November 1978 Number 71

The Mushroom Journal

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THE OFFICIAL JOURNAL OF THE MUSHROOM GROWERS' ASSOCIATION OF GREAT BRITAIN AND NORTHERN IRELAND

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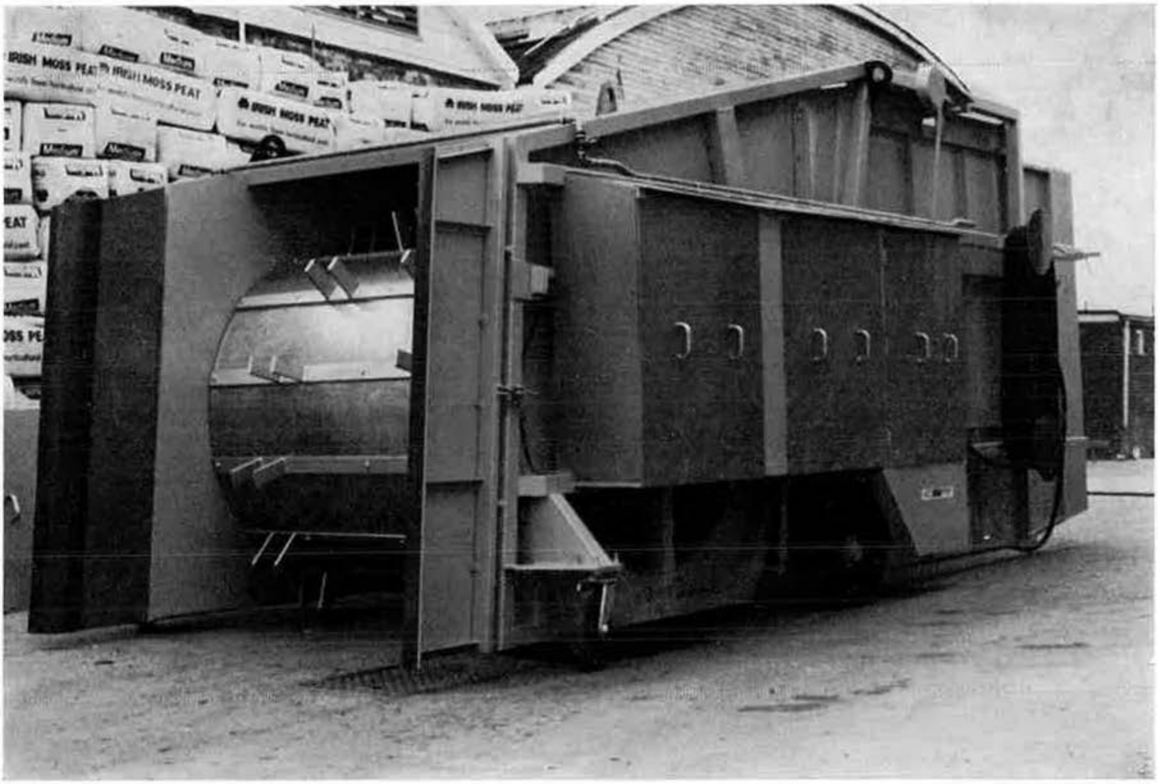

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THE MUSHROOM JOURNAL No. 71 NOVEMBER 1978

Editor: Fred. C. Atkins, O.B.E., 11 Apsley Way, Longthorpe, Peterborough PE3 6NE

Editorial . . .

CLUTCHING AT STRAWS

The European Economic Community has issued a list of 'some noteworthy weather extremes since 1960', in which the following affected Britain, according to the *Daily Telegraph* of 12th September 1978:

In 1962–63 — Coldest weather since 1740.

In 1963–64 — Driest winter in England and Wales since 1743.

In 1974–75 — Mildest winter since 1834.

In 1975 — Great heat wave in Western Europe.

In 1975–76 — Great drought in which rainfall from May 1975 onwards for 16 months was the lowest since the beginning of the record in 1727.

In 1976 — Great heat in June and early July with temperatures over a 24-day period exceeding the highest monthly mean in the 300-year record.

The EEC also says there is 'growing concern that maybe man himself is contributing to increased climatic variability or even to some major climatic changes through chemical and thermal pollution of the atmosphere.'

UK mushroom growers who keep records of past cropping levels may like to compare their yields per sq. ft. in those and more normal seasons. It would be most interesting if anyone were to find a correlation.

'The weather' is often exasperating and no year seems 'normal'. But in my advisory days I would invariably go first to the compost stacks, study the temperatures recorded, and look closely at the *condition of the straw*. Straw, physically, may be as important as is the nitrogen chemically.

Can one assess the nature of the many different straws we have to handle? An approach may have been indicated by MacCanna and Gormley. They measured the texture of mushroom caps with an Allo-Kramer Shear Press, they told us in *Mushroom Science* **7**, 1968, 488–89. If it is not applicable to the monitoring of straw texture, what about Sainsbury's machine? 'It can measure the degree of snap in biscuits', says the *Sunday Telegraph* of 28th August 1977. 'A simulated jaw can chew tough meat and register the right amount of disapproval on a graph. It can test the point at which string breaks.'

I have been discussing these questions with **John Fletcher,** who tells me a lot of work is going on with straw because of its feeding value for ruminants. **F. G. Palmer,** for instance, of the ADAS Nutrition Chemistry Department at Cambridge, has quoted 'D' (digestive) values for a number of barley varieties in a paper in the *ADAS Quarterly Review of 1976*.

Fletcher says: 'I understand that sheep are kept specifically for the extraction of ruminant liquor for 'D' value determination. The microbiologists have been looking at various bacteria which will do the same job with the view to being able to harness the enzymes produced by the bacteria in a test-tube in order to determine the degree of activity on a sample of straw and, therefore, its feed value.

