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PRACTICAL SECTION FOR GROWERS

Background and Objectives

About a quarter of a million cubic metres of peat are used annually in Britain for mushroom casing. There has been periodic environmental pressure on the horticultural industry to reduce the usage of peat. Allied to this is the increasingly broad interpretation of 'organic' production. A further benefit of peat substitution could be a more consistent and manageable casing, producing cleaner mushrooms than peat, which is potentially very soiling.

Peat alternatives

In previous experiments, a range of materials and by-products were examined as peat alternatives in casing. When used as 100% replacements, none of the materials produced mushroom yields equivalent to peat casing. However, a number of low-cost materials were identified which had potential for partial substitution of peat in casing. These included coconut fibre waste from matting production (coir), fine grade composted bark, granulated used rockwool (mineral fibre) slabs and paper sludge wastes.

Peat substitution

An experiment was set up with the most promising materials (two types of coir, composted bark, mineral fibre waste and paper sludge waste) used to substitute peat in casing at 12.5, 25 and 50% by volume, with peat casing used as a control. Two types of peat and two watering regimes were used. Sugar beet lime was used in all the casings at 10% v/v.

The effects of peat substitution on mushroom yield, dry matter content and cleanness were recorded.

Summary of Results

- Fine grade composted bark used at 25% by volume resulted in a significantly higher mushroom yield than the peat control treatment (see Figure on next page)
- Substitution of peat by 12.5 or 50% with bark, or by up to 50% with coir or mineral fibre waste did not significantly affect mushroom yield
- Paper sludge waste reduced mushroom yield at all rates used
- Substitution of peat at up to 50% with bark fines, coir, paper sludge waste or mineral fibre waste did not affect mushroom dry matter or cleanness
- Substitution of peat at up to 50% with bark fines, horticultural coir or mineral fibre waste did not affect mushroom size
- Similar watering regimes could be used for peat casing and 50% peat substitute casings.

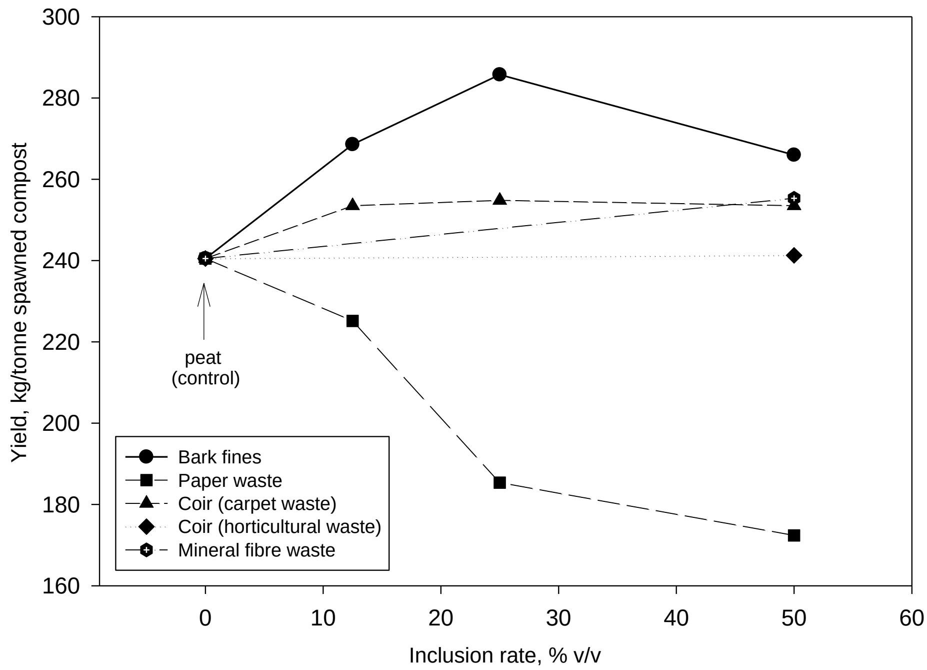
Action Points for Growers

Of the materials tested, the most promising peat substitute was composted bark fines. The material could be added at 25% v/v, resulting in a small increase in mushroom yield without affecting mushroom dry matter or cleanness. Bark fines could be used at up 50% v/v without adversely affecting mushroom yield or quality. Coir and mineral fibre waste can also be used to substitute up to 50% of peat without adversely affecting mushroom yield or quality. Paper sludge wastes are not suitable for peat substitution in casing due to a negative effect on mushroom yield.

Practical and Financial Benefits to the Industry

The work has shown that several materials can be used to substitute peat in mushroom casing, without adverse effects to cropping. The use of composted bark fines should be tested on commercial farms. Around 120,000 cubic metres of bark fines are produced annually in the UK. About 60,000 cubic metres would be needed to satisfy the whole of the UK mushroom casing market, if used at 25% by volume. The availability of this 'environmentally green' material will be useful to the industry in the face of environmental pressure on peat extraction. Bark fines are cheaper than casing peat (about £10 per cubic metre compared with £35 per cubic metre for wet dug peat). A 25% by volume bark fines casing should therefore be cheaper than a 100% peat casing.

Effect of peat substitution with different materials at different rates on mushroom yield; brown peat, wet watering treatment.



SCIENCE SECTION

1. INTRODUCTION

About 250,000 m^3 of peat are used annually in Britain for mushroom casing. Peat replaced soil for this purpose about 50 years ago. Since that time the type of peat has changed, from milled light brown sphagnum to deep dug, wet black peats. There has been periodic pressure on the horticultural industry to reduce the usage of peat, particularly from environmental groups and multiple retailers. Allied to this is the increasingly broad interpretation of 'organic' production.

In recent years, work has been conducted in Belgium, Germany, the Netherlands, UK and elsewhere in searching for alternative materials. These have included vermiculite, lignite, spruce bark, composted waste paper, flocculated rockwool, re-used spent mushroom compost, as well as several other alternative materials (HRI unpublished commercial contracts; Allen 1976; Overstijns et al, 1988; Visscher, 1988; Noble & Gaze, 1995; Dergham & Lelley, 1995; Szmidt,1995; Poppe, 2000). However, no further improved materials or replacements for peat have been identified.

