

Fig. (i) Relationship between the air filled porosity of different casing materials and mushroom yield. Each value is the mean of four replicate crops. Commercial peat + SBL casings are indicated by: Everris ○; Harte □; McDon ◊; McArdle ▲;CNC ■

- There was a trend for casing materials with an EC of <600 µS/cm to produce higher mushroom yields than casings with an EC of >600 µS/cm.
- Adding substitute materials to commercial peat + SBL casing reduced the volumetric moisture content of the casing at equivalent matric potentials (suctions). This effect was small for green waste compost and spent casing at inclusion rates up to 50%, and for wood fibre at inclusion rates up to 25%. The effect of adding 12.5% MRF and 12.5% used rockwool, individually or together, on the water release characteristics of Everris peat + SBL was also small or not detectable.

Main conclusions

- Several peat alternative materials were identified which increased mushroom yield from commercial peat + SBL casing when added to casing at 12.5% v/v in small tray experiments: multi-roll filter cake (MRF), filter-cake clay from sand quarrying, spent casing and bark.
- Used rockwool and MRF, when both added to peat + SBL at 12.5%, increased mushroom yield to a greater extent than the individual materials.
- In two farm trials, addition of spent casing at 25% by volume in fresh casing did not affect mushroom yield.

- A relationship was identified between the air-filled porosity (AFP) of casing materials and mushroom yield. The optimum casing AFP was 19 ± 4%.

Financial benefits

This project has demonstrated that spent casing can be used to replace a proportion of fresh casing without affecting yield. This could reduce the volume of fresh casing required by up to 25%. Used granulated rockwool (a waste product from glasshouse vegetable production) should be an economically and environmentally viable ingredient in casing, providing the low risk status requirements of EA waste regulations can be met. A further casing ingredient, filter-cake clay, has been identified that should be a lower cost replacement for SBL in casing. Routine testing of casing for AFP and compacted bulk density should improve the reliability of cropping performance.

Action points for growers and casing producers

- Growers should test the recycling of cooked-out, separated spent casing on the cropping performance of casing when added at up to 25% by volume.
- Casing materials should be tested for air-filled porosity and compacted bulk density on a routine basis.

SCIENCE SECTION

Introduction

To obtain casing for producing high yields of quality mushrooms, the industry is reliant on supplies of wet, deep-dug peat and sugar beet lime (SBL). However, these materials will no longer be locally available in Britain and Ireland respectively. Import of alternative sources of casing materials will increase costs.

Milled surface peat is widely available, cheaper, easier to transport, and under less environmental pressure than wet deep dug peat. However, increased use of milled peat and other materials in casing may have an impact on mushroom initiation, cropping and quality [1,2]. Selection of the optimum materials and blends will therefore be essential.

Although the casing layer has certain known requirements in terms of physical, chemical, and microbial properties [3,4], the definition of an optimum casing material in terms of mushroom yield and quality remains elusive.

The main problem with recycling spent mushroom compost (SMC) into new casing is the high salt content or electrical conductivity (EC) of the compost layer [5]. Equipment is now available for separating the casing layer from compost during emptying of SMC from shelves. Cooked-out and re-used casing could be used in new casing, and together with other by-products, may reduce reliance on peat and SBL, as well as enhancing casing properties such as mushroom initiation properties and disease suppression [6,7].

Good results have previously been obtained with fine grade composted bark, used granulated rockwool (mineral fibre), and clay by-products [8,9] but prevailing low prices of wet dug peat and SBL precluded further development as casing ingredients. Increases in landfill taxes have now made disposal of used rockwool slabs more expensive than granulating them for an alternative use. The price of SBL delivered on-site has increased due to reduced availability of supplies close to casing production. SBL is no longer produced in Ireland.

Changes to the casing material may require modified cultivation techniques such as pre-wetting, crop watering, rate of casing inoculum and crop airing. These factors need to be considered in the development and comparison of new casing materials.

Commercial Objectives

- Investigate new materials which can be beneficially added to casing to substitute wet-dug peat and SBL, and suppress diseases
- Compare a range of existing commercial casings based on wet deep-dug peat and SBL with new casing materials and blends in terms of mushroom crop husbandry, yield, and quality
- Explore the use of recycled casing, separated from the compost, as a component in new casing
- Conduct physical, chemical and microbial analyses on new and existing casing ingredients and blended mixes which relate to subsequent performance in terms of mushroom initiation, yield and quality

Materials and methods

Cropping procedure

Compost spawn-run with the strain A15 (Hooymans, Netherlands) was filled into plastic cropping trays (0.6 x 0.4 x 0.17[deep]) at 8 kg compost per tray. Caccing (spawn-run compost) was mixed into wetted casing materials at a rate of 2.3 kg/m^3. Casings were applied to trays to a depth of 40 mm. The trays were placed on the middle of three shelves at Oakfield Farm Products, Evesham, Worcestershire. The trays were watered after application, at two-day intervals until airing, after the first mushrooms were about 15 mm diameter, and after the first and second flushes of mushroom were picked. The water application in the initial mixing of the casings, and watering after application of the casings to the cropping trays was adjusted to maintain a moisture content of about 6% v/v below the water retention after drainage from saturation. The air in the cropping rooms was recirculated and the relative humidity maintained at 95-98% until mycelial growth in the casing layer had become established, 6-7 days after application. Fresh air was then introduced into the growing room and the relative humidity reduced to 88-91%.