'It seems to me that this process is almost the exact reverse of what the mushroom grower might require, and the results from such a test-tube composting could be of value to the

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industry. It is possible that I am misleading you with "D" values, but as they are basically the nutritional value of the straw it seems to me that they have direct relevance to mushroom composting'.

This year in general has been a difficult one for growers. That indicates a common causal factor. Can we blame this year's weather? Perhaps we should look back on *last year's* weather and its affect on the cereal harvest?

Get away from the farm for a couple of days and attend the Straw Conference in Oxford on 30th November and 1st December. The organizers tell me they have already had a number of inquiries from *Journal* readers about the second day. It is suggested that 'it may well be that mushroom growers would also be interested in some of the earlier sessions. Compost makers will be interested in various methods of collecting and mechanically treating straw. They may well take an informed interest in, for instance, the fermentation of straw and the chemical treatment of it. **Dr. J. J. Nielsen** from Denmark will be discussing the mixing of straw with other cellulosic and starchy materials in order to generate enzyme action in the digestive process'.

For further details write to Straw Conference, ADAS, Marston Road, New Marston, Oxford (telephone Oxford 44891).

DIARY DATES

1978

November 30–December 1: ADAS Conference on cereal straw. Oxford. (The second day could be of particular interest to mushroom growers.)

1979

January 24: Aston Seminar 4 on Mushroom Diseases and their Control.

April 3–5: 'British Growers Look Ahead.' Brighton.

mid-April: Short Course. Bath.

June 18–20: 22nd Short Course. Pennsylvania State University.

October: MGA Annual Meeting and Conference. Yarmouth.

1981

Eleventh International Conference on the Science and Cultivation of Edible Fungi. Sydney, Australia. (Why not ask the Secretariat, GPO Box 2609, Sydney, NSW, Australia 2001, to add your name to the mailing list?)

SOMYCEL LINKS WITH MONTEREY MUSHROOMS

An agreement has been reached between **Heinz Perrier S.A.** and **Amfac Foods Inc.** under which Amfac Foods Inc. will manufacture Somycel spawn under licence in the USA. The agreement was signed in May 1978.

Under the agreement, Amfac Foods Inc. will build a Spawn Plant in California and establish a distribution operation covering mushroom growers in USA, Canada, Mexico and Puerto Rico. Target date for production to commence is 1st July 1979. Until that date, Somycel USA will continue to operate from Avondale, Penn.

The new plant in California has been designed by Somycel technologists and will be built to produce spawn using the same process as at Langeais, France. Master inoculating sticks will be supplied to California from France, and the services of Somycel scientists and technologists will be available to Amfac Foods Inc. for current and future technology.

The Californian plant will be under the direction of **David Claassen**, President of Monterey Mushrooms, a subsidiary of Amfac Foods Inc. Both Mr. Claassen and the Management of Somycel are confident that North American growers will receive the same high quality spawn from the Californian plant that they are currently receiving from France. They will also benefit from a better delivery service which has suffered in the recent past due to problems at docks and airports.

JACK BURGESS JOINS MIDDLEBROOKS

John (Jack) F. Burgess joined Middlebrook Mushrooms, Brayton, as Selby Farms General Manager on 25th September 1978, in charge of the Brayton, Gateforth and Thorpe Farms.

Mr. Burgess is married with a son and daughter both studying at university, and is a Yorkshireman, having been born in Keyingham, near Hull. He has recently returned after some time in the Lebanon where he was general manager of a fruit and vegetable company. Prior to this he was with Booker Health Foods and Bovril/Marmite.

THOUGHTS OF A PAST CHAIRMAN

I have been asked by the new Editor of the *Journal* to write 'a brief résumé of your thoughts over the past twelve months'. As this will appear in print some time after I have handed over the chain of office, it makes the writing of this a little strange. I imagine the feeling I have is rather akin to that of man who has been asked to write his own obituary. I have decided to use, as the basis for these 'thoughts', my speech at the end of our 1978 Conference. So to all those who were present at the annual dinner and heard my rendition, I apologize if what follows seems a bit familiar.

David Stanley-Evans

I have always felt strongly that a Chairman should 'do his own thing'; all men are individuals to a greater or lesser extent, and I think those elected should execute the job of Chairman in their own individual way. By doing this there can be a considerable benefit to our Association, for not only will different skills be applied in different directions, but also the general direction of the Association will not be allowed to become too radical or reactionary. By the time a grower is elected as Vice-Chairman by the Executive, the members of that committee know him fairly well, certainly in relation to the way he will acquit himself as Chairman. Therefore there is to a large extent a built-in safeguard. I would go so far as to say that provided a Chairman is consistent, in that his work as Chairman is carried out at a level and standard similar to his previous work on the Executive, it is more the fault of the Executive for electing him than of the individual if his performance disappoints.

I have enormously enjoyed my term as Chairman and, although I have not made a conscious effort to 'do it my way', I am sure that I have done just that, simply because I have made no attempt to avoid an individual approach. I am sure there are some in our Association who feel I have done too much, and been too closely involved in the running of the MGA — certainly my fellow directors at home would not argue. This is the only way I know how to work in such a situation. If it is my head on the chopping block, then I want to be fully informed and to have been involved in the making of any major decisions. However, I would never say that my way was the only one. Every Chairman in my opinion should do the job his way and for that year it will be 'the right way'. The one very real danger is that precedents are set and a Vice-Chairman, when he takes office as Chairman, could tend to follow the work pattern of his predecessor. But I think this is avoided to a great extent and I hope and pray we never reach a stage where the duties of a Chairman are decided for him, and the whole job is formalized. If this ever happened, I am sure the Association and its members would be the losers.