Tests at HRI have shown that partial substitution of peat is more promising than complete replacement (MAFF Project HH1301SMU). A number of potential materials have been identified which satisfy the initial requirements of availability and cost. These are:

- Waste granulated mineral fibre slabs. In Britain about 450 ha of glasshouse production uses rockwool (mineral fibre) slabs which produce a potential 11,000 m^3 of granulated waste.
- Composted fines bark. An estimated 700,000 m^3 of conifer and broadleaf bark (around 90% is spruce bark) is harvested annually. A significant proportion (about 15%) is composted fines material, which has a higher water holding capacity than other bark products.
- Waste paper sludge from newsprint manufacture. Annual production is in excess of 100,000 tonnes/annum.
- Specific sources of coconut waste (coir). There are stockpiles of several million cubic metres in the Far East. In addition, there are sources of coir in the UK from coconut matting production. Preliminary tests at HRI have shown significant differences in the suitability of different sources of coir for use in casing.

Objectives

To compare peat casing materials variously substituted by alternative materials in different proportions, under two watering management regimes, with regard to mushroom yield, quality and timing.

2. MATERIALS AND METHODS

2.1 *Experimental work*

HRI Formula 3 compost (Noble et al, 1998) was spawned with the strain A15 and filled into wooden cropping trays (0.9 x 0.6 x 0.2[deep]) at 50 kg compost per tray (48 kg spawn-run compost per tray). Sugar beet lime (SBL) was mixed at 10% by volume in the casing. The casing water tension (matric potential) treatments in the experiment were maintained by adjusting the water application in the initial mixing of the casings, and by adjusting watering after application of the casings to the cropping trays. 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, 6-8 days after application. Fresh air was then introduced into the growing room and the relative humidity reduced.

Treatments

(a) Alternative materials
- (i) waste granulated mineral fibre (supplied by Cultilene UK Ltd)
- (ii) composted bark fines, predominantly spruce bark (supplied by Melcourt Industries Ltd)
- (iii) paper sludge waste (supplied by Headland Agrochemicals Ltd)
- (iv) coir - horticultural grade (supplied by Marson Biocare Ltd, Bombay, India)
- (v) coir - carpet matting production waste (supplied by Rawtex Ltd)

(b) Inclusion rate
(i) 0% (control) (ii) 12.5% (iii) 25% (iv) 50%

(c) Peat type
(i) Black wet-dug bulk (ii) Brown wet-dug bulk

(d) Casing water tension (matric potentials)
- (i) - 9 kPa (control, 'normal' moisture)
- (ii) - 4 kPa (wetter than control)

(e) Blends of 3-way mixtures (1:1:1), all with brown peat and the normal casing moisture treatment
- (i) peat: coir: bark
- (ii) peat: coir: paper sludge
- (iii) peat: bark: paper sludge

Treatments (a) to (d) were set out in a cropping room in 4 x 4 x 2 x 2 (x 2 replicates) factorial design, i.e. only the smallest interactions had 2 replicates, main treatments (a) to (d) had 32 replicates. The design was verified by HRI Biometrics Department. There were four trays each of the additional 3-way mixture treatments (e).

Measurements
- (i) Total yield and proportion in size grades (small and large buttons, open mushrooms, and waste). Where possible, mushrooms were picked with the veils closed at a diameter of 35 – 45 mm, over a 23 day period (3 flushes) with the first flush being picked *c.* 17 days after the application of the casing. On some treatments, due to overcrowding of mushrooms or premature opening, mushrooms had to be picked with a smaller diameter or with the veils open.
- (ii) Mushroom dry matter content (Burton & Noble, 1993)
- (iii) Mushroom cleanness on 0-5 scale (Noble et al, 1999)
- (iv) Casing moisture content at application and throughout cropping.

2.2 *Properties of peat types and casing soils*

The following physical and chemical analyses were conducted on the peat and casing samples before and after use for mushroom culture: air filled porosity (AFP), bulk density, pH and EC (Noble et al, 1999). Air filled porosity was measured using two different methods, described in HDC report M35. These are based on the volume of drainage water from a saturated sample, and on a formula based on the density of organic matter in peat. Ash and dry bulk density determinations were also conducted on the peat samples. Water retention characteristics of peat and casing samples were determined using a modified method from Noble et al (1999), based on a water tension table constructed from Bucnher funnels.

3. RESULTS

3.1 *Properties of peat types, alternative materials and mixed casing materials*

Properties of the peat types and alternative materials are shown in Table 1. The brown peat had the lowest pH. The black peat, bark fines and carpet waste coir were slightly acidic. The paper waste, mineral fibre waste and horticultural coir were slightly alkaline. The mineral fibre waste and two types of coir had significantly higher conductivities than the other materials.

Peat and horticultural coir had lower air filled porosity (AFP, measured with the two different methods) than the other materials. Paper waste had the highest air filled porosity. Peat and paper waste had the highest compacted bulk densities. Carpet waste coir had the lowest density before wetting. The water retentions of peat and coir were higher than those of the other materials. Mineral fibre waste had the lowest water retention.

Water release curves of the materials are shown in Figs. 1 and 2. The black peat and horticultural coir had the same water release characteristics (Fig. 1). Carpet waste coir and mineral fibre waste both released more water under applied tension than black peat (Figs. 1 and 2). The paper waste and bark fines both released less water than black peat (Fig.2)

The pH and conductivity of the mixed casing materials are shown in Table 3. The values shown are for peat or 50:50 peat: substitute blends, with SBL added at 10% v/v. Values are shown for materials before and after use in the cropping experiment. Before use, 50% carpet waste coir casing had a higher pH than the other casing mixes (Table 2). After cropping, the pH of all the 50% substitute mixes was slightly higher than the pH of the peat casings. The conductivity of the 50% substitute mixes was higher than that of peat casings, before and after cropping.

The physical properties of the casing materials are shown in Table 3. Before use, the peat casings had a lower AFP than the 50% substitute mixes, except horticultural coir casing, which had a lower AFP based on the drainage water method, but a higher relative value based on the formula method. After cropping the 50% carpet waste coir casing had the lowest AFP based on either method. The compacted bulk density of the 50% paper waste and 50% mineral fibre waste casings were higher than those of the other materials.

