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PRACTICAL SECTION FOR GROWERS

Objectives and background

A wide range of casing materials and management techniques are used in the UK mushroom industry. Although an HDC funded survey (M 20) identified a number of trends relating casing materials and management practices to performance, the independent effects of materials and management could not always be separated. The overall aim of this project was to determine the effects of individual factors on mushroom yield and quality, in order to clarify the complexity of interactions of casing factors.

In the first two experiments, the following casing factors were examined: peat extraction method (wet-dug or milled), peat decomposition (brown or black), chalk/lime source and rate, casing depth and moisture status. In the third and fourth experiments, the relationship between casing moisture status (water tension) and mushroom yield and quality were examined on a range of peat/chalk or lime mixtures. The feasibility of using tensiometers for monitoring the casing water tension during cropping was also explored. In the fourth experiment, the interaction between the effects of the casing material and the growing environment (humidity) was also examined.

Summary of Results

Sugar beet lime produced a casing with a slightly higher water retention than powder chalk and resulted in a consistently higher yield. Milled brown peat produced a higher proportion of small button mushrooms than other peat types. However, within any particular category of peat type, there was significant variation in physical properties from batch to batch. There were no significant differences in yield or dry matter content between chalk/lime rates of 9% and 25% by volume. There was no mushroom yield or quality advantage of using a 55 mm depth casing layer compared with a 45 mm depth layer. Mushroom yield and dry matter content or tissue firmness from different casing treatments were negatively correlated. The firmest mushrooms and those with the highest dry matter content were produced at the two extremes of casing moisture level, which also produced lower yields. The highest dry matter mushrooms were produced in 'wet' casing at high humidity or in 'dry' casing at low humidity.

The optimum casing water tension (matric potential) in terms of mushroom yield, for a range of peat and chalk mixtures was –8 to –10 kPa mm water. However, mushroom yield was less sensitive to 'wet' casing using milled peats and less sensitive to 'dry' casing using 'bulk' peats. Casing water tension could be measured accurately on a continuous basis using electronic tensiometers. The casing water tension could rise significantly during the development of a flush.

Wet-dug, bulk brown peats produced cleaner mushrooms than bulk black, milled brown or milled black peat casings. Chalk or lime source or rate did not affect mushroom cleanness. The most important factor to affect mushroom cleanness was casing moisture: a drier casing

Mushrooms with hollow stems and caps were prevalent in wet casing in combination with a lower humidity atmosphere. Mushrooms growing in dry casing had longer and thinner stipes, and tended to open earlier than unstressed mushrooms. A range of water stress symptoms including distorted caps, exuded water droplets and water soaked patches were recorded in dry casing treatments following watering.

Action points for growers

- Due to the higher water retention, sugar beet lime will generally produce higher yields than powder chalk.

- The proportion of small button mushrooms will be increased by the use of brown milled peat.

- Milled peat casings are more tolerant of 'wet' conditions whereas bulk peat casings are more tolerant of 'dry' conditions. A blend of bulk and milled peat may produce a casing which is tolerant of a wider range in casing moisture.

- The casing moisture content should be monitored regularly since yields are significantly reduced by casing which is too wet or too dry.

- The physical properties of a casing supply should be monitored, particularly the moisture, and water and air holding characteristics, since these will affect the watering management of crops.

- Modifying the casing material or management to maximise yield may be at the expense of mushroom dry matter content or firmness. Use of bulk wet-dug brown peat will improve cleanness compared with other types of peat.

- A 'wet' growing regime, particularly pre-harvest, may increase the risk of dirty mushrooms.

- Large numbers of hollow mushrooms may be an indication of over-wet casing in combination with a low humidity environment. Mushrooms with long thin stipes which open prematurely may be an indication of an over-dry casing. Other water stress symptoms may be an indication of a fluctuating watering regime or water supply to the crop.

- Casing depth should be regularly monitored since casing layers deeper than 45 mm are not necessarily beneficial.

Practical and financial benefits to the industry

The work has identified individual casing factors which influence the yield and quality of mushrooms, i.e.:

- sugar beet lime generally produces a higher yield than powder chalk
- the proportion of small buttons can be influenced by the use of brown milled peat
- blending of milled and bulk peats may result in casings which are more tolerant of wet and dry conditions
- cleanness can be improved by the use of bulk brown peat and avoiding wet casing pre-harvest
- choosing casing materials or treatments which produce a high yield may be at the expense of mushroom dry matter content
- excessively deep casing layers (55 mm or greater) may be wasting casing material.

The techniques which have been developed to measure the air and water holding characteristics of peat and casing mixes should enable growers to monitor physical changes in the properties of the materials used and adjust the watering management accordingly.

The relationship between casing water tension and mushroom yield should enable better water management to be achieved. The use tensiometers to monitor the moisture status of the casing could be developed into a reliable method of controlling the watering of the crop.

INTRODUCTION

In an HDC funded survey of UK casing materials and practices (Noble & Gaze, 1993) a wide range of casing materials (peat and lime sources) and casing practices were found. There was a significant trend for blacker, more decomposed peats to produce cleaner mushrooms. The independent effects of chalk/lime source could not be clearly identified from the survey since sugar beet lime was generally used with black peats on the farms which were examined. Due to the large number of different materials used on the farms and limited replication of individual types, no conclusion could be drawn regarding the optimum properties of the casing material.

The management factor in the survey which was most closely correlated with yield was casing depth, with the optimum in the range 45-55 mm. The independent effects of casing materials and management could not always be separated since casing moisture content and depth were greater with black peat casings.

The aims of this series of experiments were:

1. To determine if the trends found in the survey could be repeated under controlled conditions.

2. To determine the effects of individual factors on mushroom yield and quality, in order to clarify the complexity of interactions of casing factors.

In the first two experiments, the following casing factors were examined: peat extraction method (wet-dug or milled), peat decomposition (brown or black), chalk/lime source and rate, casing depth and moisture status. The most important factor affecting the yield, dry matter content and cleanness of the mushrooms was the water status of the casing. It was found that the most reliable method of defining the water status of a range of casing materials was the tension at which the water was held in the casing. In the third and fourth experiments, the relationships between the casing water tension and mushroom yield and quality were examined in more detail. It was found that casings prepared with bulk wet-dug peats were more sensitive, in terms of mushroom yield, to casing water tension than casings prepared with milled peats. The aims of the fourth experiment were:

(i) To examine the use of tensiometers for controlling the casing moisture status;

(ii) To further examine the differences in sensitivity to casing water tension between different casing materials (peat and chalk/lime sources);

(iii) To examine the interaction between the effects of the casing material and the growing environment (humidity) with respect to mushroom yield, dry matter content and texture.

MATERIALS AND METHODS

Treatments (Experiment 4)

1. Peat sources

    (i) Bulk extracted, wet dug black peat (blackness 5.0 'black')
    (ii) Milled black peat (blackness 4.0 'black')
    (iii) Bulk extracted, wet dug brown peat (blackness 2.5 'brown')
    (iv) Milled brown peat (blackness 2.0 'brown')

2. Chalk/lime sources

    (i) Chalk, superfine grade, 95% $\leq$ 20 microns
    (ii) Sugar beet lime

3. Casing water tension (kPa)

(i)	-2.7	(iv)	-9.3
(ii)	-4.9	(v)	-11.5
(iii)	-7.1	(vi)	-13.7

4. Cropping house humidity (after airing)

    High, 94-96%
    Low, 84-86%

    Two replicate cropping rooms at each humidity were used. Each room contained a single tray of each peat source x chalk source x water tension factorial treatment.

The treatments in all four experiments are shown in Table 1.

Properties of casing materials

Peat sources were assessed for decomposition according to 'blackness' on a modified von Post scale of 1 (young, pale) to 5 (decomposed, black) (Noble & Gaze, 1994). The following properties were determined on the peat sources and mixed samples of the casing materials: air filled porosity (AFP), bulk density (air dried material and at field capacity), water retention, conductivity and pH. Bulk density, AFP and water retention were determined using the 'Campot' method (Anon, 1990).

Measurement of casing water tension

Casing water tensions were measured by taking 100 g casing samples from the plots at two-daily intervals and determining the moisture content by oven drying. The moisture contents were then converted into water tensions by using a calibration curve for each material. The calibration curves were obtained by using a Buchner funnel method described in HDC report M20b.

Casing water tensions (matric potentials) were also measured with miniature tensiometers (Type SWTS, Delta-T Devices Ltd) connected to a Delta-T data logger. Data was recorded at two-hourly intervals. The tension values obtained were used to adjust the quantities of water added to the casing treatments.

Water tensions are expressed in units of pressure, Pascals (1 kPa = 101.7 mm of water or 7.5 mm of mercury). Since the tension is exerted as a 'suction' rather than a positive pressure, the units are preceded by a minus sign.