In the future, it is vital that the duties of Chairman can be sufficiently flexible to allow any member of our Association to hold office, be he a grower in the North of Scotland or one in Greater London. Twenty years ago there were Chairmen whose only regular tasks were to attend Executive meetings and make a regular weekly 'phone call' to the MGA office. This can and must be possible in the future.

ARTHUR TATTUM

We learn with regret of the sudden death of Arthur Tattum, Executive Manager in charge of Country Kitchen Foods' Avon Farm. He died suddenly of a heart attack on 15th August, at the age of 39.

Arthur joined Country Kitchen Foods in 1973 after a very successful career with the National Coal Board. Originally working as Deputy Farm Executive at the Avon unit, he was subsequently promoted to Manager of Buxton Farm, returning to Avon when that farm closed in 1976. He will be much missed by all his friends and colleagues.

Dr. Zenjiro Takahashi is a distinguished research scientist in the mushroom field in Japan. Having graduated in physical chemistry at Hokkaido University in 1935, he engaged in chemical research in Tohoku University and in 1938 moved to the Toyo Institute of Food Technology to do scientific research. In 1948 he began to investigate the possibilities of rice straw as a substrate for mushroom growing at the Toyo Institute as chief of the mushroom research section. In 1968 he transferred to the Toyo Junior College of Food Technology where he heads the mushroom team and continues his studies of rice-straw utilization.

Much rice is grown in Europe, particularly in Italy, Hungary and Rumania, and Takahashi and two colleagues have prepared this paper on rice-straw mushroom compost for the *Mushroom Journal.*

Dr. Z. Takahashi

RICE-STRAW COMPOST: A NEW FORMULA

Z. Takahashi, S. Takahashi and N. Oka

Toyo Junior College of Food Technology, Japan

Rice straw is an essential substrate for the growing of *Agaricus bisporus* in Asia. In Japan, Taiwan and Korea, rice-straw composts have been used for many years with consistent results. Rice straw is rich in nutrients and regarded as the best material for mushroom growing in all countries which produce rice, e.g. China, the Philippines and Indonesia.

The real development in Japan of mushroom growing on rice straw was initiated on a very small scale in 1948 by the present author (Z. Takahashi). By 1970 there was a cropping area of more than a million square metres; the entire output was canned. Production from rice-straw composts started in Taiwan in 1959 and in Korea in 1967.

In Japan, unfortunately, mushroom production in recent years has decreased for economic reasons. In practice the question of economics in mushroom growing is becoming more and more important. For instance, low capital expenditure on houses and composting machinery and low manual-labour costs are required.

We have achieved consistent results recently from rice-straw compost. This method is effective for the economical use of raw materials and the shortening of hours of labour. This paper is a report on the growing method.

Preparing the compost pile: short composting technique

Materials: Rice Straw	(air dry)	(% of dry matter)
Composition:	Crude Ash	13.44
	Total Nitrogen	0.74
	Crude Cellulose	36.08
	Reducing Sugar	27.73
	Lignin	16.58
	K_2O	2.1
	Na_2O	0.07
	CaO	0.41
	MgO	0.18
	MnO	0.11
	CuO	0.004
	Fe_2O_3	0.042
	ZnO	0.01
	Al_2O_3	0.035
	SiO_2	12.6
	P_2O_5	0.26

Mushgen (Ferro Enamels (Japan) Limited, proprietary activator)

Composition:	Na_2O	1.5
	K_2O	2.0
	CaO	33.5
	MgO	3.4
	MnO	1.8
	Fe_2O_3	2.4
	Al_2O_3	3.9
	SiO_2	13.6
	B_2O_3	0.8
	P_2O_5	10.1

The figures given are percentages. Metal ingredients are supplied in sintered form.

Straw and Fertilizers

Our formula which has been tried by many growers with satisfactory results is as follows. The figures are given in kg. per ton of rice straw.

Air-dry Rice Straw	1,000.0 kg.
Ammonium Sulphate	22.5 kg.
Urea	7.5 kg.
Mushgen	20.0 kg.

Composting Schedule

A basic turning schedule could be as follows:

Day −1: Chop and heap the straw, adding water.

Day 0: Make the stack, adding the nitrogenous supplements, Mushgen and any water required.

Day 5: First turn, water as required.

Day 10: Second turn, fill into peak-heat.

Stacking of Rice Straw

The length of the composting time determines the loss of organic materials.

The rice straw is chopped by machine. The chopped straw about 15 cm. long is assembled on the concrete area in a large heap 2.0 metres high, 1.8 metres wide, and 17 metres long by Tekla Composting Machine.

Such a pile usually contains 4 tonnes of straw. The turning machine would then be required to mix the ingredients. The straw must be thoroughly mixed as the pile is built up. At the same time, tramping and packing down would be required to keep it compact. The heap may be turned by means of a mechanical turner (e.g. a Tekla).

Water is added liberally with a rose spray as the pile is built up.

Attempts must be made to get the required amount of water into the compost on the first two turns so that subsequently little or no water need be added.

Composting

One day after assembling the heap, all ingredients are spread over the surface and the pile is turned.

Thorough mixing is essential during this turn. Water is again added but much less will be required. If the pile is loose, tramp it down again. Within two days the compost will be hot and generate heat up to 73°C in the upper and inside part of the compost.

First Turn

The first turn is generally done 5 days after the pile was made. Ordinarily in this process only a little water will be required.

After this process the temperature inside the compost will reach 76°C.