Treatments

(a) Alternative materials

- (i) used granulated rockwool slabs (obtained from cucumber and tomato growers)
- (ii) multi-rolled filter cake (MRF) (obtained from UK Coal)
- (iii) wood fibre (obtained from Scotts/Everris)
- (iv) green waste compost (GWC), 6-9 months old (obtained from Organic Recycling ORL Ltd, Peterborough, and J. Moody Ltd, Wolverhampton).
- (v) recycled, cooked-out separated spent mushroom casing (SSMC) (obtained from Oakfield Farm Products)
- (vi) aged spruce bark fines (obtained from Lindum, Norway)
- (vii) filter-cake clay from a sand quarry dewatering plant (Marshalls, Rawtenstall, Lancashire)

(b) Peat-based casing types

The following commercial casing materials, consisting of blends of wet dug black and brown peats and 8-10% v/v SBL, were used:

- (i) Scotts/Everris (GB)
- (ii) McDon (Ireland)
- (iii) CNC (Netherlands)
- (iv) McArdle (Ireland)
- (v) Harte (Ireland)

(c) Inclusion rate (% v/v) of alternative materials:

- (i) 0 (all commercial casing materials)
- (ii) 12.5 (with Everris and McDon casings)
- (iii) 25 (with Everris and McDon casings)
- (iv) 50 (with Everris casing)

(d) Blends of 2-way and 3-way mixtures of alternative materials:

- (i) 12.5% rockwool, 12.5% MRF (with Everris and McDon casings)
- (ii) 12.5% rockwool, 25% MRF (with Everris casing)
- (iii) 12.5% rockwool, 12.5% SSC (with Everris casing)
- (iv) 12.5% rockwool, 12.5% GWC, ORL (with Everris casing)
- (v) 12.5% rockwool, 12.5% wood fibre, 25% MRF (with Everris casing)
- (vi) 12.5% rockwool, 12.5% GWC, 12.5% MRF (with Everris casing)

The above combinations of (a) peat casings (b) alternative materials (i) to (v) and (c) inclusion rates produced 30 factorial treatments, with a further six treatments (d) of 2- and 3-way blends. Four replicate crops of each of the 36 treatments were prepared. In each crop, a tray of each treatment and two cropping trays of the unamended Everris (control) treatment were prepared. In the fourth replicate crop, two additional alternative materials (vi) bark and (vii) filter-cake clay, were examined at 12.5% and 25% by volume with Everris casing, with two cropping trays of each treatment.

Mushrooms were picked with the veils closed at a diameter of 35–45 mm, over a 23 day period (three flushes) with the first flush being picked c. 17 days after the application of the casings.

Properties of casing materials

The following physical and chemical analyses were conducted on the peat + SBL casing samples and alternative materials before and after mixing: air filled porosity (AFP), compacted bulk density, pH and EC [4]. Air filled porosity was measured using two different methods, described in HDC report M 35. These are based on the volume of drainage water from a saturated sample, and on the fresh and dry weights of a saturated and drained sample, and a formula based on the density of organic matter in peat. The water holding capacity after free drainage in a ‘Campot’ test cylinder was determined according to HDC Report M 35. Water retention characteristics of peat, alternative materials and casing samples were determined using a method based on a water tension table constructed from Buchner funnels (Haynes apparatus) [4].

Pseudomonas spp. and total bacteria in the casing materials were determined by plating casing suspensions on selective media [10].

Farm Casing Trials

Casing trials were conducted with proportions of cooked-out spent recycled casing at two commercial tray mushroom farms: (A) G's Vegetables Haymes Farm, Cheltenham and (B) J Rothwell & Son, Little Hall Farm, Ormskirk. At each site, cooked-out trays without salt treatment of the casing were used for obtaining spent casing. Harte casing and the white spawn strain Sylvan A15 were used, and trays were cased to a depth of 50 mm. Three flushes of mushrooms were picked.

At Farm A, trays with surface area 2.3 m^2 were filled with 180 kg of Phase III Tunnel Tech compost. Spawn-run compost (caccing) was added to casing at a rate of 6.3 kg/m^3. Spent casing was added to fresh casing at rates of 0 (control), 12.5, 17.5 and 25% v/v. Two trays were cased with each treatment. Two stacks of fours trays contained one tray of each treatment in a randomised order.

At Farm B, trays with surface area 0.93 m^2 were filled with 90 kg of spawned Phase II compost. The trays were cased after a 16-day spawn run with casing containing either 0 (control) or 25% v/v spent recycled casing. The spent casing from 20 trays was sufficient to produce casing for 40 trays at an inclusion rate of 25% v/v mixed with new casing. Casing inoculum (CI) was added to casing at 2 $litres/m^3$. Thirty trays of each treatment were prepared with 15 trays of each treatment placed in two cropping rooms.

Results

Properties of peat types, alternative materials and mixed casing materials

Commercial peat-based casing materials

CNC, Harte and McDon casings had higher compacted bulk densities and lower air filled porosities than Everris and McArdle casings (Table 1). Air filled porosity based on drainage water was lower than that based on the fresh and dry weights of the drained casing samples. CNC and McDon casings had higher water holding capacities at saturation than the other commercial casings. At application to the trays, the gravimetric water contents of the commercial casings were 78.5 – 81%. McArdle casing had the lowest EC and Everris had the highest. All the casings had a pH of 7.5-7.8 (Appendix Table A1). Everris casing had a higher total bacterial population and a slightly higher Pseudomonad population than the other commercial casings (Table 1).

Table 1. Physical, chemical and microbial properties of commercial casing materials. Each value is the mean of four replicate samples

Casing	CNC	Everris	Harte	McArdle	McDon
CBD [a] g/L	727	602	733	587	727
AFP1 [b] %v/v	10.3	19.3	6.2	13.4	8.6
AFP2 [c] %v/v	12.5	23.3	13.4	18.5	12.5
Water capacity, % v/v	76.2	69.0	70.2	72.1	75.0
Moisture [d], % w/w	80.0	78.5	81.0	78.8	79.7
EC, uS/cm	207	297	172	98	138
pH	7.7	7.6	7.7	7.8	7.5
Total bacteria, cfu/g	3.0×10^6	2.1×10^7	7.2×10^6	3.2×10^6	3.1×10^6
Pseudomonads, cfu/g	3.8×10^5	6.1×10^5	3.9×10^5	4.0×10^5	3.9×10^5

[a] compacted bulk density
[b] air filled porosity based on drainage water from a 1 litre saturated sample
[c] air filled porosity based on the fresh and dry weights of a saturated and drained sample, and the dry bulk density of peat
[d] at application to cropping trays.