Cropping procedure

The experiment was conducted in controlled environment cropping rooms using wooden trays (0.9 x 0.6 x 0.2 (deep) m). Each tray contained 50 kg compost spawned with the strain Hauser A12 and supplemented with Betamyl 1000 at 1% w/w. Fourteen days after spawning, the trays were cased with casing material which contained Hauser 'Growmaster' casing spawn (caccing), at a rate of 4 kg/m^3 casing. Casing materials were wetted and mixed before application in a mechanical mixer for 1-2 minutes depending on the material and desired moisture content. The compost temperature was maintained at 25°C (due to the smaller than commercial size trays, the air temperature could be maintained at 21-23°C; for larger trays, a higher compost temperature than 25°C will be required before airing). Fresh air was introduced into the growing room after 6.5 days to obtain a CO_2 concentration of 0.09-0.10% v/v; air temperature was maintained at 17·5°C. Evaporation in the growing rooms was monitored with Piché evaporimeters (Anon, 1986), positioned 0.2 m above the upper layer of trays.

All the trays were watered immediately after the casing was applied. Further waterings to the different casing moisture treatments were adjusted to maintain the desired moisture levels (water tensions).

Where possible mushrooms were picked as large buttons (diameter 30-40 mm) but some mushrooms were picked smaller due to overcrowding on some plots. Mushrooms were picked over a 27 day period (3 flushes), with the first flush being picked *c.* 17 days after application of the casing.

Mushroom cleanness, dry matter content and texture

Before each flush was picked, the mushrooms on each tray were assessed for cleanness on a 0 (clean) to 5 scale (Project M20a Annual Report 1997). After picking, three containers of 30 mushrooms from each tray from the first three flushes were assessed for cleanness (Photos 1-3). The percentage dry matter of 20 mushrooms from each tray from the first three flushes were determined according to Burton & Noble (1993).

Mushroom tissue texture was determined on cylinders of 5 mm diameter and 5 mm height and taken from the top of mushroom caps. Samples were then immediately tested for their stiffness on an Instron Universal Testing Instrument (model 4301, High Wycombe, UK). The samples were compressed at 5 mm/min with a flat probe to a displacement of 2 mm. The stiffness of the tissue sample was determined from the slope of the force/displacement curve.

RESULTS

Properties of peat sources and casing materials

Between the batches of peat used in the experiments, there was considerable variation (Table 2). However, the sources of the four peat types differed between experiments. Milled brown peat generally had the lowest air-filled porosity (AFP) and water retention, except in Expt. 4 where the milled black peat had the lowest values.

Bulk peat produced a casing with a higher water retention than milled peat (Table 3). Sugar beet lime resulted in a casing with a higher water retention but lower AFP than casing prepared with chalk. Sugar beet lime also produced a higher conductivity than chalk (Table 4).

Conductivity rose during the cropping period from about 500 μS to about 800 μS by the end of third flush (Table 4).

Mushroom yield

In all four experiments of Project M20a, sugar beet lime resulted in a significantly higher yield than chalk (Table 5). In Expt 1, a milled black peat produced the highest yield; in Expts. 2 and 3 a milled brown peat produced the highest yield; in Expt. 4 the highest yield was from a bulk black peat. However, the sources of the peat types differed between experiments. Average yields from different peat sources (Table 6) showed no overall 'best peat type' in terms of yield. In all four experiments, milled brown peat produced a significantly higher proportion of small buttons compared with the other peat types (Table 7).

The most important factor affecting yield was the moisture status of the casing. The optimum casing water tension was 800-1000 mm water for all casing materials in Experiments 2, 3 and 4 (Figures 1-3). The casing water tensions shown in Figures 1-3 are average values throughout the cropping period. Milled peat casings were more tolerant of 'wet' conditions whereas bulk peat casings were more tolerant of 'dry' conditions. Yields at 95% r.h. (low evaporation) were slightly higher than at 85% r.h. (high evaporation) (figure 2) although the amounts of water applied to achieve similar casing moisture levels were 11% higher in the latter environment.

The relative yields from the different peat and chalk/SBL mixtures were unaffected by the cropping humidity in Expt. 4.

Mushroom dry matter content and texture

There was a negative relationship between mushroom yield and dry matter content in all three experiments (Figures 3 and 4) but no significant relationship at 85% r.h. in Expt 4. Mushrooms from Experiment 2 had a lower dry matter content, at an equivalent yield, than mushrooms from Experiments 1 and 3. In the first three experiments, the first flush had a lower dry matter content than the second and third flushes. However, in Experiment 4, the first flush had the highest dry matter content. Mushrooms grown at low humidity with a greater number of waterings had a similar dry matter content to mushrooms grown at high humidity with fewer waterings. Mushrooms with the highest dry matter content were produced in 'wet' casing at high r.h. or in 'dry' casing at low r.h. (Table 8).

In Experiments 3 and 4, there was a negative relationship between mushroom yield and firmness, and a positive relationship between firmness and dry matter content (Figure 6). Firmness was slightly higher in the extremes of 'wet' or 'dry' casing.

Mushroom cleanness

In the first two experiments, the bulk black peat casing produced the dirtiest mushrooms (Table 9). The bulk brown peat casings generally produced the cleanest mushrooms. There was no difference in mushroom cleanness between sugar beet lime or chalk casings in any of the experiments.

In all four experiments the drier casing management regimes produced cleaner mushrooms than the wetter regimes (Table 10).

Casing water status

The casing water tensions (matric potentials) measured with tensiometers during the cropping period of Experiments 3 and 4 are shown in Figures 8-10. The graphs show the water tensions in different casing treatments given drier or wetter moisture regimes. The figure shows the development of higher tensions during the development of each of the three flushes. The very wet treatments, which produced lower yields of mushrooms, developed only small tensions during the cropping period. There was a close correlation between the average casing water tension measured with tensiometers and the Buchner funnel method (Figure 11).

Evaporation

Piché evaporimeter readings in the high and low humidity cropping houses are shown in Figure 12. The evaporation rates wer 3 and 44 litres/m^2/h from the high and low humidity houses respectively.

Mushroom water stress symptoms

As a result of the different watering regimes, some of the treatments produced mushrooms with various water stress symptoms. For comparison, mushrooms without stress symptoms from an intermediate water level are shown in Photo 4. Mushrooms growing in continuously dry casing (Photo 5) had longer and thinner stipes, and tended to open earlier than unstressed mushrooms. Mushrooms with hollow stems and caps were observed in flushes 2 and 3 and were most prevalent in wet casing in a low humidity (Photo 6 and Figure 13). Symptoms which occurred following watering on a dry casing were distorted caps, water soaked areas on the cap and water droplets exuding from the stipes (Photos 7, 8 and 9).

DISCUSSION

This work has shown that high mushroom yields can be obtained on a range of materials with differing air and water-holding characteristics. However, to maximize the yield from each material, the management, particularly watering regime, had to be adjusted. The most important factor influencing yield was the tension at which the water was held in the casing. If the casing is too wet (ie tension too small), the air spaces were restricted, and this probably accounted for the reduced mushroom growth and yield. The smaller particle size of sugar beet lime compared with powder chalk, resulted in a higher water holding capacity (on a weight basis) and the water being held at a slightly higher tension. When compared on an equivalent moisture by weight basis, sugar beet lime produced a higher yield than chalk, but when casings were compared at equivalent tensions there was no overall difference between the chalk/lime sources.

Early work using mercury manometer tensiometers to control the moisture status of the casing was unsuccessful due to the difficulty in using the equipment (Reeve, *et al.*, 1959). Electronic tensiometers, as used here, are more convenient, particularly if they are connected to a data-logger or an environmental control computer. The values obtained relate closely to those obtained using the Buchner funnel method of determining casing water tension.

Visscher (1988) reported that sugar beet lime gave the casing a denser structure resulting in a smaller number of larger mushrooms. However, no difference between the effects of chalk/lime source or rate on the size of mushrooms were found in the present experiments. The main factor affecting mushroom size was the peat source: brown milled peat casings produced a higher proportion of small button mushrooms than the other three peat sources used.

The results show that casing treatments have opposite effects on mushroom yield and dry matter content or firmness. However, since different crops produce different dry matter contents and mushrooms with differing firmness values at the same level of yield, other factors, such as the compost, are involved. The effects of different composts, particularly their moisture content, on the suitability of different casing materials should be investigated further. In the first three experiments, first flush mushrooms had a lower dry matter content than second or third flush mushrooms whereas in the fourth experiment, first flush mushrooms had the highest dry matter content. Burton and Noble (1993) found no differences in dry matter content between the first three flushes while Laborde and Delpech (1991) found that dry matter content was higher in the first flush than in subsequent flushes. Kalberer (1985) found that flush differences in dry matter content varied according to the depth of the casing.