The water retentions of the 50% bark fines, paper waste or mineral fibre waste casings were lower than those of the other casing mixes, both before and after cropping (Table 3). Water release curves of the casing mixes are shown in Figs. 3 and 4. The water release curves of the different casing mixes were similar, except for the 50% carpet waste coir casing, which released more water under applied tensions. Moisture levels on trays during cropping are shown in Figs. 5 and 6. The moisture content of the peat and 50% coir casings were higher than those of the 50% bark fines, mineral fibre and paper waste casings. The black peat casings had a higher moisture content during cropping than the brown peat casings (about 3% higher moisture content). The wet treatment had, on average, a 3% higher casing moisture content than the normal watering treatment (Figs. 5 & 6).

3.2 *Effect of treatments on mushroom yield*

The effects of substitution of peat in casing with different materials and inclusion rates are shown in Fig. 7. Substitution of peat with paper sludge waste significantly (P<0.001) reduced yield, with the yield decrease proportional to the inclusion rate. Substitution of peat with coir (horticultural or carpet waste) or mineral fibre waste at rates up to 50% v/v did not significantly affect yield. Substitution of peat with bark fines at 25% v/v resulted in a small but significant increase in mushroom yield. Mushroom yields from 12.5 and 50% bark fines casings were not significantly different to those from the peat casing.

A comparison of mushroom yields from peat casing and 50% peat substitution casing is shown in Fig. 8. The only significant effect is the reduction in yield from the 50% paper waste casing.

The brown peat casing produced a higher mushroom yield than the black peat casing, and all the peat substitutes produced higher yields with the brown peat than with the black peat. The wetter casing regime produced a higher mushroom yield for all the brown peat casing mixes, but watering regime did not significantly affect yield for the black peat casing mixes. Yields from the 3-way mixes (66% peat substitution) were slightly lower than from the 50% substitute mixes.

3.3 *Effect of treatments on mushroom size*

Mushroom size grades from the different peat substitute mixes are shown in Fig. 9. The proportion of waste mushrooms was less than 1% from all the treatments. The 50% carpet waste coir and paper waste casings produced greater proportions of open mushrooms than the other treatments; the carpet waste coir also produced a greater proportion of small mushrooms than the other treatments. There were no differences in the proportions of mushroom size grades between the peat casing and the bark fines, mineral fibre or horticultural coir substitute casings, at any of the inclusion rates.

3.4 *Mushroom dry matter content*

The effects of peat substitution with different materials and at different rates on mushroom dry matter content are shown in Figs. 10 and 11. Substitution of peat with coir or bark fines, at up to 50% v/v did not significantly affect mushroom dry matter content. Substitution of peat with paper waste or mineral fibre waste at 50% v/v resulted in a small increase in dry matter content (significant at P<0.05).

There were no significant effects of peat type or watering treatment on mushroom dry matter content.

3.5 *Mushroom cleanness*

The effects of peat substitution on mushroom cleanness are shown in Figs. 12 and 13. Substitution of peat with 50% mineral fibre waste significantly improved mushroom cleanness. None of the other materials significantly affected mushroom cleanness at any of the rates used. There was no significant difference in cleanness between the peat types or watering treatments.

4. CONCLUSIONS

1. Fine grade composted bark used at 25% v/v resulted in a significantly higher mushroom yield than the peat control treatment.
2. Substitution of peat by 12.5 or 50% v/v with bark, or by up to 50% v/v with coir or mineral fibre waste did not significantly affect mushroom yield, but paper sludge waste reduced yield at all rates used.
3. Substitution of peat at up to 50% v/v with coir or bark did not significantly affect mushroom dry matter content or cleanness. Substitution with 50% mineral fibre waste resulted in small increases in dry matter content and cleanness quality.
4. Substitution of peat with bark fines, horticultural coir or mineral fibre waste did not affect the proportions of mushroom size grades. Substitution of peat with 50% carpet waste coir or paper waste increased the proportion of open mushrooms.
5. Similar watering regimes could be used for peat and 50% peat substitute casings.
6. There were significant differences in air and water holding characteristics of peat and the five alternative materials used. However, differences in properties between peat casings and 50% substitute casing mixes (with sugar beet lime added) were small.
7. There were no relationships between the chemical or physical properties of the peat sources and peat substitutes and their performance in terms of mushroom yield.
8. The best performing peat substitute mix (25 % v/v bark fines) slightly reduced the water retention but increased the air filled porosity of the casing, compared with peat casing mixes.

GLOSSARY

List of symbols and units used in the report

<u>Symbol</u>	<u>Meaning</u>
AFP	air filled porosity, expressed as % of total volume
EC	electrical conductivity, expressed in microSiemens
SBL	sugar beet lime

<u>Unit</u>	<u>Meaning</u>
kPa	kiloPascal, unit of pressure, 1 bar = 100 kPa negative values indicate suction or tension
uS	microSiemens, unit of electrical conductivity (EC)

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Table 1. Properties of materials used in the experiment

Material	pH	Conductivity µS	AFP* %	AFP* formula %	CBD** g/l	Water retention, % w/w
Peat (brown)	4.37	46	8.48	13.14	598	88.56
Peat (black)	6.55	141	13.28	21.85	480	82.22
Bark fines	5.67	101	14.7	33.59	303	74.08
Paper waste	7.67	242	30.95	34.34	581	73.4
Mineral fibre waste	7.35	1429	26.74	32.5	274	67.01
Coir (carpet waste)	5.93	1116	19.4	25.6	169	87.7
Coir (horticultural)	8.09	922	10.7	17.84	409	88.85

* air filled porosity measured from Campot drainage water or using the formula method described in Section 2.2
** compacted bulk density (before wetting)

Table 2. Chemical properties of casing materials before and after cropping.
Values for peat substitutes are for 50% inclusions rate and are means of brown and black peat, normal moisture.