Effect of substitute materials on casing properties

The water release characteristics obtained from Buchner funnel (Haynes apparatus) tests of the peat and substitute materials are shown in Fig. 1. The curves show the decrease in volumetric water content as the matric potential was decreased i.e. as the suction pressure on the sample was increased. Under the same applied matric potential (suction pressure) wet dug peat had a higher volumetric moisture content than milled peat. At saturation (0 matric potential), peat and wood fibre contained >85% v/v water. However, as the matric potential of the samples was decreased (suction increased), wood fibre contained much less water than the peat samples. Conversely, SBL, MRF and green compost all contained less water than peat at saturation but contained similar or greater volumes of water under applied suction pressure. Used rockwool had similar water release characteristics to milled peat. The effects of adding different substitute materials to Everris peat + SBL casing at increasing proportions from 0 to 100% are shown in the Appendix (Fig. A1). When added to Everris peat + SBL casing, all the substitute materials reduced the volumetric moisture content of the casing at equivalent matric potentials (suctions). This effect was small for green waste compost and spent casing at inclusion rates up to 50%, and for wood fibre at inclusion rates up to 25%. The effect of adding 12.5% MRF and 12.5% used rockwool, individually or together, on the water release characteristics of Everris peat + SBL was also small or not detectable.

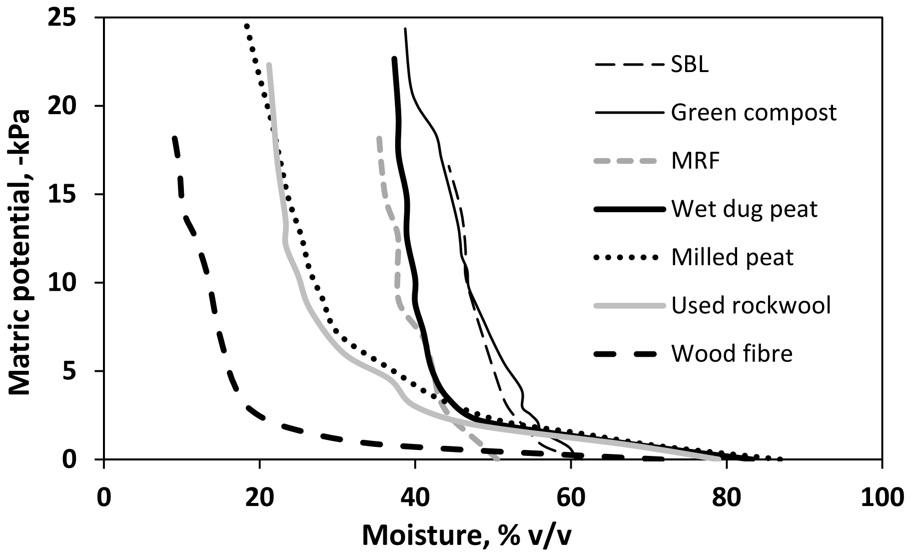

Fig. 1. Water desorption curves of different peat and alternative casing materials using a Haynes apparatus. Each curve is the mean of two replicate samples

Gravimetric moisture content of casing at application to cropping trays decreased with increasing proportion of substitute material. This effect was greatest for green compost and MRF and least for spent casing, wood fibre and bark (Table 2). Compacted bulk density of the casing was increased by the addition of green compost, MRF and used rockwool and decreased by the addition of wood fibre. Addition of spent casing at 25 or 50% slightly decreased the compacted bulk density of the casing (Table 3). Air filled porosity measured using both methods was decreased by addition of green compost, or MRF, unaffected by the addition of used rockwool, and increased by the addition of spent compost or wood fibre to casing (Tables 4 and 5). Volumetric water holding capacity of Everris casing was increased by the addition of 25% green compost but reduced by the addition of MRF, used rockwool, spent casing or wood fibre (Table 6). However, the moisture content of the casing at application to trays decreased with increasing volume of green compost (ORL or Moody) (Appendix Table A2).

All of the alternative materials except filter-cake clay increased the electrical conductivity of Everris casing; the largest increases were with green compost and MRF (Table 7). All of the substituted casings (up to 50% by volume) had pH values within the range 7.5 to 8.0 (Appendix Table A1).

The effect of addition of the two different sources of green compost, ORL and Moody, on the electrical conductivity and pH of Everris and McDon casings was similar (Appendix Table A3 and A4).

Addition of filter-cakes (MRF or sand filter-cake clay) to casing reduced the total bacterial population but did not affect the Pseudomonad population (Table 8). The Pseudomonad population of casing was increased by the addition of spent casing.

Physical and chemical properties of casings containing two- and three- way blends of alternative materials with Everris casing, including 12.5% used rockwool, are shown in Table 9. All the blends had higher compacted bulk densities, and with the exception of the blend containing wood fibre, lower air filled porosities than Everris casing (Table 9). Blends that contained green compost had higher water holding capacities than Everris casing whereas the other blends had lower water holding capacities. All the two- and three way blends had higher ECs, and with the exception of casing containing spent casing, higher pH vales than Everris casing.

Table 2. Gravimetric moisture content of Everris peat + SBL casing, and casings with proportions of different substitute materials at application to cropping trays. Each value is the mean of four replicate samples, or single samples of bark and filter-cake clay casings. LSD (*P* 0.05) = 2.1

Rate, % v/v	green compost	MRF	used rockwool	spent casing	wood fibre	bark	filter-cake clay
0	78.5	78.5	78.5	78.5	78.5	78.5	78.5
12.5	72.0	66.6	76.3	76.6	78.1	76.7	75.9
25	63.7	48.1	71.4	75.9	77.5	76.2	–
50	50.0	43.6	67.9	71.6	74.7	–	–

Table 3. Effect of substitution of Everris peat + SBL casing with proportions of different materials on compacted bulk density, g/L. Each value is the mean of four replicate samples, or single samples of bark and filter-cake clay casing. LSD (*P* 0.05) = 15

Rate, % v/v	green compost	MRF	used rockwool	spent casing	wood fibre	bark	filter-cake clay
0	602	602	602	602	602	602	602
12.5	669	723	614	609	578	661	680
25	747	746	652	581	558	639	–
50	763	824	683	578	508	–	–