A bulk black produced the dirtiest mushrooms, particularly when used in combination with a 'wet' regime. This was mainly due to deep pinning and 'smearing' on the caps. Previous work (Noble & Gaze, 1995) has shown that very young peats (paler than those used here) may also produce dirty mushrooms due to a problem of undegraded sphagnum particles sticking to the caps. The most important factor influencing mushroom cleanness in the three experiments was casing moisture: wetter casings consistently produced dirtier mushrooms than casing which were kept at a slightly lower moisture content.

CONCLUSIONS (From Experiments 1 to 4)

1. The optimum casing water tension (matric potential) in terms of mushroom yield, for a range of peat and chalk mixtures is -8 to –10 kPa.

2. Mushroom yield was less sensitive to 'wet' casing when milled peat was used but was less sensitive to 'dry' casing when bulk peat was used.

3. Sugar beet lime produces a casing with a slightly higher water retention than powder chalk and resulted in a consistently higher yield. There were no significant differences in yield or dry matter content between chalk/lime rates of 9% and 25% by volume.

4. There were no consistent yield differences between different types of peat but milled brown peat produced a higher proportion of small button mushrooms than other peat types.

5. Within any particular category of peat type (eg brown wet-dug or milled black) there was significant variation in physical properties from batch to batch.

6. Mushroom yield and dry matter content or tissue firmness from different casing treatments were negatively correlated. The highest dry matter mushrooms were produced in 'wet' casing at high humidity or in 'dry' casing at low humidity.

7. Bulk brown peat casing generally produced cleaner mushrooms than bulk black, milled brown or milled black peat casings.

8. Chalk or lime source or rate did not affect mushroom cleanness.

9. A drier casing management regime produced cleaner mushrooms than a wetter regime.

10. Casing water tension could be measured accurately on a continuous basis using tensiometers. The casing water tension can rise significantly during the development of a flush.

11. Mushrooms with hollow stems and caps were more prevalent in wet casing in combination with a lower humidity atmosphere. Mushrooms growing in dry casing had longer and thinner stipes, and tended to open earlier than unstressed mushrooms.

12. A range of water stress symptoms including distorted caps, exuded water droplets and water soaked patches were recorded in dry casing treatments following watering.

13. There was no mushroom yield or quality advantage of using a 55 mm depth casing layer compared with a 45 mm depth layer (only examined in Experiment 1).

RECOMMENDATIONS

1. The use of tensiometers for monitoring and controlling the casing moisture status should be examined in commercial crops.

2. The casing water tension (matric potential) of commercial crops using different casing materials, watering regimes and growing systems should be determined and compared with those obtained experimentally.

3. The properties of casing should be monitored regularly since the air and water holding characteristics can change significantly between batches and these will affect the watering management of crops.

4. The differences in sensitivity to casing water tension between different casing materials should be examined further: ideally, a casing material should produce high yields across a wide range of water tensions. This may be achieved using a blend of milled and bulk peats since milled peats are more tolerant of wet conditions whereas bulk peats are more tolerant of dry conditions.

5. Picking mushrooms off wet casing reduces cleanness; cleaner mushrooms are obtained off a drier casing pre-harvest. Use of bulk wet-dug brown peat will improve cleanness compared with other types of peat.

6. The effect of casing materials, casing water and compost water on water stress symptoms should be examined further.

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Table 1. Treatments in Experiments 1, 2, 3 and 4

Variable	Experiment 1	Experiment 2	Experiment 3	Experiment 4
Peat extraction method	Milled or Wet-dug	Milled or Wet-dug	Milled or Wet-dug	Milled or Wet-dug
Peat decomposition	Brown or Black	Brown or Black	Brown	Brown or Black
Chalk/lime source	Powder chalk or Sugar beet lime	Powder chalk or Sugar beet lime	Powder chalk or Sugar beet lime	Powder chalk or Sugar beet lime
Chalk/lime rate, % v/v	9	9 or 25	25	25
Casing depth, mm	45 or 55	45	45	45
Casing moisture level, % w/w below field cap.	1-2 or 3-4	1-2 or 3-4	Range	Range

Table 2. Properties of peat types used in Experiments 1, 2, 3 and 4. The sources of the four peat types differed between experiments

Peat Type	Expt	pH	Conductivity µS	Moisture* %	Ash % of d.m.	AFP† %	Dry bulk density g/l	Water ret. % w/w
Bulk Brown	1	5.6	58	89.6	7.70	18.0	149	92.9
	2	5.3	66	88.5	5.42	14.9	142	90.5
	3	6.3	31	91.6	2.2	11.8	185	91.6
	4	5.4	43	90.0	1.7	10.1	132	92.3
Milled Brown	1	3.6	94	66.2	2.20	12.2	154	86.0
	2	4.2	86	68.6	4.39	12.3	199	81.0
	3	4.8	54	75.6	1.59	10.1	145	75.6
	4	4.5	99	58.0	1.7	9.4	140	85.3
Bulk Black	1	4.9	72	88.7	5.70	19.8	303	92.0
	2	4.9	46	88.8	3.2	14.3	220	90.3
	3	-	-	-	-	-	-	-
	4	5.1	44	88.4	1.3	13.1	180	91.3
Milled Black	1	3.5	92	80.2	1.80	16.9	238	88.3
	2	5.2	47	86.1	5.35	19.5	226	88.3
	3	-	-	-	-	-	-	-
	4	4.4	178	72.3	2.3	5.1	214	81.4

* Before addition of water
† Air filled porosity

Table 3. Effects of casing treatments on physical properties, Experiment 4

Treatment mean	AFP %	Bulk density g/litre	Water retention % w/w
Peat			
Bulk black	10.48	811	75.7
Milled black	6.87	899	66.7
Bulk brown	8.73	822	75.9
Milled brown	6.50	792	72.2
Lime source			
Sugar beet lime	8.04	816	75.2
Chalk	8.25	846	70.1
Moisture*			
Wet	8.05	893	72.9
Dry	8.24	769	72.3

* Average of three wettest and three driest treatments

Table 4. **Effects of casing treatments on pH and conductivity, before application and after cropping, Experiment 4**

Treatment mean	Casing pH		Conductivity, µS	
	Before	After	Before	After
Peat				
Bulk black	7.58	7.63	470	868
Milled black	7.27	7.65	683	795
Bulk brown	7.72	7.69	463	864
Milled brown	7.52	7.66	558	778
Lime source				
Sugar beet lime	7.50	7.80	684	880
Chalk	7.54	7.52	403	773
Moisture*				
Wet	7.51	7.73	541	722
Dry	7.54	7.58	546	930

* Average of three wettest and three driest treatments

Table 5. **Effects of chalk/lime source on mushroom yield (kg/tonne compost). Mean of different peat sources**

	Experiment 1	Experiment 2	Experiment 3	Experiment 4
Chalk	270	264	239	263
Sugar beet lime	284	280	246	265

Table 6. **Effect of peat source on mushroom yield (kg/tonne) compost. Mean of different chalk/lime sources**

	Experiment 1	Experiment 2	Experiment 3	Experiment 4
Bulk brown	314	264	235	265
Milled brown	306	285	250	264
Bulk black	290	275	-	276
Milled black	322	266	-	262

Table 7. **Effect of peat source on the proportion of small buttons (%) in the total mushroom yield**

	Experiment 1	Experiment 2	Experiment 3	Experiment 4
Bulk brown	12	15	16	23
Milled brown	17	18	24	30
Bulk black	11	15	-	21
Milled black	13	16	-	24

Table 8. Effect of casing moisture and cropping humidity on mushroom dry matter content, Expt. 4

Moisture regime*	Cropping relative humidity, %	
	85	**95**
'Wet'	7.6	7.9
'Dry'	7.9	7.6

* average of the three wettest and three driest watering treatments

Table 9. Effect of peat source on mushroom cleanness after picking. Mean of 3 flushes.