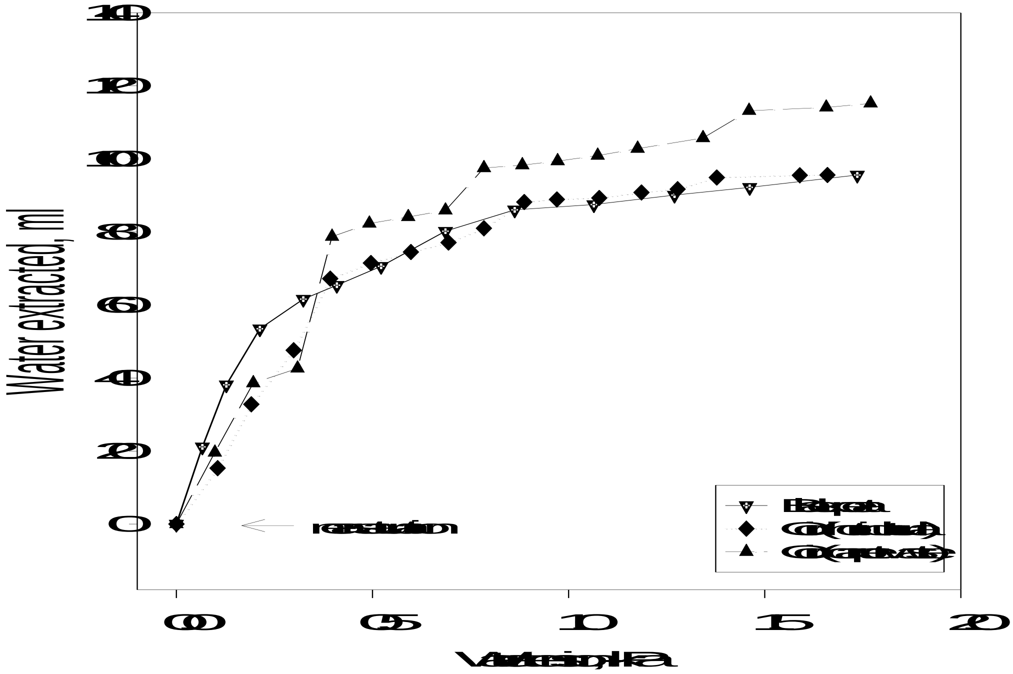
Materials	pH		Conductivity, µS	
	before *	after *	before	after
Peat (brown)	7.5	7.01	361	795
Peat (black)	7.69	7.27	409	725
Bark fines	7.64	7.46	452	1095
Paper waste	7.75	7.62	656	1136
Mineral fibre waste	7.82	7.65	609	1114
Coir (carpet waste)	8.04	7.42	584	1030
Coir (horticultural)	7.93	7.75	634	1258

* materials before and after cropping

Table 3. Physical properties of casing materials before and after cropping.
Values for peat substitutes are for the 50% inclusion rate and are means of brown and black peat, normal moisture.

Casing materials	AFP*, %		AFP*, % (formula)		CBD**, g/l		Water retention, % w/w	
	before	after	before	after	before	after	before	after
Peat (brown)	7.51	17.68	9.7	24.51	631	569	83.4	83.2
Peat (black)	9.23	16.62	11.29	21.87	681	604	81.7	81.1
Bark fines	14.45	16.13	22.98	26.39	648	539	76.6	77.25
Paper waste	12.85	17.95	15.53	22.89	721	676	78.6	78.05
Mineral fibre waste	18.56	21.14	21.13	26.53	727	609	74.85	74.8
Coir (carpet waste)	11.06	12.07	15.96	17.68	604	500	83.6	84.9
Coir (horticultural)	9	15.89	15.02	23.62	642	542	80.85	81.9

* air filled porosity measured from Campot drainage water or using the formula method described in Section 2.2.
** compacted bulk density


Water extracted, ml

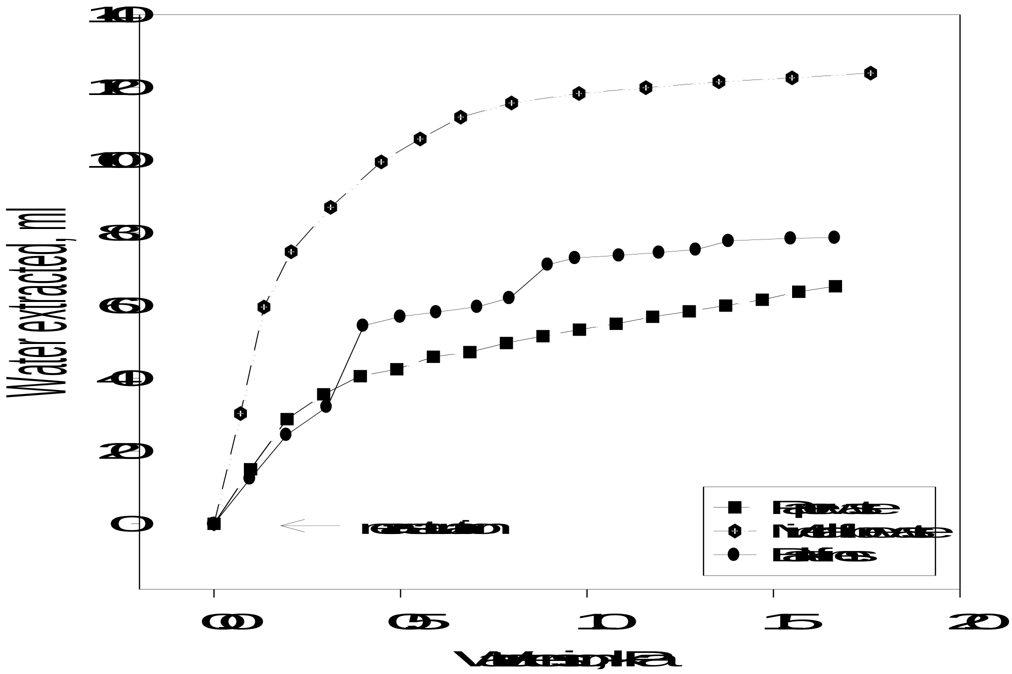
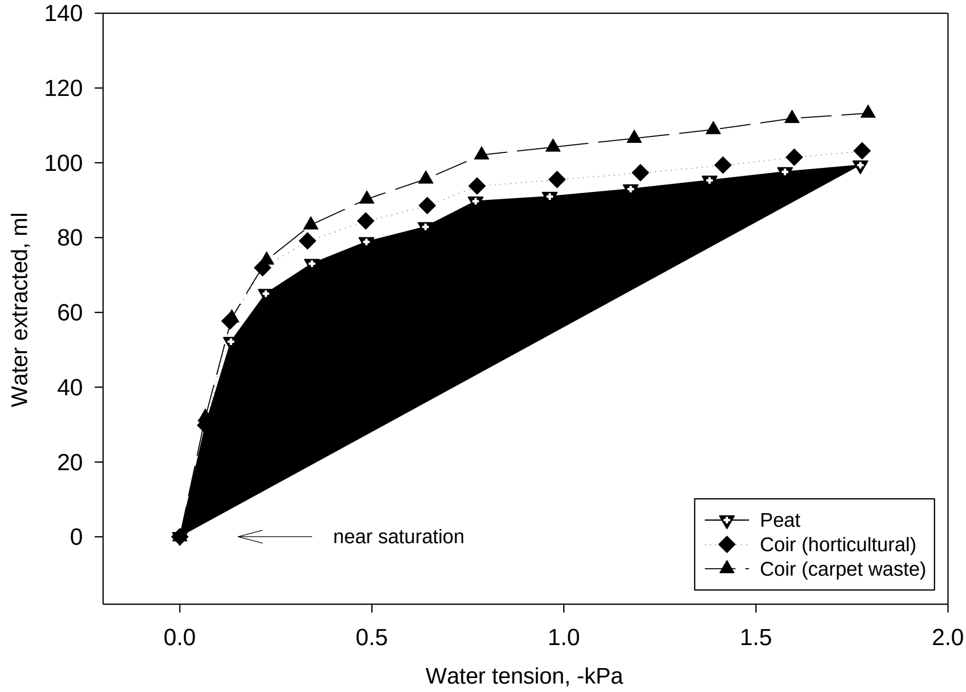