Table 4. Effect of substitution of Everris peat-based casing with proportions of different materials on air filled porosity based on drainage water from a saturated sample, %v/v. Each value is the mean of four replicate samples, or single samples of bark and filter-cake clay casings. LSD (*P* 0.05) = 1.2

Rate, % v/v	green compost	MRF	used rockwool	spent casing	wood fibre	bark	filter-cake clay
0	19.3	19.3	19.3	19.3	19.3	19.3	19.3
12.5	15.8	15.4	19.4	19.0	18.9	19.0	18.1
25	13.5	15.4	19.5	20.3	27.1	22.0	–
50	12.7	15.0	19.3	22.9	31.6	–	–

Table 5. Effect of substitution of Everris peat-based casing with proportions of different materials on air filled porosity based on the fresh and dry weights of saturated and drained samples, %v/v. Each value is the mean of four replicate samples, or single samples of bark and filter-cake clay casings. LSD (*P* 0.05) = 1.3

Rate, % v/v	green compost	MRF	used rockwool	spent casing	wood fibre	bark	filter-cake clay
0	23.3	23.3	23.3	23.3	23.3	23.3	23.3
12.5	16.7	22.4	22.5	22.9	23.5	22.5	20.4
25	13.9	21.1	23.8	24.9	31.0	25.8	–
50	12.2	17.7	23.0	28.8	33.7	–	–

Table 6. Effect of substitution of Everris peat-based casing with proportions of different materials on volumetric water holding capacity, %. Each value is the mean of four replicate samples, or single samples of bark and filter-cake clay casings. LSD (*P* 0.05) = 1.7

Rate, % v/v	green compost	MRF	used rockwool	spent casing	wood fibre	bark	filter-cake clay
0	69.0	69.0	69.0	69.0	69.0	69.0	69.0
12.5	70.8	68.0	68.4	68.5	68.0	68.1	69.3
25	74.8	60.3	64.7	66.2	60.4	64.5	–
50	73.5	54.3	64.0	61.0	57.1	–	–

Table 7. Effect of substitution of Everris peat-based casing with proportions of different materials on electrical conductivity (µS/cm). Each value is the mean of four replicate samples, or single samples of bark and filter-cake clay casings. LSD (*P* 0.05) = 19

Rate % v/v	green compost	MRF	used rockwool	spent casing	wood fibre	bark	filter-cake clay
0	297	297	297	297	297	297	297
12.5	302	412	298	370	465	280	230
25	675	847	457	499	478	280	–
50	1017	945	523	728	508	–	–

Table 8. Effect of substitution of Everris peat-based casing with 25% v/v of different materials on populations of total bacteria and Pseudomonads (cfu x 10^5 /g casing). Each value is the mean of three replicate samples

Material	Everris casing	MRF	used rockwool	spent casing	wood fibre	bark	filter-cake clay*	LSD (*P* 0.05)
Total bacteria	210	69	220	170	168	150	67	21
Pseudomonads	6.1	6.9	8.4	15.0	6.0	4.9	12.0	1.2

* single replicate at 12.5% v/v

Table 9. Physical and chemical properties of two- and three-way peat substitute mixes containing Everris casing and 12.5 %v/v used rockwool. Each value is the mean of four replicate samples

Ingredient A Rate, %v/v	spent casing 12.5	MRF 25	compost 12.5	MRF 12.5	MRF 25	MRF 12.5
Ingredient B Rate, % v/v	–	–	–	–	wood fibre 12.5	compost 12.5
CBD [a] g/L	671	719	719	821	810	793
AFP1 [b] %v/v	17.2	15.3	11.5	14.2	28.3	12.2
AFP2 [c] %v/v	22.8	22.3	10.1	19.5	30.3	11.8
Water capacity, %	67.0	59.7	78.8	65.2	51.7	77.1
Moisture [d], %	76.1	52.4	68.7	64.6	53.2	55.1
EC, uS/cm	360	835	494	469	833	591
pH	7.7	8.1	8.0	8.1	8.1	8.1

[a] compacted bulk density
[b] air filled porosity based on drainage water from a 1 litre saturated sample
[c] air filled porosity based on the fresh and dry weights of a saturated and drained sample, and the dry bulk density of peat
[d] at application to cropping trays

Mushroom cropping

Commercial peat-based casing materials

Under the cropping conditions of the experiments, and without the addition of any alternative materials, mushroom yields were higher from the McArdle and McDon peat + SBL casings than from the CNC, Harte and Everris casings (Fig. 2).

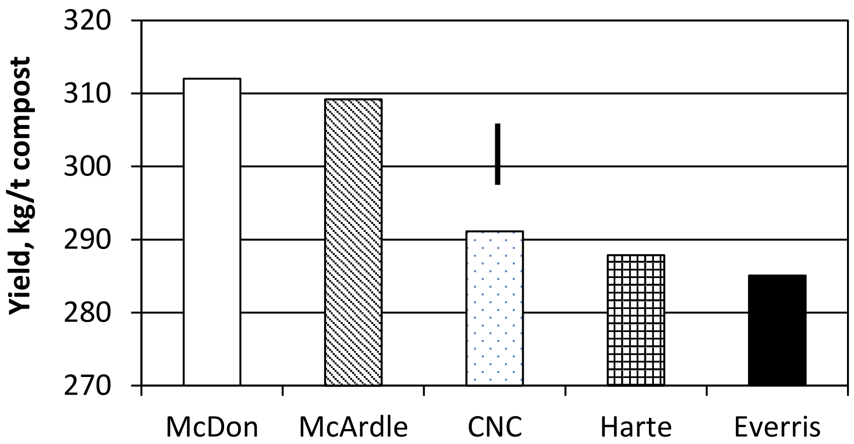

Fig. 2. Mushroom yields from commercial peat and SBL casing mixes. Each value is the mean of four replicate crops. Bar represents LSD, $P = 0.05$

Effect of substitute materials on mushroom cropping

Inclusion of separated spent casing (SSC) or MRF at 12.5% in Everris casing slightly increased mushroom yield (Fig. 3). Filter-cake clay at 12.5% (yield 322 kg/t compost) or bark at 12.5 and 25% (337 kg/t compost) also increased mushroom yield compared with a yield of 286 kg/t compost from the Everris casing. However, the latter two materials were only examined in a single replicate crop. Inclusion of MRF, used rockwool or green compost at 25% did not affect average yield compared with the unamended Everris control casing (Fig. 3). However, results with the green compost were variable, with individual replicate crops showing yield benefits and deficits compared with the control treatment (results not shown). All the materials at 50% v/v and SSC and woodfibre at 25% v/v in casing reduced yield compared with the unamended Everris peat + SBL control treatment.