Second Turn

In five days a second turn is made after which the compost may be ready for filling. The compost temperature is 75–76°C. It has a pH of 7.8 and a mild smell. It may be put into the house immediately.

Filling

The shelf system is used in Japan. Synthetic compost generally from 100–150 kg. of original straw by our method fills shelf area 3.3 sq. metres. In the most recent trials our composts have produced between 350 and 400 kg. of mushrooms per tonne of compost at filling.

The compost at filling generally has the following analysis:

	(% of dry matter)
Crude Ash	21.41
Total Nitrogen	1.80
Crude Cellulose	30.62
Reducing Sugar	21.50
Lignin	15.31
K_2O	2.65
Na_2O	0.12
CaO	1.44
MgO	0.34
MnO	0.11
CuO	0.0007
ZnO	0.016
Fe_2O_3	0.15
SiO_2	17.20
P_2O_5	0.71

The beds are generally filled after the second turning. The filling of the beds constitutes an adequate mixing of the straw.

Peak-Heat

After filling, the procedure generally is the same as with horse manure. Pasteurization for seventy-two hours at a temperature of 55–60°C is adequate provided the pH is 7.6. If the pH is below 7.6 the house may be cooled down as rapidy as possible and the spawn planted. After peak-heating the compost generally has the following analysis:

	(% of dry matter)
Crude Ash	24.68
Total Nitrogen	1.97
Reducing Sugar	18.90
Lignin	15.59
K_2O	3.03
Na_2O	0.095
CaO	1.55
MgO	0.45
MnO	0.1
CuO	0.0009
ZnO	0.015
Fe_2O_3	0.17
SiO_2	19.80
P_2O_5	0.65

Immediately after cooldown at the end of peak-heat the bed compost is planted with spawn of *Agaricus bisporus* based on sterilized rice-straw compost or spawn grown on wheat grain.

Casing

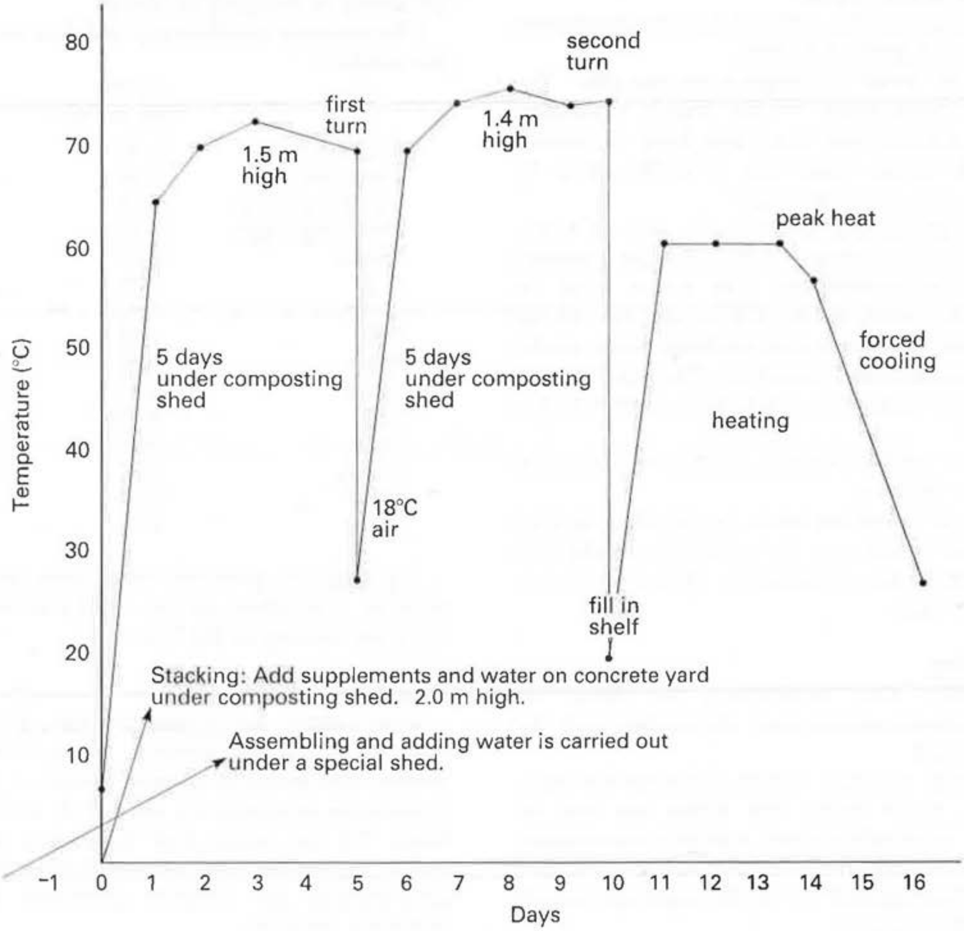
Three weeks after spawning, sphagnum peat (Hokkaido) pasteurized with hot water and neutralized with 2% of calcium hydroxide is used. The casing layer is 4 cm. deep.

Picking starts three weeks after casing. Yields of mushrooms (uncut) are as follows:

Relationship between two different weights of straw per bed:

Quantities (kg.) of fresh rice straw per sq. metre	Picking days	Yield (kg.) of uncut mushrooms per sq. metre
30	60	15
45	60	24

Substrate temperature throughout composting period and pasteurization



Yield

Mushroom yields were in excess of 20 kg. per sq. metre. The beds flush every 5 to 7 days depending on the temperature, strain of spawn and the stage at which the mushrooms are picked.

Cropping in an air temperature of 16–17°C. produced the best results in yield.