Water extracted, ml

Fig.3 Water release curves for peat and 50% coir casings.
Mean of black and brown peat, new and used casings.



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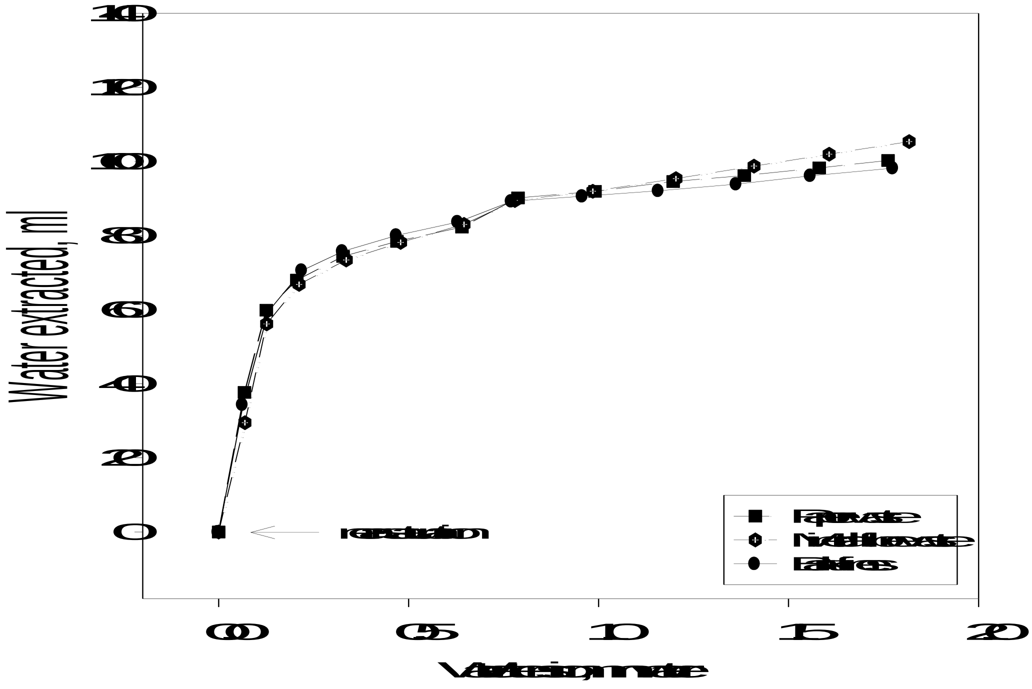