	Experiment 1	Experiment 2	Experiment 3	Experiment 4
Bulk brown	3.8	3.9	3.8	3.6
Milled brown	3.9	4.3	3.7	4.1
Bulk black	4.3	4.7	-	3.7
Milled black	4.3	4.0	-	4.3

Table 10. Effect of casing moisture treatment on mushroom cleanness before and after picking. Mean of 3 flushes

Moisture regime	Experiment 1		Experiment 2		Experiment 3		Experiment 4	
	Before	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**
'Wet'	4.2	4.5	4.1	4.4	4.4	4.4	4.0	3.9
'Dry'	3.7	4.0	3.6	3.8	3.5	3.6	3.4	3.5

* average of the three wettest and three driest watering treatments

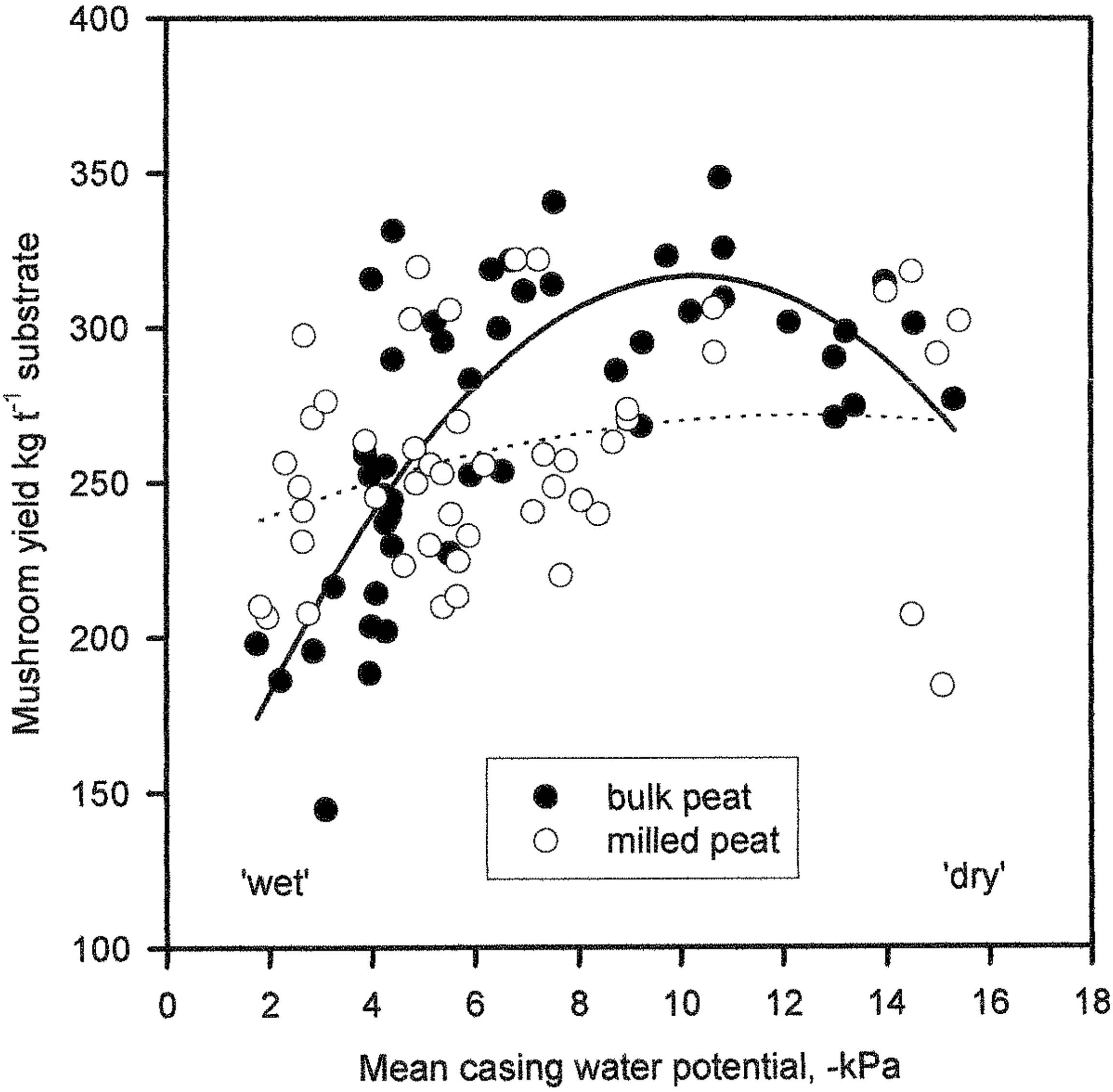


Fig.1 Relationship between casing water potential and mushroom yield using milled peat and bulk peat casings, Experiment 4

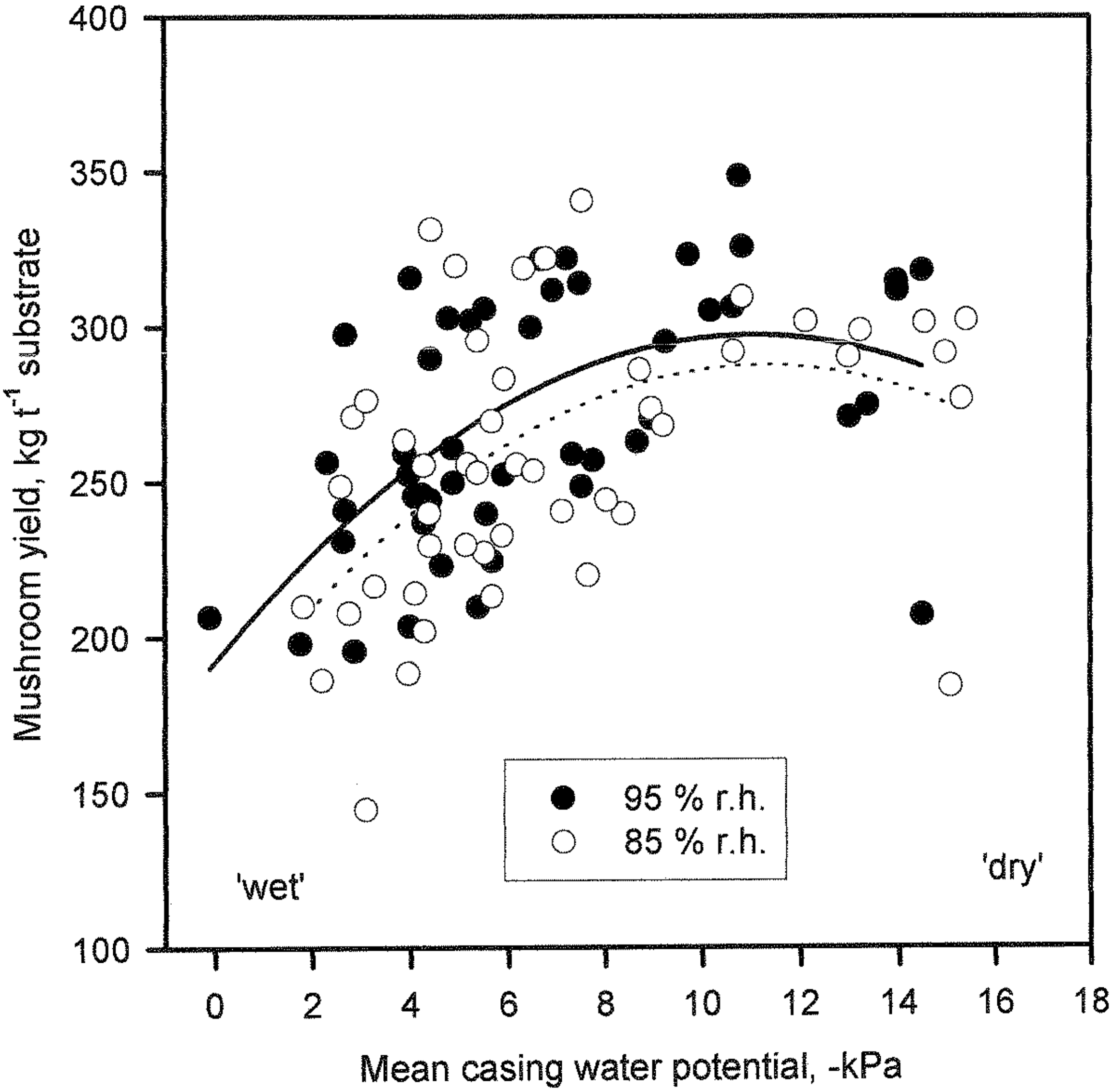


Fig.2 Relationship between casing water potential and mushroom yield at two relative humidities