The composition of mushrooms grown by our method is as follows:

	(% of dry matter)
Moisture	92.9
Total Nitrogen	6.39
Reducing Sugar	18.25
Crude Ash	10.97
K_2O	7.22
Na_2O	0.053
CaO	0.036
MgO	0.26
MnO	0.003
CuO	0.005
ZnO	0.011
Fe_2O_3	0.004
Al_2O_3	0.0005
SiO_2	0.1
P_2O_5	3.44

Nowadays in Japan this method of mushroom growing is in common use, with 350,000 square metres a year laid and an average yield of 18 kg. per sq. metre (uncut mushrooms); the best yield is 30 kg. per sq. metre.

We expect this method to become widely used in Asia.

PICKING BY POST

People who complain of postal delays may be interested in a letter in the correspondence column of a Barrow-in-Furness weekly paper from a reader who saw four Post Office vans parked on a roadside while six postmen were furiously picking mushrooms in a nearby field.

Peterborough in *Daily Telegraph*, 31st August 1978. He added this footnote four days later.

My recent note about four Post Office vans parked in a row near a field in which six men were engaged in unaccustomed toil picking mushrooms has led to a curious riposte from the Post Office. After lengthy enquiries Post Office officials have absolved postmen from any blame. It was apparently six men from the telecommunications department who were so hard at work.

Fred. C. Atkins *writes about:*

GERDA FRITSCHE — JENNY WALTON — ANDY ANDERSON

The dedicated Fritsche

During the French Congress I had the opportunity to talk again to the dynamic, intellectual, redhead **Dr. Gerda Fritsche.** I asked her about her career.

She was born in Merseburg in central Germany in 1929. 'Before I could study horticulture,' she told me, 'I had to gain some practical experience. I worked for a while on a small nursery at Ilfeld in East Germany, and then I spent almost two years as a gardener in Erfurt and at a nursery where vegetables and flowers were bred.

'I became most interested in plant breeding and from 1952 until 1956 I studied horticulture at the Technical University in West Berlin. Subsequently I went to the Institute of Heredity

and Breeding Research and in 1957 I began to work on mushroom genetics with **Professor Dr. von Sengbusch** at the Max Planck Institute for Cultureplantbreeding in Hamburg.

'My project there was research into methods of breeding and the maintenance of strains of *Agaricus bisporus*. I graduated in 1964 in West Berlin; the title of my thesis was Trials on the Question of the Transference of Characteristics with the Cultivated Mushroom *Agaricus* (*Psalliota*) *bisporus* (Lge.) Sing.'

Professor von Sengbusch retired almost immediately after the Hamburg Congress and the Max Planck Institute there was closed. The mushroom department was enabled to continue for a further three years. Gerda stayed on until the Experiment Station in Horst, Holland, had a vacancy for a scientist to work on mushroom strains and breeding. She could not resist the challenge, and was glad to be able to continue her studies in such a well organised station. In 1971 she began to work there, mostly on *Agaricus bitorquis*. Her success in that field was demonstrated by Darmycel's commerical interest in her strains K26 and 32.

Is your work confined to *bitorquis*, I asked her? She replied: 'No. I am also breeding *A. bisporus* and have now started on *A. arvensis*. My duties also involve comparing current commercial strains and researching into the maintenance of strains.'

The mushroom industry is fortunate to have such a dedicated scientist working in these significant fields.

I am always interested in people's outside interests; what are hers? 'I love Nature and like to walk and swim. Furthermore I like to hear music, especially classical music and folk songs. I am in the choir at my church.'

Welcome Jenny!

Miss **Jennifer Walton**, who has joined the MGA as Secretary, is in her late twenties. She is of farming stock, coming originally from County Durham. Having taken her 'O' levels at school she spent six years in the Civil Service.

During that time she travelled overland to India with a Commonwealth Expedition and two years later, having been invited to lead a contingent of the same Expedition to the Far East, she resigned from her job to do so.

'When I returned home,' Jenny tells me, 'I started training to be a nurse, but quickly decided it wasn't "me", so I studied shorthand and typing and joined the BBC, where I spent the last four years working for the early-morning Farming Today.'