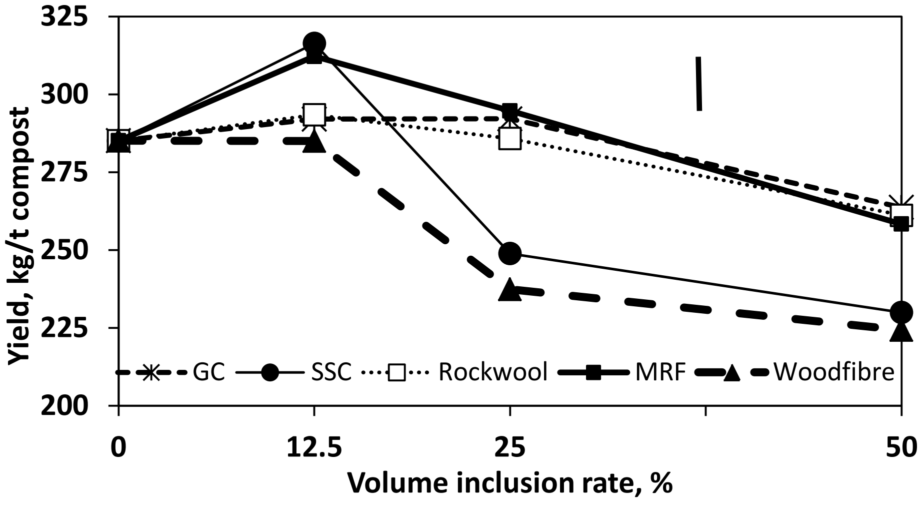

Fig. 3. Effect of inclusion of various substitute materials at different rates in Everris peat + SBL casing on mushroom yield. Each value is the mean of four replicate crops. Bar represents LSD, $P = 0.05$

Adding green compost to Everris or McDon casings generally reduced mushroom yield in proportion to the inclusion rate (Fig. 4). The exception was green compost from ORL added to Everris casing. However, as explained previously, the relative difference in mushroom yield between this combination treatment and the control treatment was also variable between replicate crops.

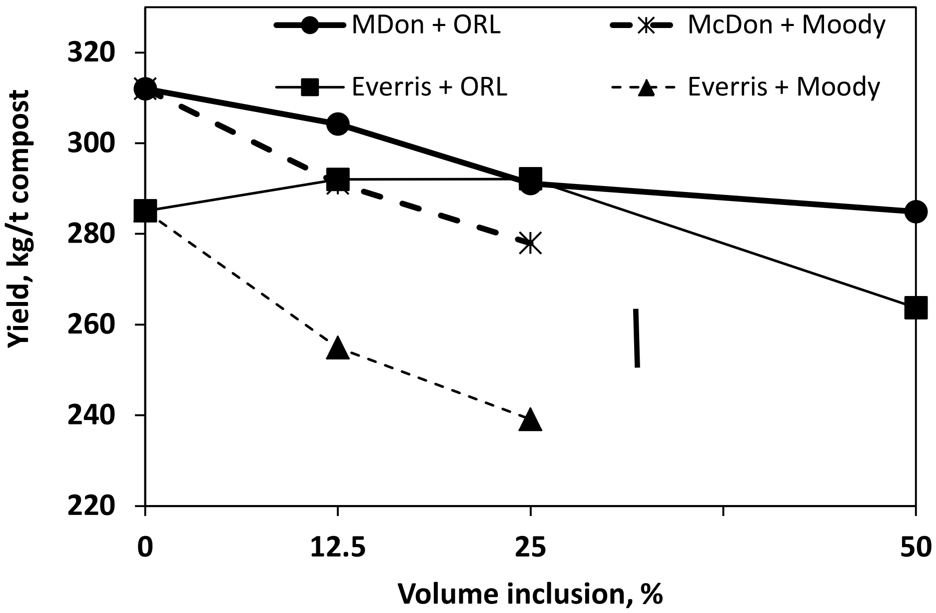

Fig. 4. Effect of inclusion of two sources of green compost (ORL or Moody) at different rates in Everris and McDon peat + SBL casings on mushroom yield. Each value is the mean of four replicate crops. Bar represents LSD, P = 0.05.