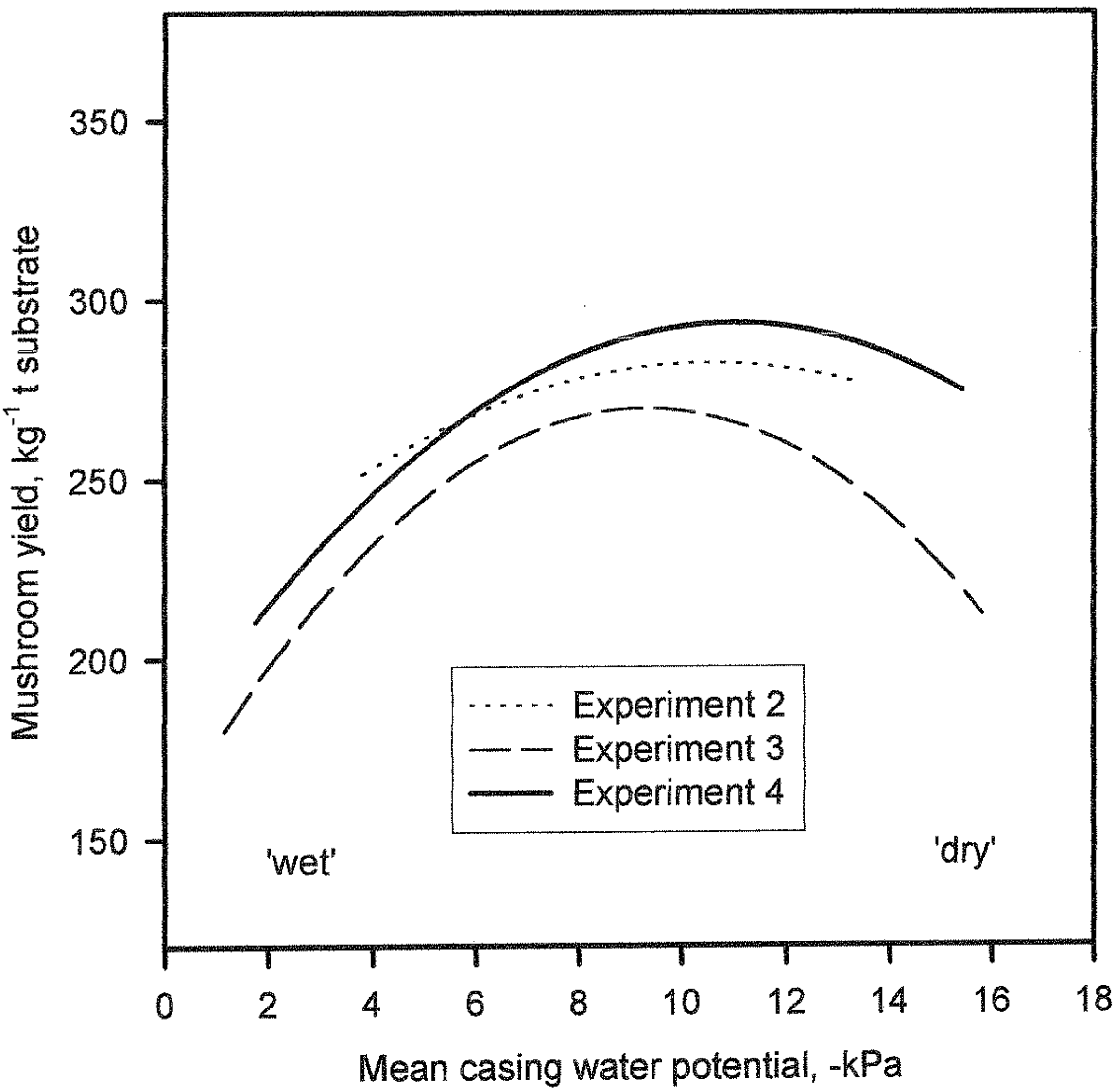
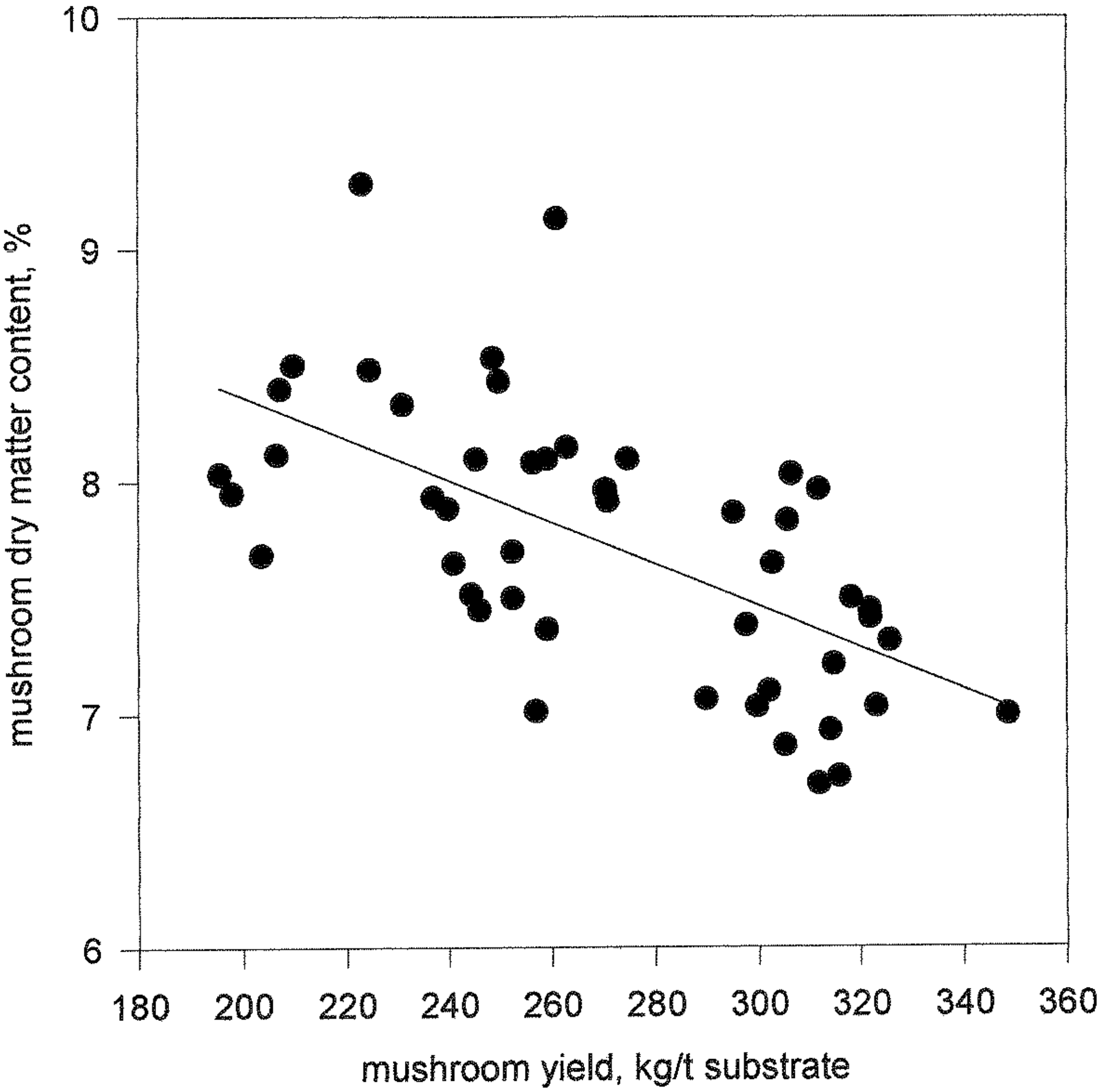


Fig. 3 Relationship between casing water potential and mushroom yield in Experiments 2, 3 and 4

Fig.4 Relationship between mushroom yield and dry matter content, Expt 4, 95 % r.h.