Miss Jennifer Walton

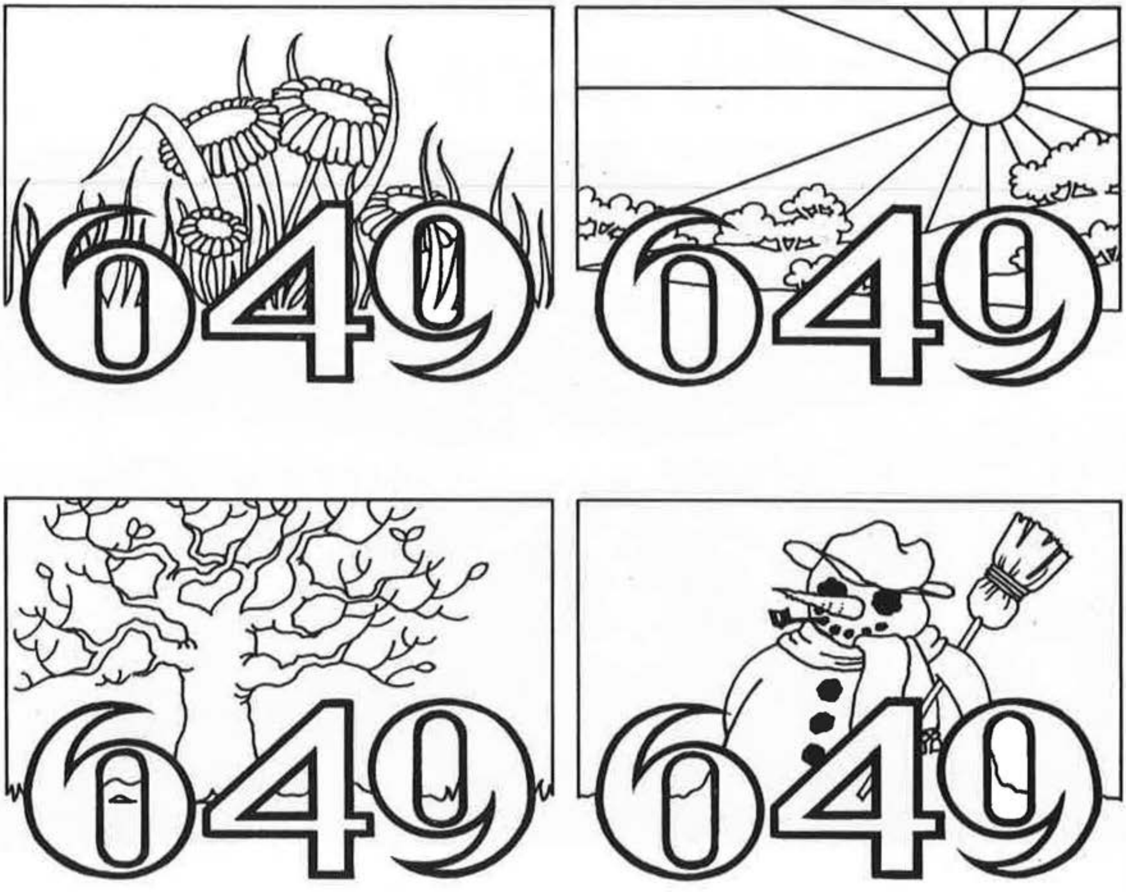
And in her spare moments? 'I live in central London, enjoy the theatre and entertaining, and also do a certain amount of work for the national society for mentally-handicapped children.'

Another Lambert Link

Another link with the past has been broken by the death of **Forrest E. Anderson,** of Glenmore, Pennsylvania. I first met Andy in June 1958, when I was his guest at a Coatesville Rotary Club lunch. He was a son-in-law of the legendary Uncle Lou Lambert, and I was introduced to him by George Lambert, Ted's brother, then in charge of the L. F. Lambert Inc. mushroom cannery. He was good company.

FULLER HOPE

G. Fuller, of Hazeldene, Puddock Road, Warboys, has applied for permission to build five prefabricated mushroom growing sheds near his home. *Cambridge Evening News*, 22nd August 1978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The significance of gypsum applied to mushroom compost, in particular in relation to the ammonia content

J. P. G. Gerrits, *Mushroom Experimental Station, Horst (L), the Netherlands*

Accepted: 15 September 1977

Key words: mushroom, gypsum, mushroom compost, ammonia

Summary

The way gypsum affects mushroom yield has been investigated. With gypsum the nitrogen loss in the compost is slightly reduced and the pH is decreased. Curvilinear relationships were established between the NH_4 content of the compost at filling and the yield in the presence or absence of gypsum and with or without supplementation with soya bean meal. These curves (four parabolas) give a clear picture of the significance of gypsum under various circumstances. The optimum quantity of gypsum proved to be 25 kg. per 1000 kg. of horse manure. Its time of application is not very important, but an early application favours a uniform distribution and a longer action. The drop in pH caused by gypsum influences the dissociation of NH_4^+ ions considerably, i.e. in the presence of gypsum less NH_3 is present in the compost. A possible mechanism by which gypsum lowers the pH is discussed.

Introduction

During the preparation of compost for mushroom growing a specific microflora develops in the compost, and is responsible for the conversions taking place during composting. For the development of the right microflora two factors can be considered of primary ecological importance. The first one is the amount of water, which is directly responsible not only for the moisture content of the compost, but also for the amount of air present in the compost heap (Gerrits, 1972b). The second factor is the ammonia content. It has already been shown that for horse manure compost (Gerrits, 1977) as well as for synthetic compost (Gerrits, 1974) the optimum percentage of NH_4 at filling amounts to 0.4% with a pH between 8.3 and 8.5. At the same time a relationship between this NH_4 content and the length of the peak-heating process was established (Gerrits, 1976a).

Gypsum, normally added in a proportion of 25 kg. but sometimes of 10–15 kg. per 1000 kg. of compost, also plays an important role. According to Pizer, gypsum strongly affects the structure of the compost, whereas Treschow points out that Ca^{++} ions could prevent a harmful effect of an excess of Na^+, K^+ and Mg^{++} ions. Ca^{++} ions should also neutralize the oxalic acid produced by the mushroom mycelium. According to Pizer (Kligman, 1950), gypsum lowers the pH of the compost. Earlier investigations showed a highly variable influence of gypsum on yield, among others, depending on the nature of the horse manure used and the amount of chicken manure added to it (Gerrits, 1970, 1976a). Riber Rasmussen (1967) and Bech & Riber Rasmussen (1968) could not demonstrate a positive effect of gypsum, but they added at the same time sulphate of ammonia and calcium carbonate to the compost.

In this paper a number of experiments, designed to obtain a better insight into the action of gypsum, will be discussed. The percentage of ammonia in the compost appears to play an important role. Also the influence of the quantity of gypsum and its time of application is studied.

In mushroom growing it is possible to supplement the compost immediately before casing with soya bean meal or similar materials. This method was developed by Sinden & Schisler (1962) and Lemke (1963) and elaborated for practical Dutch circumstances by Gerrits (1972a, 1976b). In this paper attention will also be paid to the influence of gypsum and the percentage of NH_4 in the compost on the supplementation of compost at casing time.