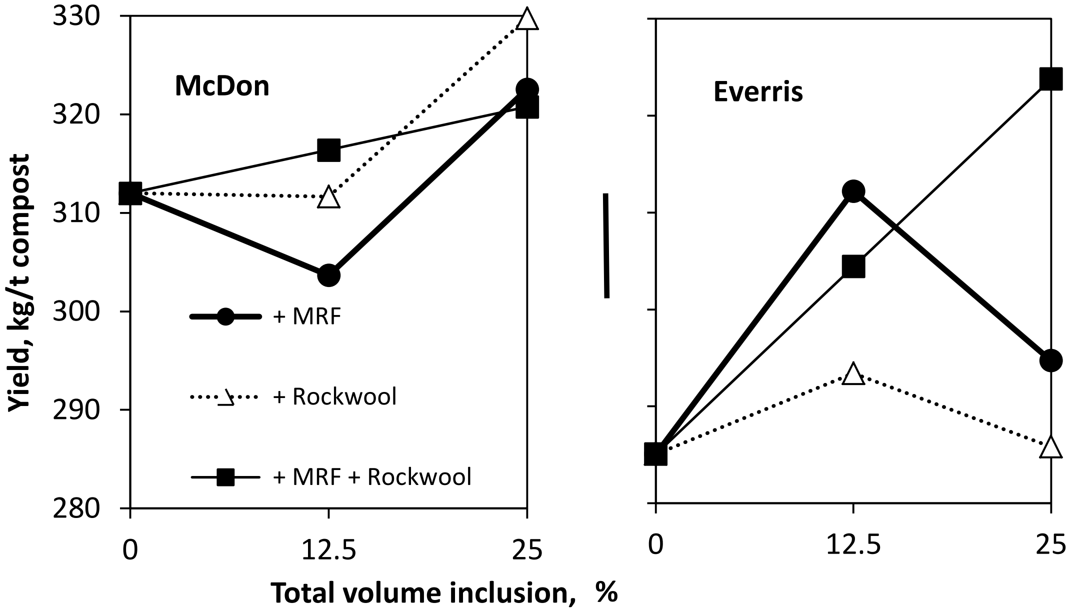

Fig. 5. Effect of inclusion of 12.5% MRF and/or 12.5% used rockwool in McDon and Everris peat + SBL casings on mushroom yield. Each value is the mean of four replicate crops. Bar represents LSD, P = 0.05.

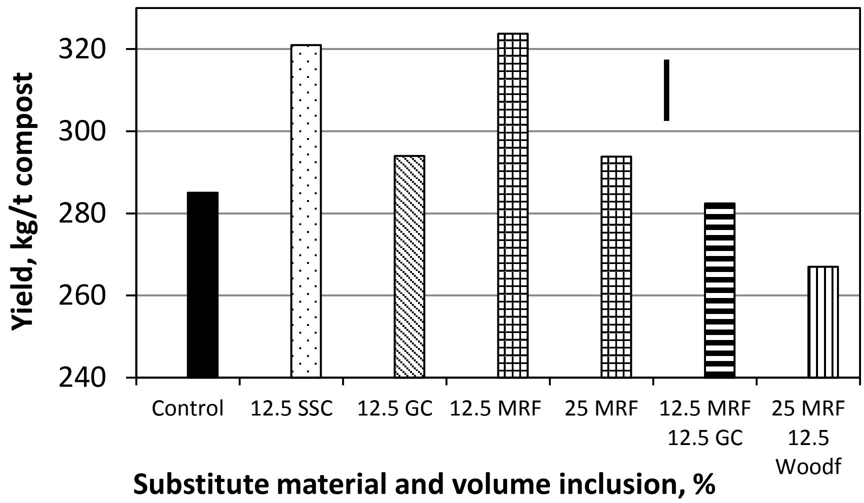

Fig. 6. Effect of inclusion of separated spent casing, green compost and MRF at different rates in Everris peat + SBL + 12.5% rockwool casings on mushroom yield. Each value is the mean of four replicate crops. Bar represents LSD, *P* = 0.05.

Substitution of McDon casing with 12.5% by volume of MRF and/or 12.5% rockwool had a small positive effect on mushroom yield compared with the unamended casing (Fig. 5). With Everris casing, MRF or rockwool at 25% v/v had no effect on mushroom yield, although the combined MRF + rockwool (12.5% v/v of each material) performed better than the individual substitution treatments or the unamended control.

Mushroom yields from Everris peat + SBL casings containing 12.5% rockwool in two- and three-way blends of substitute materials are shown in Fig. 6. The highest yields were obtained from casings containing 12.5% rockwool with either 12.5% spent casing or MRF which were both higher yielding than the unamended control casing.

Relationships between casing properties and mushroom cropping

Relationships between the physical properties of casings materials (commercial peat + SBL casings with and without proportions of substitute materials) and the yield of mushrooms obtained were examined. These properties were: air filled porosity measured from (1) drainage water and (2) fresh and dry weights of a saturated drained sample, volumetric water retentions at matric potentials from 0 to 20 kPa, and compacted bulk density. Similarly, relationships between chemical properties of casings (pH and electric conductivity) and mushroom yield were also examined.

Of all the measured physical properties of casing materials, AFP (method 2) had the closest relationship with mushroom yield (Fig. 7). This parameter accounted for 50% of the variability in mushroom yield. The fitted regression line indicated that the optimum AFP in terms of mushroom yield was 19 ±4%. Several other physical properties were also significantly correlated with mushroom yield, although they accounted for smaller percentages of variability in yield than AFP (method 2). These properties, with their respective percentages, were AFP method 1 (35.3%), water retention after drainage (43.5%), and compacted bulk density (48.5%). These parameters are inter-correlated so that a multi-variate regression does not explain more of the variation in mushroom yield. Of the five commercial casings, McArdle and McDon casings had AFP values closest to the centre of the optimum range in AFP; the Everris casing had a higher AFP value and the CNC and Harte casings had a lower AFP value than the other commercial casings.

An optimum AFP value indicates that both gas exchange (higher AFP values) and water holding capacity (lower AFP values) are important for achieving high mushroom yields.

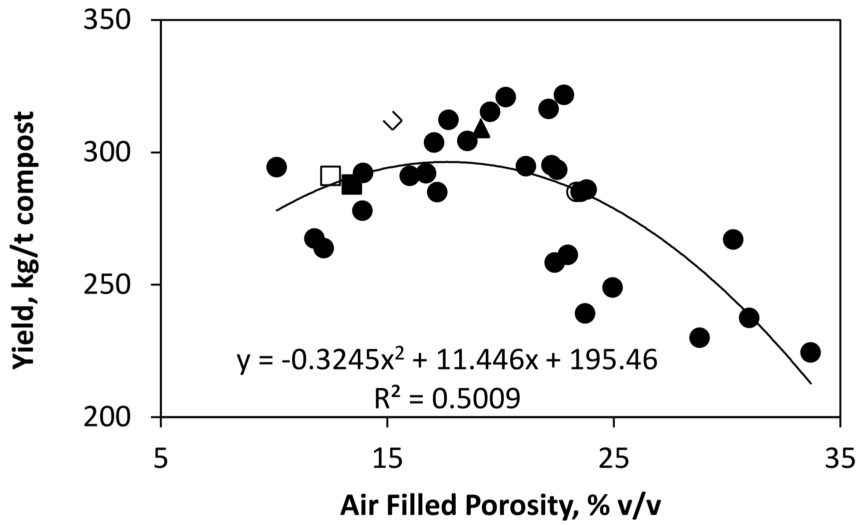

Fig. 7. Relationship between the air filled porosity of different casing materials and mushroom yield. Each value is the mean of four replicate crops. Commercial peat + SBL casings are indicated by: Everris ○; Harte □; McDon ◊; McArdle ▲;CNC ■

There was no significant relationship between casing pH (mean = 7.78 ± 0.37) and mushroom yield. Although there was a negative trend for the effect of electrical conductivity on mushroom yield, the relationship was not statistically significant (Fig. 8). However, the ten casing materials that produced the highest mushroom yields all had an EC below 600 µS/cm, and all of the casings with an EC greater than 600 µS/cm produced a mushroom yield of <300 kg/t compost.