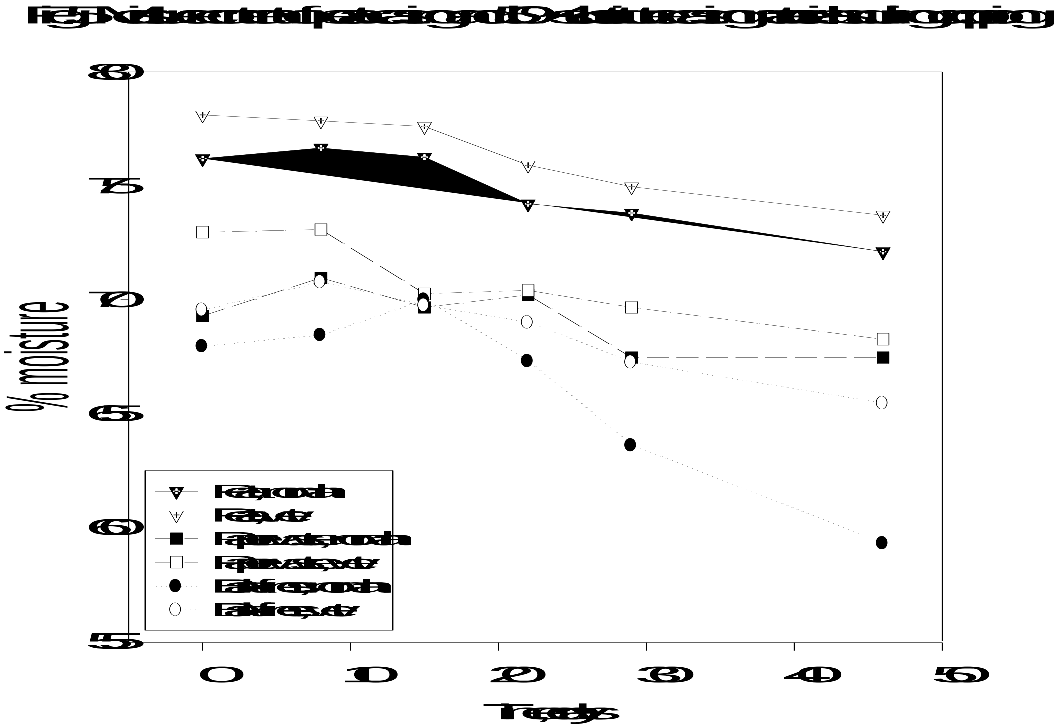
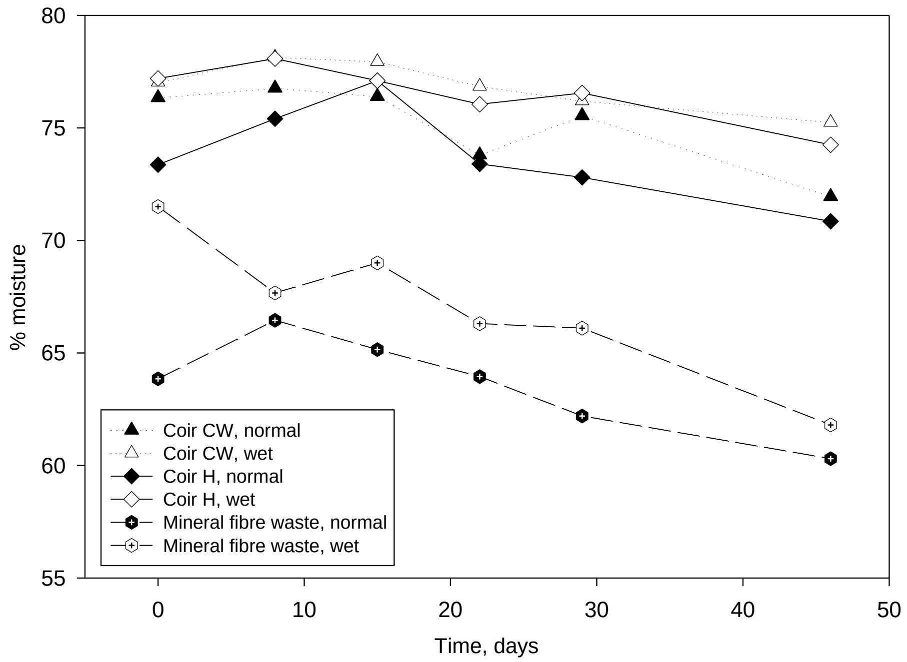
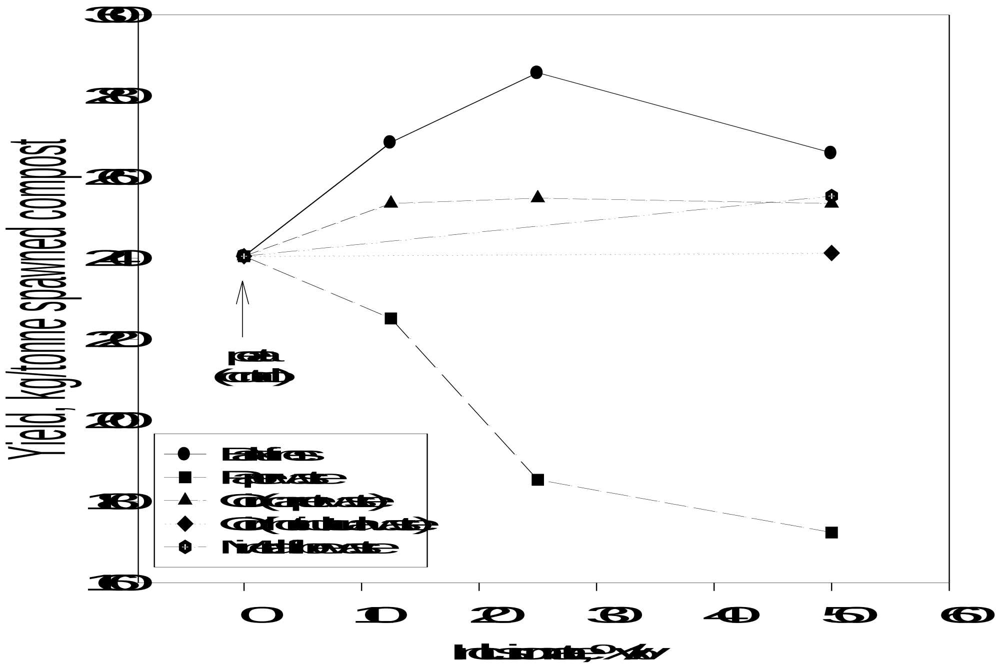