Experimental

The compost was prepared in heaps of either 600 kg. or 750 kg. of fresh horse manure. In most experiments 16 heaps were built into a

continuous row without separation in order to function as one large pile. The turning schedule — 3, 0, 4, 7, 8 was used throughout unless otherwise indicated. On day -4 the fresh horse manure was weighed and on day -3 wetted with an amount of water dependent on the moisture content of the fresh manure. The quantity of water to be given was derived from previous work (Gerrits, 1972b). For every kg. of chicken manure about 1.5 litre of water had to be added in order to achieve an equivalent moisture content of the compost at various levels of chicken manure (Gerrits, 1977). Normally chicken manure was applied on day 0 at the time of stacking and on day 4 the gypsum (standard 25 kg./1000 kg. of horse manure) was added just before turning. The gypsum used was plaster of Paris ($CaSO_4 \cdot \frac{1}{2} H_2O$). In specially designed experiments the time of application of chicken manure and gypsum was varied. On day 7 there was another turning and on day 8 the trays or shelf units were filled with exactly 100 kg. of compost per m^2. Generally the peak-heating period lasted for 10 days and the mycelium growth 12 days. In some experiments 1 kg. of soya bean meal per m^2 was mixed into the compost just before casing. The compost was cased with 4 cm. of a mixture of black peat, white peat and calcium carbonate. The pH of that mixture was 7.5. Cropping started usually three weeks after casing. The mushrooms were harvested for 5 weeks and all yields in this paper are expressed as kg. cut mushrooms picked in 5 weeks per m^2 and per 100 kg. of compost at filling.

The average composition of the chicken manure was on a fresh weight basis: 37% moisture, 12% ash, 51% organic matter, 2.4% P_2O_5, 24.1% C, 2.5% N and the C:N ratio was 9.5. The chicken manure comes from broilers held for 7 weeks in the pen on wood shavings. The fresh horse manure was supplied by the Compost Enterprise of the CNC (Co-operative Dutch Mushroom Growers' Association) at Ottersum. The average moisture content was 63% varying from 54–74% at the time of arrival.

All the supplements were given per ton of fresh horse manure independent of the variation in moisture content. The reason for this is discussed by Gerrits (1977).

The experiments were carried out either in experimental plots in shelves of 1.3 m^2 in growing rooms of 120 m^2 or in trays of 0.27 m^2 in growing rooms of 25 m^2. All the houses were treated according to the one-zone system. In the houses there are 5 layers with 16 plots or 18 trays in one layer. In most experiments factorial designs were used such as a 2^4 or $4 \times 2 \times 2$ layout or as a randomized block design with 16 treatments in 4 or 5 replicates. The layers were considered as blocks and the treatments were randomized in the layers. The factor gypsum was studied in combination with other factors in 21 experiments. In fresh samples of compost, ammonia was distilled off in the presence of magnesia (MgO) to determine the ammonia content of the compost. This ammonia content is expressed as % NH_4 in the dry matter. In dried, finely-ground samples (0.5 mm. mesh) ash was determined by burning at 600°C., carbon by burning the samples and weighing the CO_2, and nitrogen according to the Kjeldahl method. The pH was measured immediately after the samples were taken and after one day just before the NH_4 was determined.

Results

N, NH_4, pH and gypsum

In Figs 1–4 the amount of chicken manure added per 1000 kg. of horse manure is plotted against some parameters of the compost at filling and at spawning. The relevant relationships are all calculated with and without gypsum. Some data for 0, 100 and 200 kg. chicken manure derived from those figures are tabulated in Table 1. Figure 1 shows that the N content of the compost increases slightly after the addition of chicken manure. With gypsum this N content is somewhat lower than without gypsum. This difference is a result of the influence of gypsum on the ash content of the compost.

Figure 2 shows that the addition of chicken manure increases the NH_4 content of the compost at filling more than the N content. There is no difference between the absence or presence of gypsum. A similar relationship between chicken manure and N and NH_4 content of the compost at filling (only in the presence of gypsum) has already been shown (Gerrits, 1977). Figure 3 shows a similar relationship between chicken manure and NH_4 content at spawning time, i.e. after peak-heating. Also in this figure there is no difference between the lines with and without gypsum.

Figure 4 shows the relationships between the amount of chicken manure and the pH at filling and at spawning time, with and without gypsum, determined directly after the samples were taken and after about one day. The following facts can be established:

— The pH increases with increasing amounts of chicken manure, i.e. a higher NH_4 content gives a higher pH (see also: Gerrits, 1977).

— As a result of the addition of gypsum the pH decreases. The drop in pH at filling is smaller than at spawning.

— There is a considerable drop in pH during peak-heating, already a well-known fact.

— One day after sampling the pH is lower than immediately after sampling. This drop in pH depends on the initial pH value. Figure 5 shows that the pH decreases more at high than at low initial pH values.

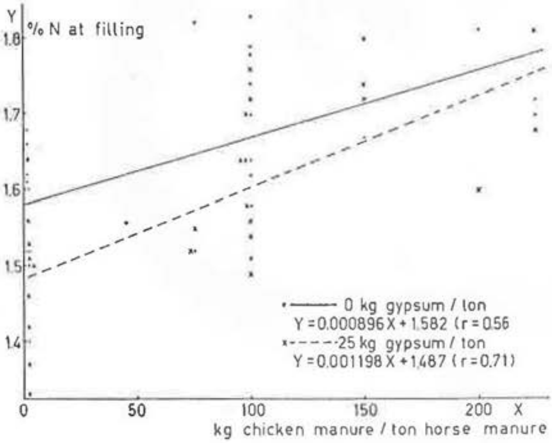

Fig. 1. Relationship between the amount of chicken manure added per 1000 kg. of horse manure and the percentage N at filling with and without gypsum

As has already been noticed the ash content of the compost increases with the addition of gypsum. Therefore the percentage organic matter as well as the percentage N and NH_4 decreases.