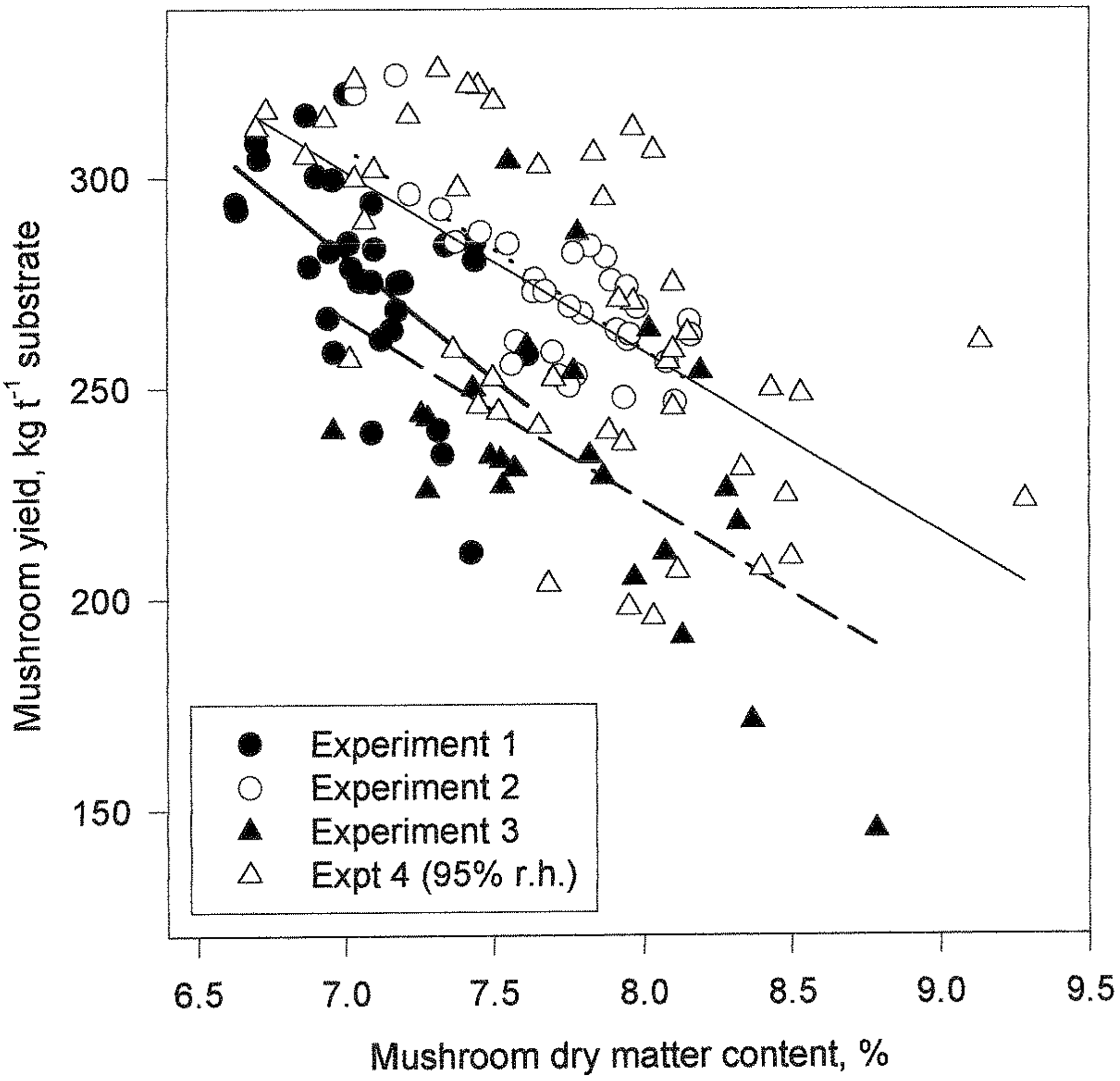


Fig. 5 Relationship between mushroom dry matter content and yield, Experiments 1, 2, 3 and 4