Fig.6 Moisture content of 50% substitute casing materials during cropping




Yield, kg/tonne spawned compost
0
10
20
30
40
50
60

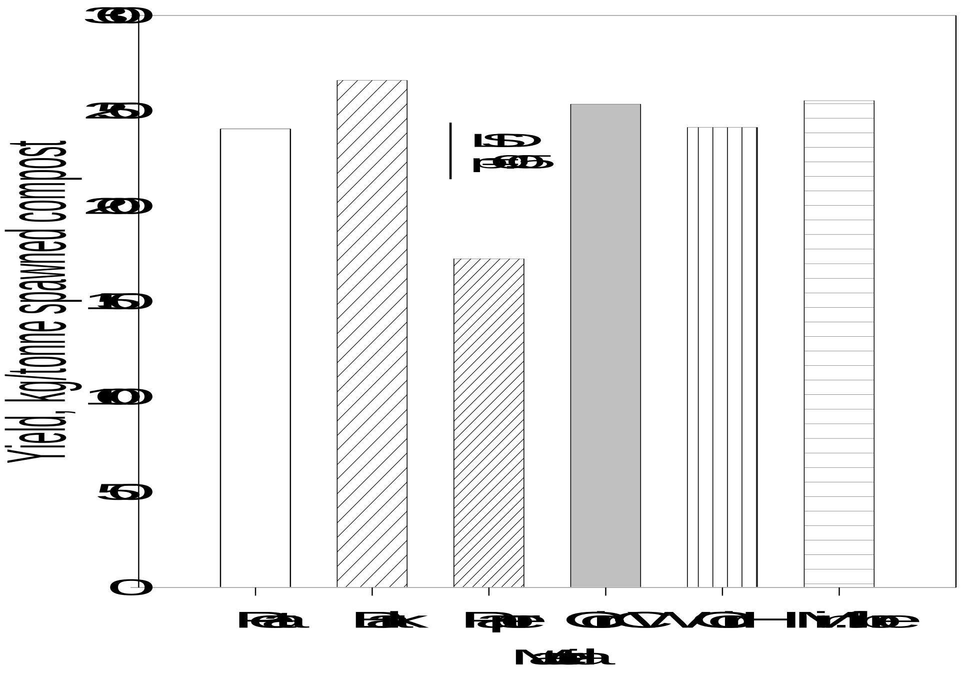

Yield, kg/tonne spawned compost
0
50

Fig. 9 Effect of peat substitution with different materials at 50% v/v on the proportions of different mushroom size grades

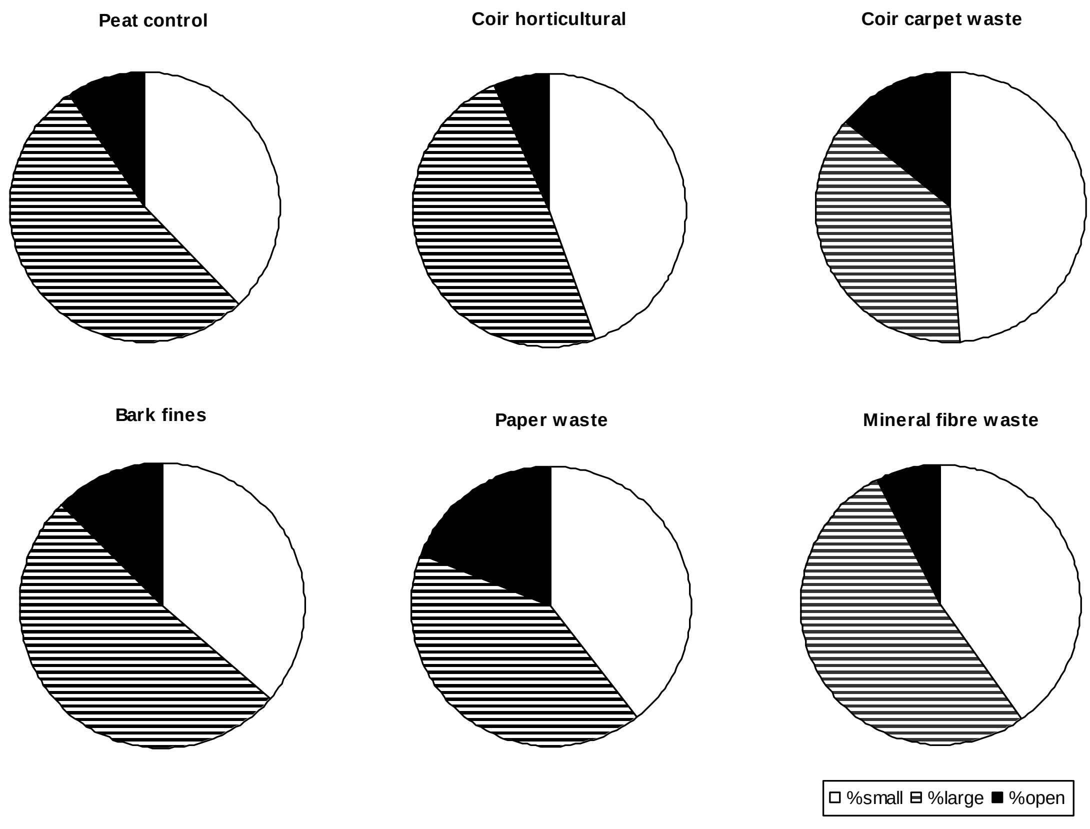


Fig.10 Effect of peat substitution with different materials at different rates on mushroom dry matter content. Mean of 2 peat types, 2 watering treatments and 3 flushes.