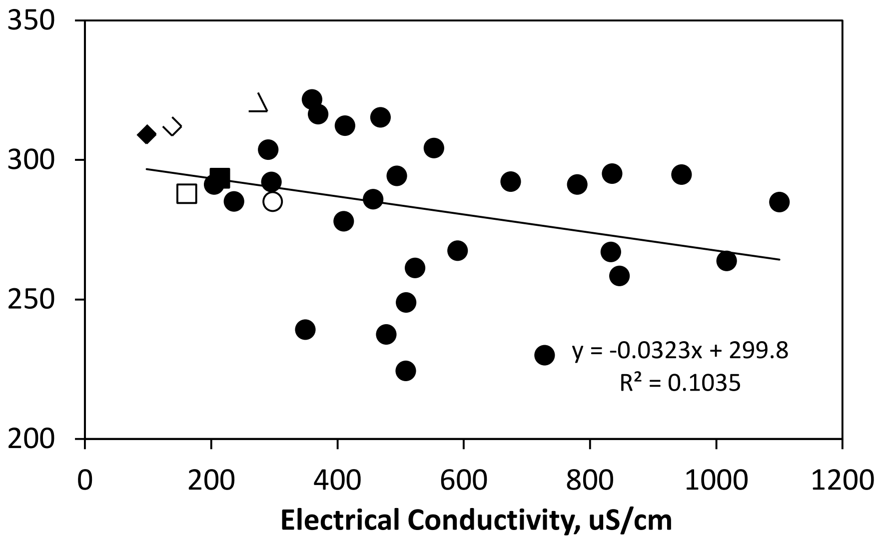

Fig. 8. Relationship between the electrical conductivity of different casing materials and mushroom yield. Each value is the mean of four replicate crops. Commercial peat + SBL casings are indicated by: Everris ○; Harte □; McDon ◊; McArdle ▲;CNC ■

Farm casing trials

Casing properties

There were no significant differences in pH between new Harte casing, the spent casing or any of the new + spent casing blends (7.5 ± 0.1). The electrical conductivity of the spent casings were higher than those of the new casings; the EC of the casings containing proportions of spent casing were also slightly higher than those of new casings (Table 10). The moisture content of casing at application to trays at Farm A (82.7 ± 0.9 %w/w) was higher than at Farm B (78.2 ± 0.5 %w/w) but was not significantly affected by the addition of spent casing.

Table 10. Effect of proportion of spent casing to new Harte casing on electrical conductivity. Each value is the mean of three replicate samples

%v/v Spent casing	**0 (control)**	**12.5**	**17.5**	**25**	**100**	**LSD (*P* 0.05)**
Farm A	247	423	413	470	950	21
Farm B	229	–	–	393	857	20

Mushroom cropping

At both farms, addition of spent casing to new casing resulted in a small amount of whisker mold on the casing by the time of airing. However, this had disappeared by the time of the first flush. There was no effect on disease incidence of the spent casing addition at either farm. The addition of spent casing to new casing did not significantly affect mushroom yield at either farm (Table 11).

Table 11. Effect of addition of spent Harte casing to new Harte casing on mushroom yield in three flushes, kg/m^2. Phase II and III composts were used in Farms A and B respectively

%v/v Spent casing	0 (control)	12.5	17.5	25	LSD (*P* 0.05)
Farm A	25.5	25.9	26.5	25.5	1.9
Farm B	24.0	–	–	24.4	1.6

Conclusions

- Several peat alternative materials were identified which increased mushroom yield from Everris peat + SBL casing when added to casing at 12.5% by volume in small tray experiments: MRF, filter-cake clay, spent casing and bark. Used rockwool and MRF, when both added to peat + SBL at 12.5%, increased mushroom yield to a greater extent than the individual materials
- When used at 25% by volume in Everris casing, the effect of the above materials on mushroom yield was not significant, except spent casing which slightly reduced yield in small tray experiments
- In two farm trials, addition of spent casing at 25% by volume in Harte casing did not affect mushroom yield
- The effects of adding green waste compost to casing on mushroom yield were variable.
- Wood fibre reduced mushroom yield when added at more than 12.5% by volume to casing
- Under the cropping conditions of the experiments, and without the addition of any alternative materials, mushroom yields were higher from the McArdle and McDon peat + SBL casings than from the CNC, Harte and Everris casings
- A relationship was identified between the air-filled porosity (AFP) of casing materials and mushroom yield. The optimum casing AFP in terms of mushroom yield was 19 ± 4%

- There was a trend for casing materials with an EC of <600 µS/cm to produce higher mushroom yields than casings with an EC of >600 µS/cm
- Adding substitute materials to commercial peat + SBL casing reduced the volumetric moisture content of the casing at equivalent matric potentials (suctions). This effect was small for green waste compost and spent casing at inclusion rates up to 50%, and for wood fibre at inclusion rates up to 25%. The effect of adding 12.5% MRF and 12.5% used rockwool, individually or together, on the water release characteristics of Everris peat + SBL was also small or not detectable
- All of the alternative materials except filter-cake clay increased the electrical conductivity of Everris casing; the largest increases were with green compost and MRF

Glossary

AFP Air-filled porosity
EC Electrical conductivity
MRF Multi-roll filter cake, a clay-like product from the coal industry
ORL Organic Recycling Ltd, green waste compost producer
SBL sugar beet lime
SMC spent mushroom compost, a mixture of used casing and compost
SSC separated spent casing

Technology transfer

R. Noble. Presentation on Peat Alternatives in Casing at All-Ireland Mushroom Conference, Co. Monaghan, November 2011.
Noble R (2012) Peat substitution in mushroom casing. HDC Brochure on Peat Substitution.