Fig.7 Relationship between casing water potential and mushroom tissue stiffness

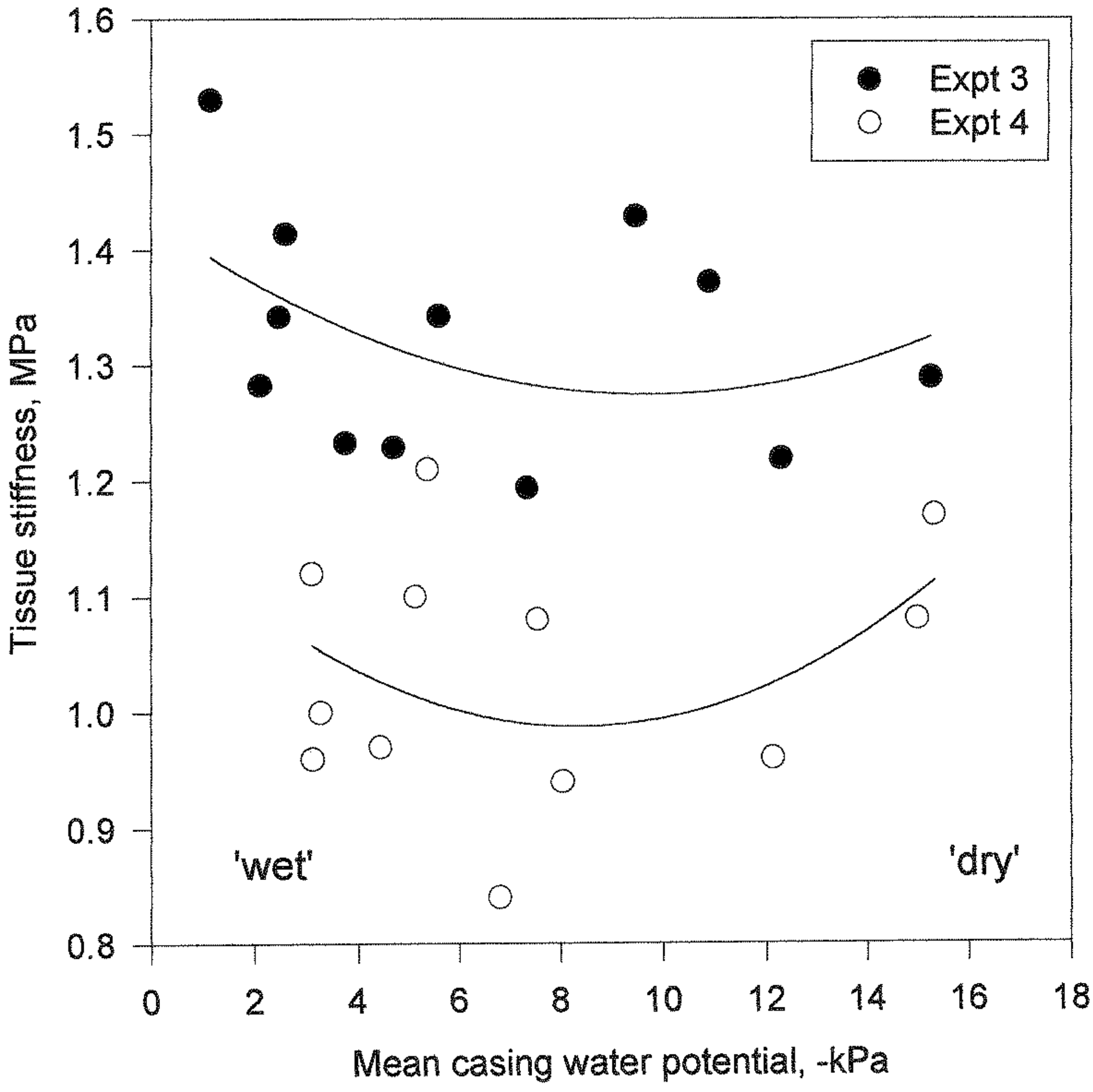


Fig.8a Matric potentials in bulk peat / SBL casings
Expt. 4

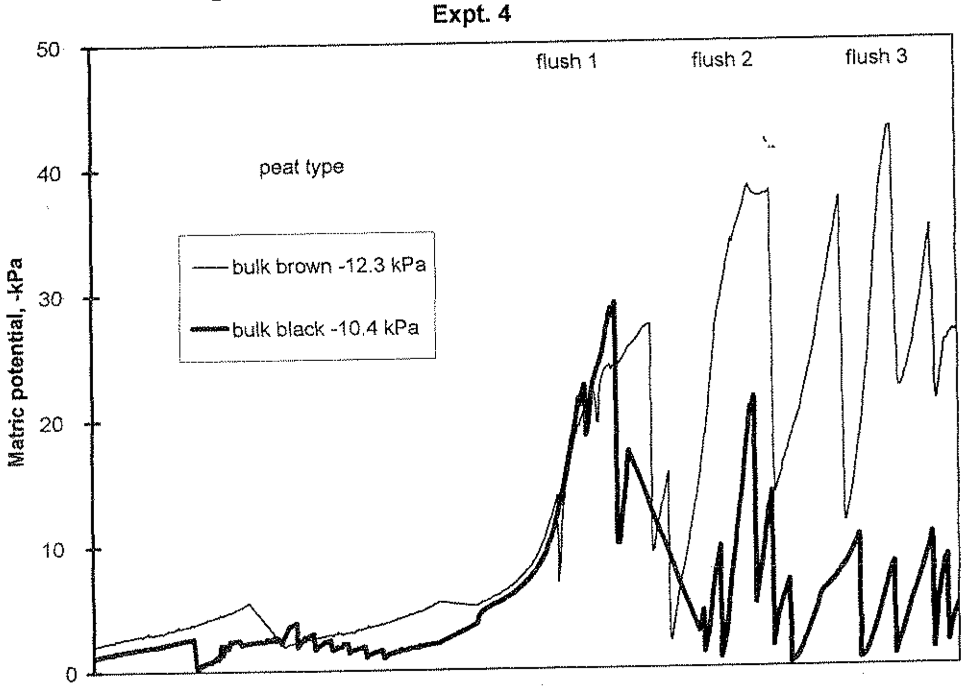


Fig.8b Matric potentials in milled peat / SBL casings, Expt. 4

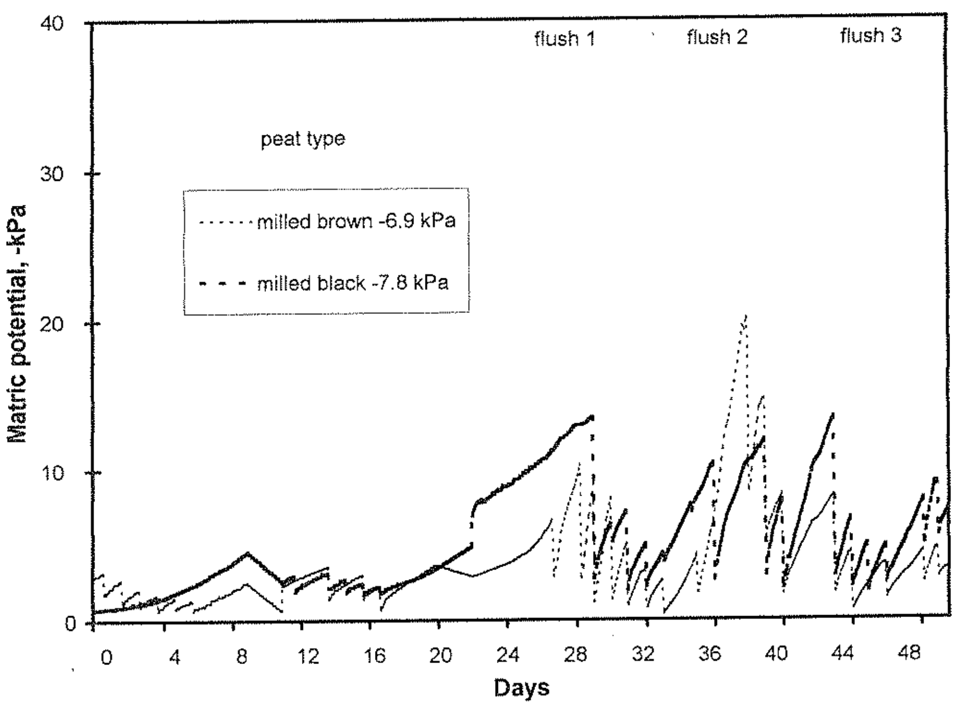


Fig.9a Matric potentials in bulk peat / chalk casings, Expt. 4

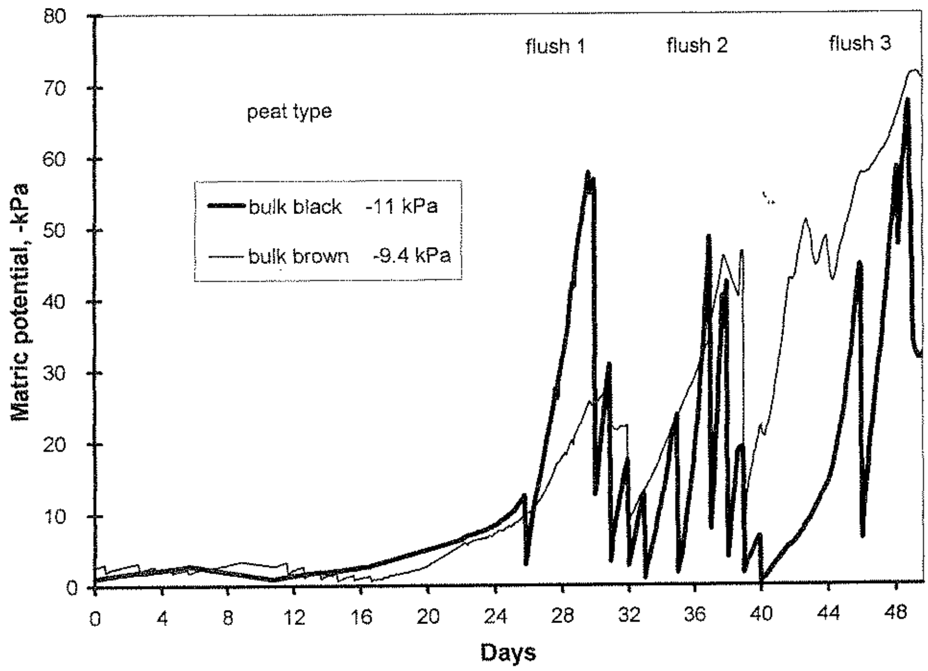


Fig.9b Matric potentials in milled peat / chalk casings, Expt. 4

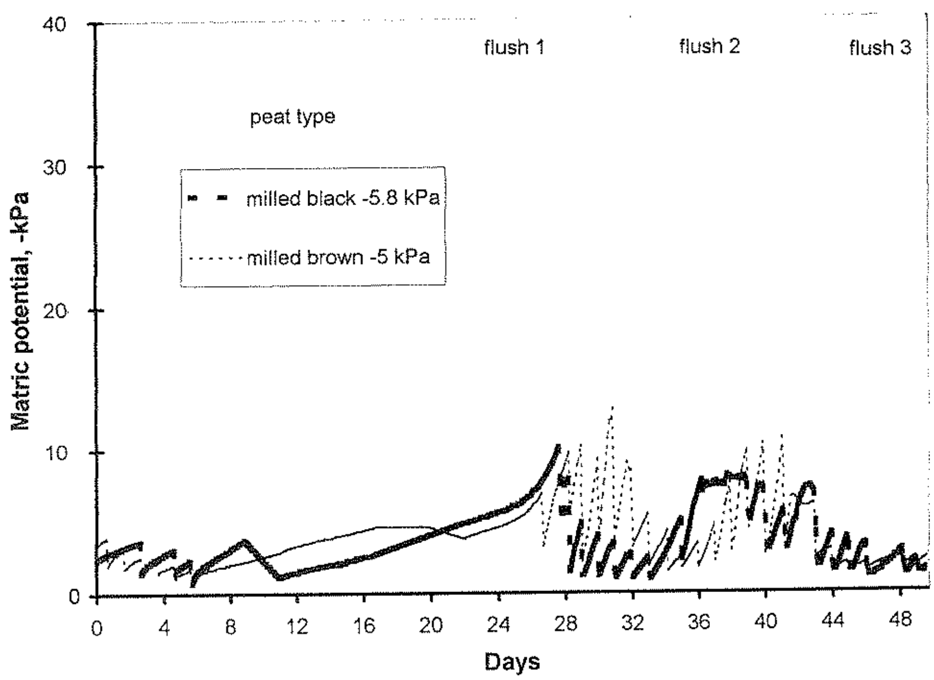


Fig. 10 Compost and casing moisture status
25% sugar beet lime casings

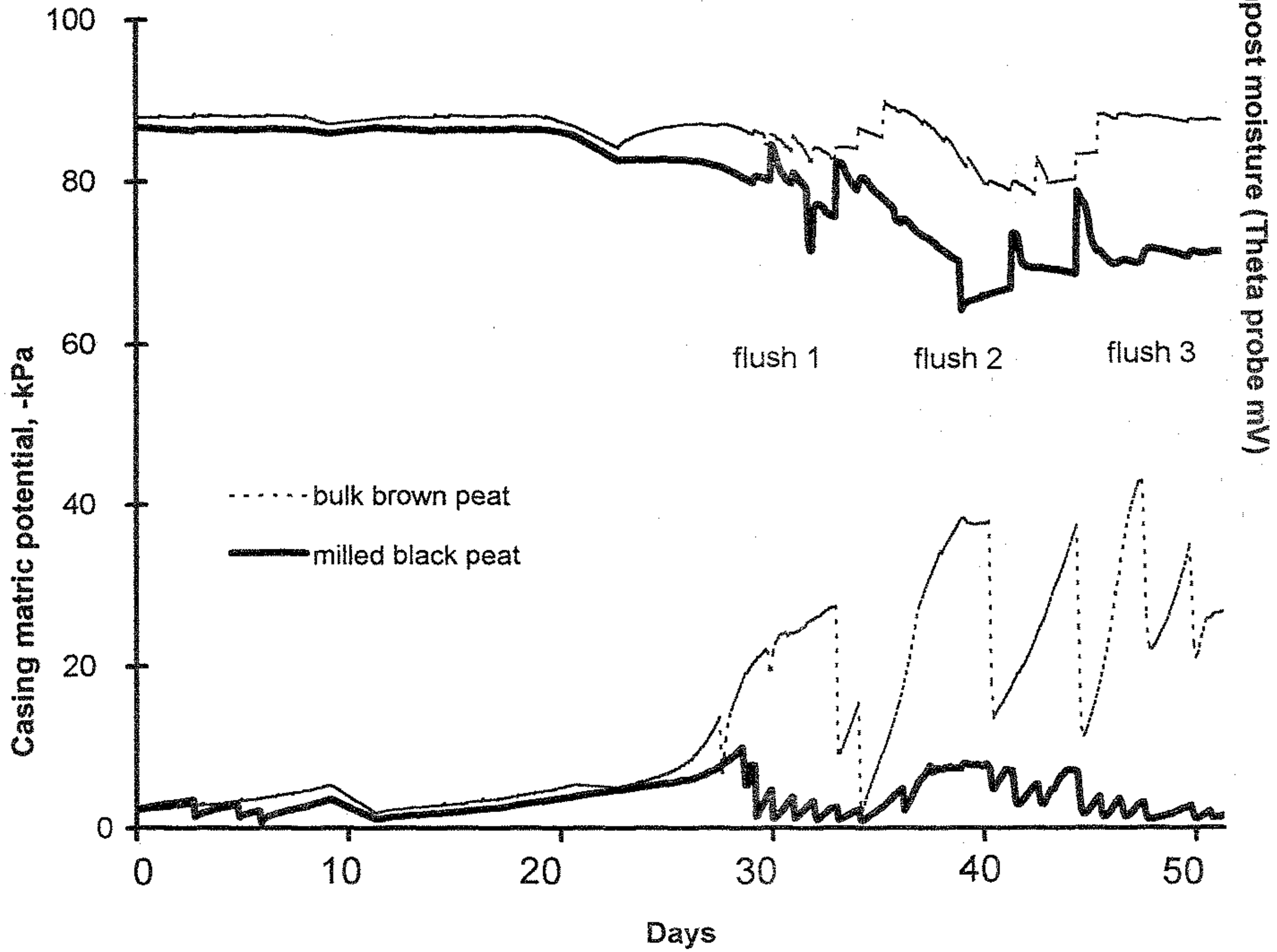


Fig.11 Average casing matric potential measured with Buchner funnels and Electronic tensiometers