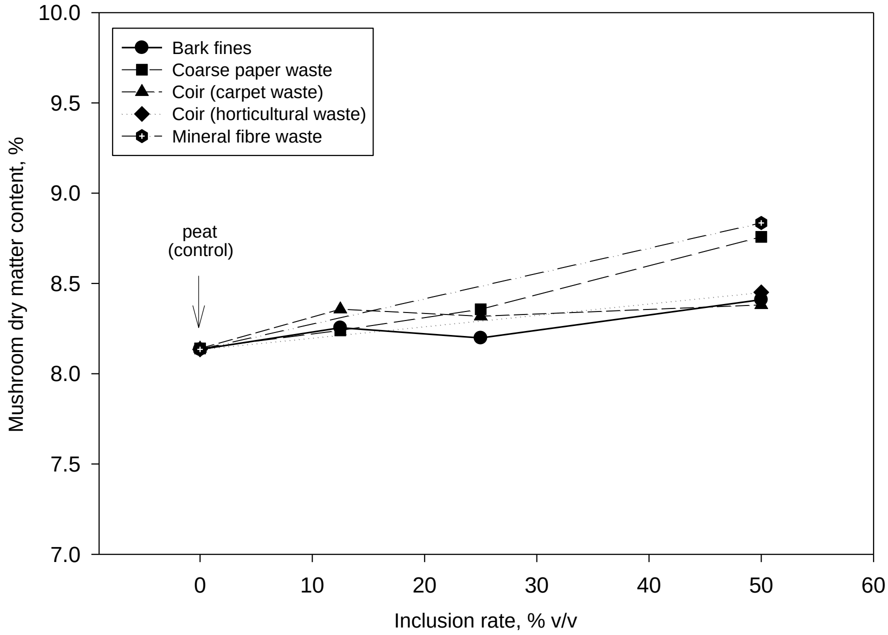
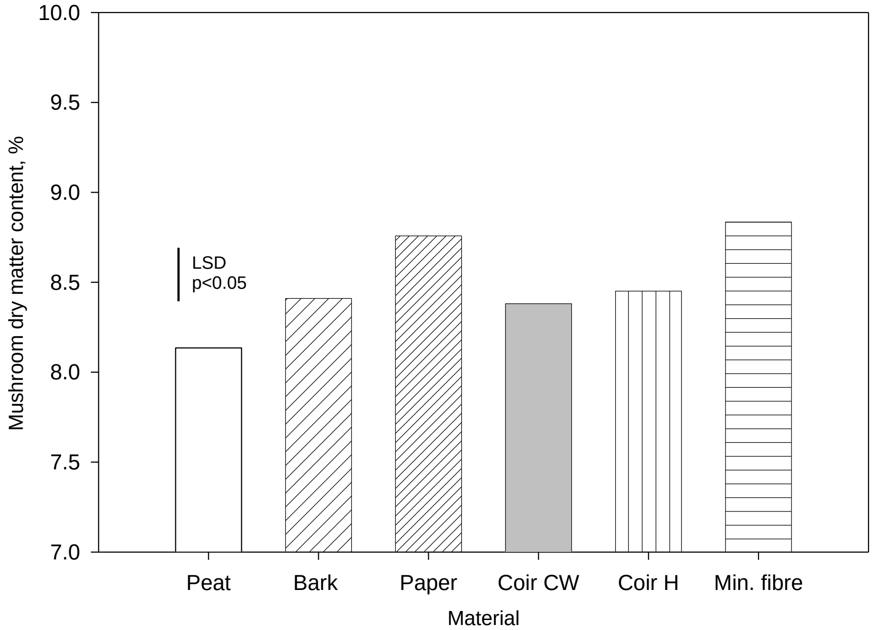
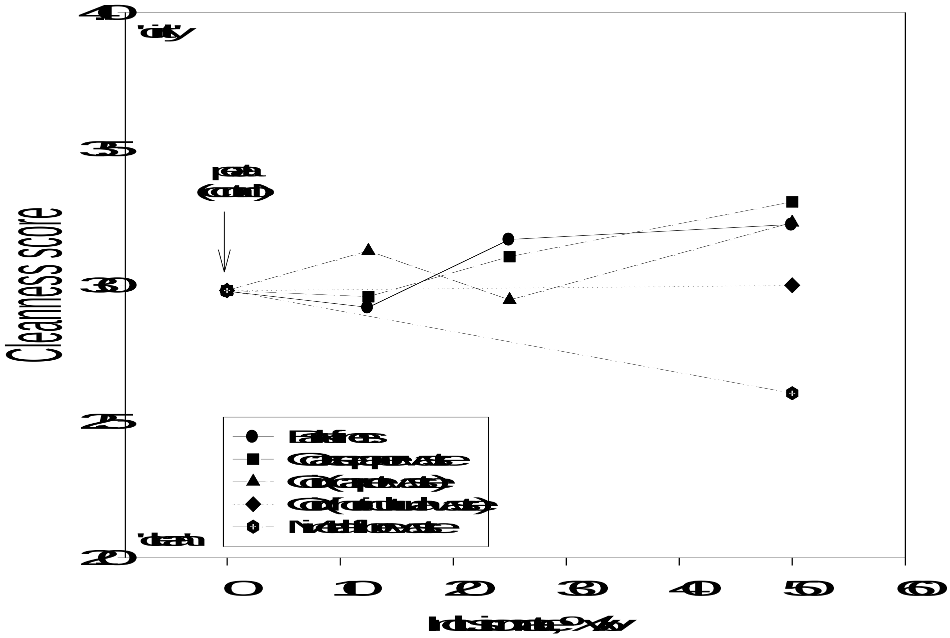


Fig.11 Effect of peat substitution with different materials at 50% v/v on mushroom dry matter content. Mean of 2 peat types, 2 watering treatments and 3 flushes.

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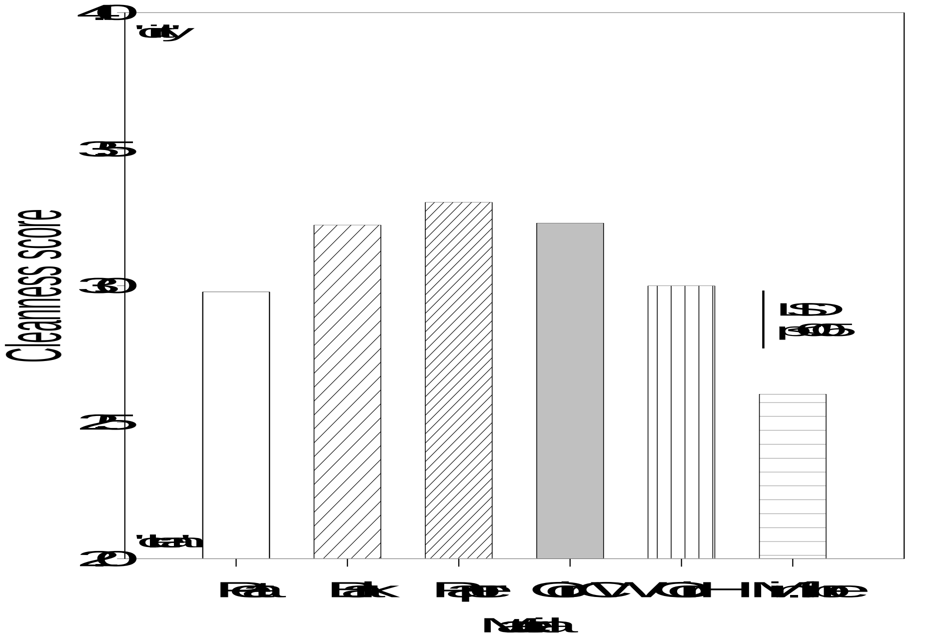
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