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APPENDIX

Table A1. Effect of substitution of Everris peat-based casing with proportions of different materials on pH. Each value is the mean of four replicate samples except filter-cake clay casing

Rate % v/v	green compost	MRF	used rockwool	spent casing	wood fibre	bark	filter-cake clay
0	7.6	7.6	7.6	7.6	7.6		7.6
12.5	8.0	7.8	8.0	7.5	7.7		7.5
25	7.9	7.9	7.9	7.7	7.7		–
50	7.9	7.9	7.9	7.6	7.7	–	–

Table A2. Gravimetric moisture content (% w/w) of Everris and McDon casings substituted with two sources of green composts at different rates. Each value is the mean of four samples

Green compost	None		ORL		Moody
Rate, % v/v	0	12.5	25	50	25
Everris casing	78.5	72.0	63.7	50.0	71.2
McDon casing	79.7	70.1	69.8	62.2	71.5

Table A3. Electrical conductivity (µS/cm) of Everris and McDon casings substituted with two sources of green composts at different rates. Each value is the mean of four samples

Green compost	None		ORL		Moody
Rate, % v/v	0	12.5	25	50	25
Everris casing	29	302	675	1017	349
McDon casing	138	553	780	1388	410

Table A4. pH of Everris and McDon casings substituted with two sources of green composts at different rates. Each value is the mean of four samples

Green compost	None		ORL		Moody
Rate, % v/v	0	12.5	25	50	25
Everris casing	7.6	8.0	7.9	7.9	8.1
McDon casing	7.5	7.5	7.5	7.5	7.8

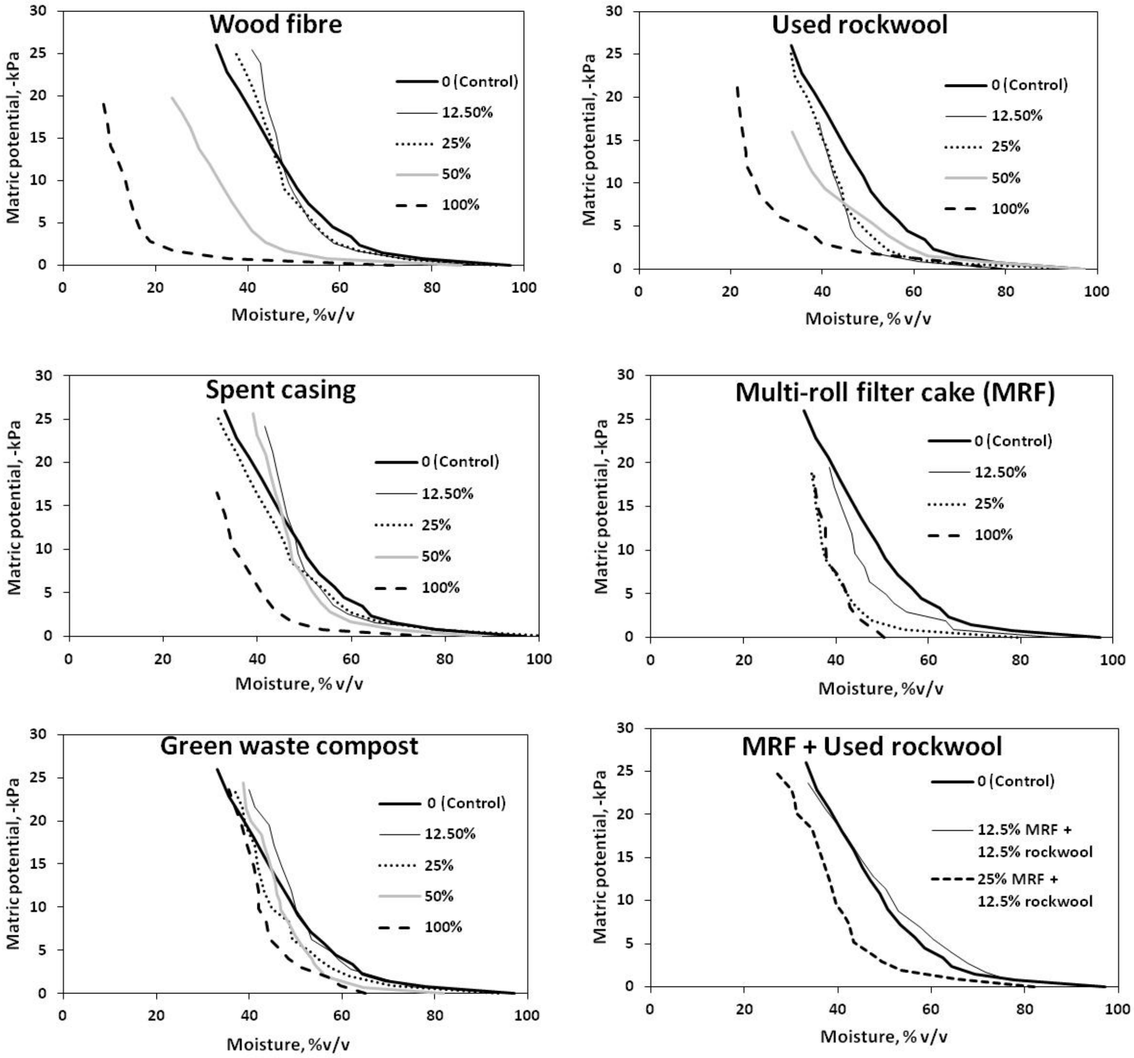

Fig. A1. Effect of substitution of Everris peat + SBL casing with different materials at increasing rates from 0 to 100% v/v/ on water release curves. Each fitted curve is the mean of two replicate samples of casing or ingredient material