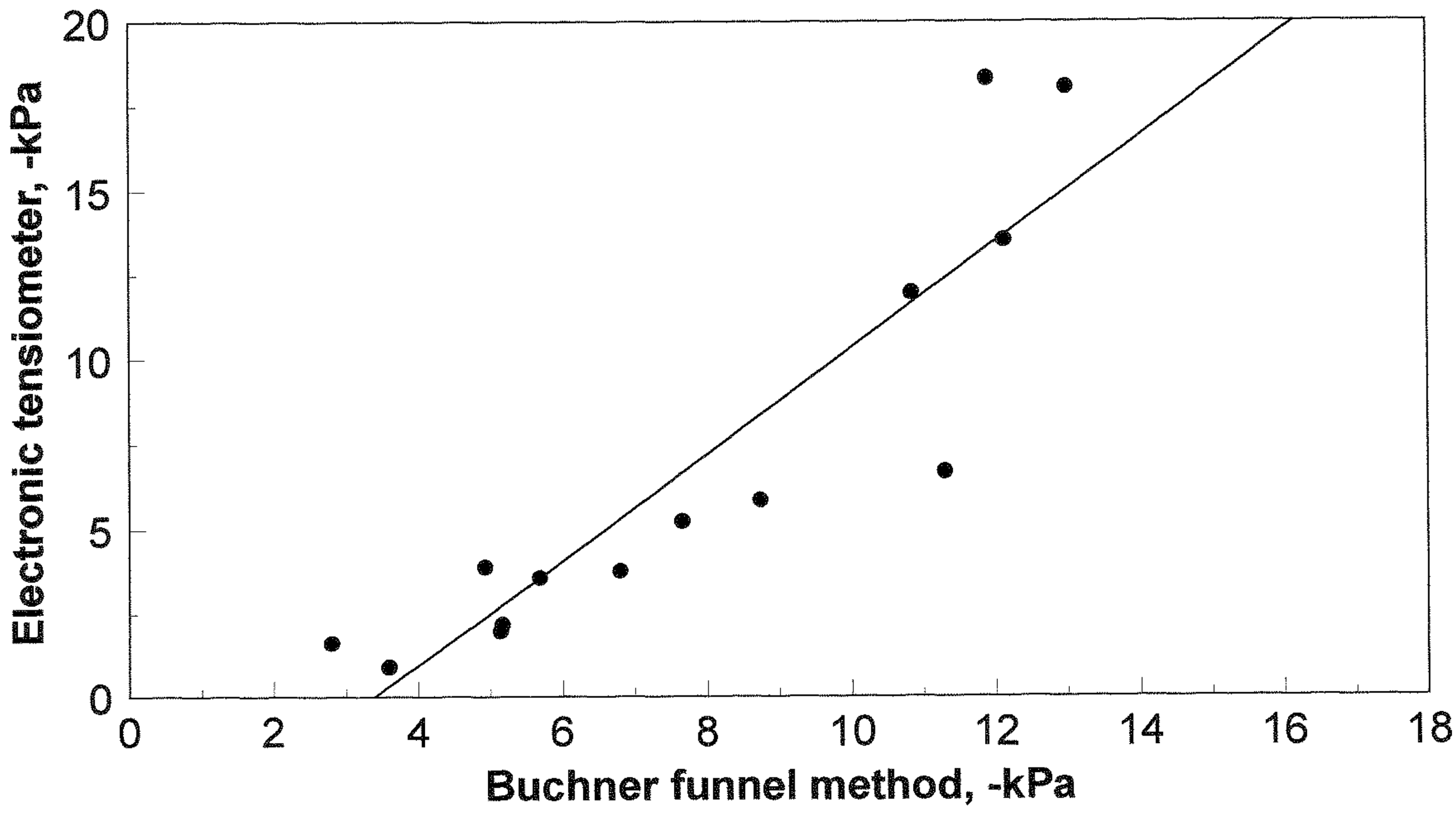


Fig.12 Piche Evaporimeter readings

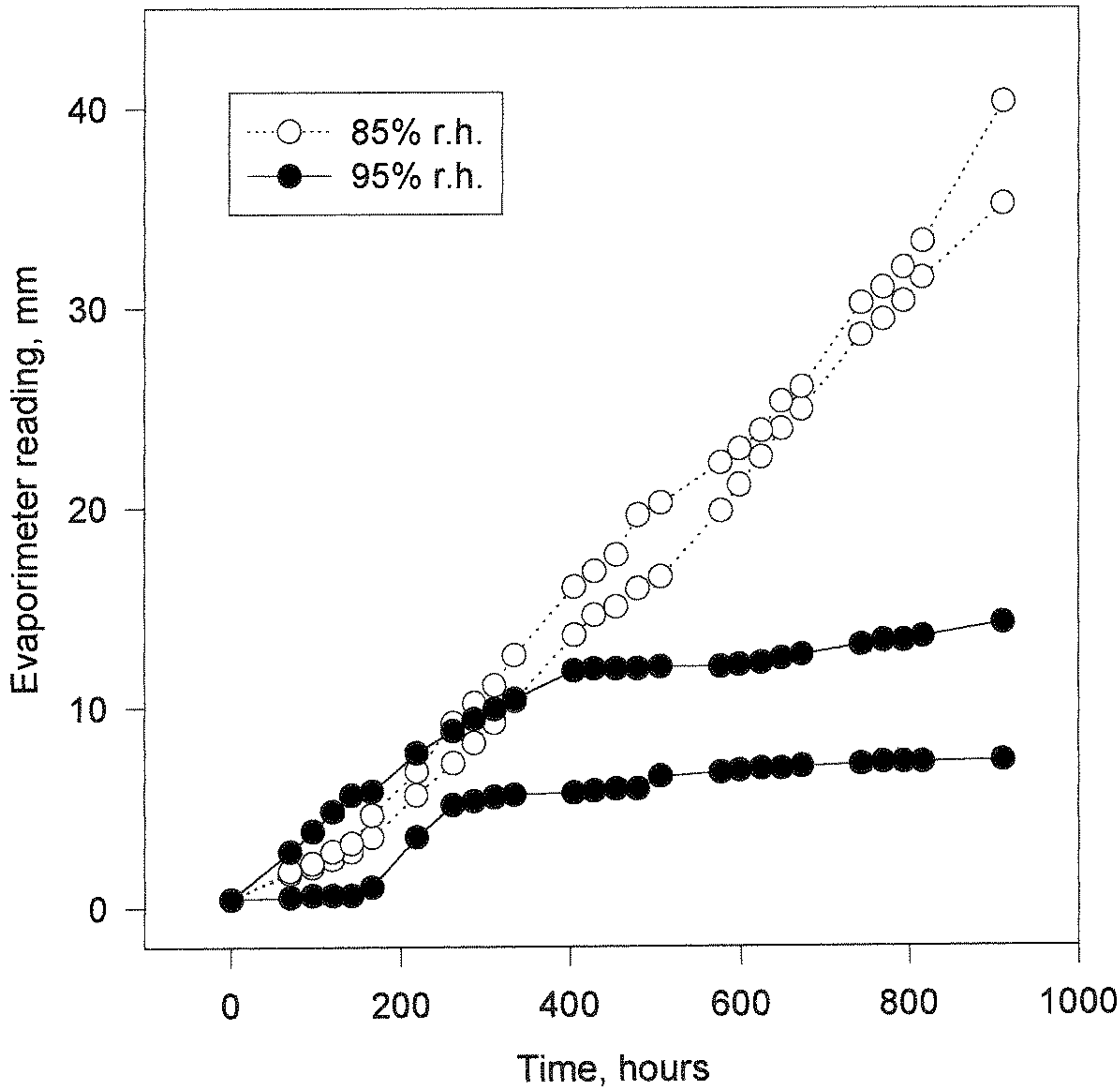


Fig. 13 Relationship between casing water potential, cropping humidity and the percentage of hollow mushrooms