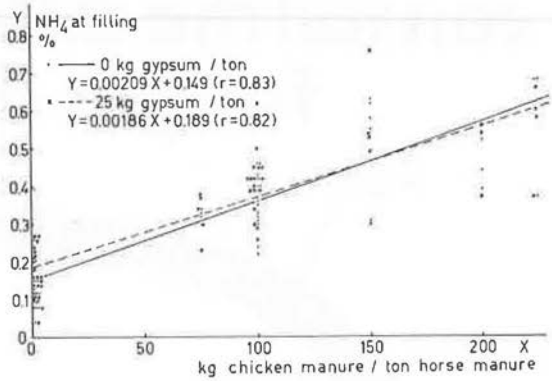

Fig. 2. Relationship between the amount of chicken manure added per 1000 kg. of horse manure and the percentage NH_4 at filling with and without gypsum

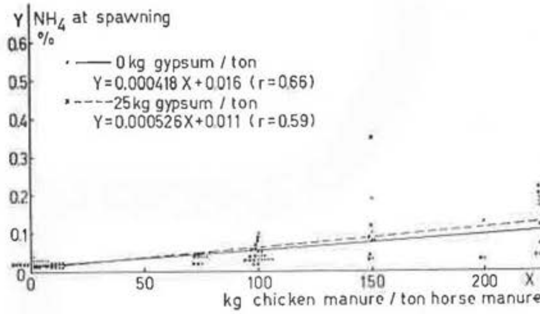

Fig. 3. Relationship between the amount of chicken manure added per 1000 kg. of horse manure and the percentage NH_4 at spawning with and without gypsum

Table 1 Some data derived from Figures 1–4

Chicken manure (kg./1000 kg. manure)	Gypsum (kg./1000 kg. manure)	At filling				At spawning		
		% N	% NH_4	pH at sampling	pH after one day	% NH_4	pH at sampling	pH after one day
0	0	1.58	0.15	8.86	8.21	0.02	8.20	7.85
100	0	1.67	0.36	9.02	8.44	0.06	8.49	8.07
200	0	1.76	0.57	9.18	8.67	0.10	8.77	8.29
0	25	1.49	0.19	8.41	7.83	0.01	7.55	7.28
100	25	1.61	0.38	8.54	8.06	0.06	7.65	7.40
200	25	1.73	0.56	8.67	8.28	0.12	7.75	7.51

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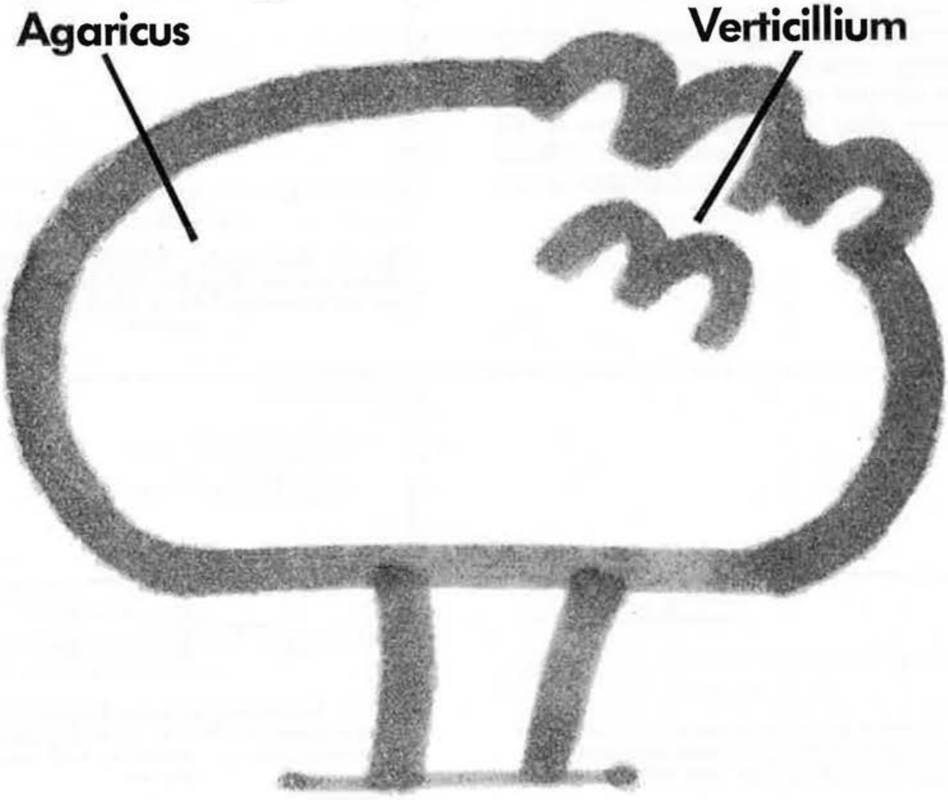

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Table 2. Nitrogen balance at filling (calculated as percentages of the organic matter)

Chicken manure (kg./1000 kg. manure)	Gypsum (kg./1000 kg. manure)	% N	% NH_4–N	% N-total	N-total increase (% units)
0	0	2.10	0.16	2.26	
100	0	2.22	0.37	2.59	
200	0	2.34	0.58	2.92	
0	25	2.13	0.21	2.34	+0.08
100	25	2.30	0.42	2.72	+0.13
200	25	2.47	0.62	3.09	+0.17

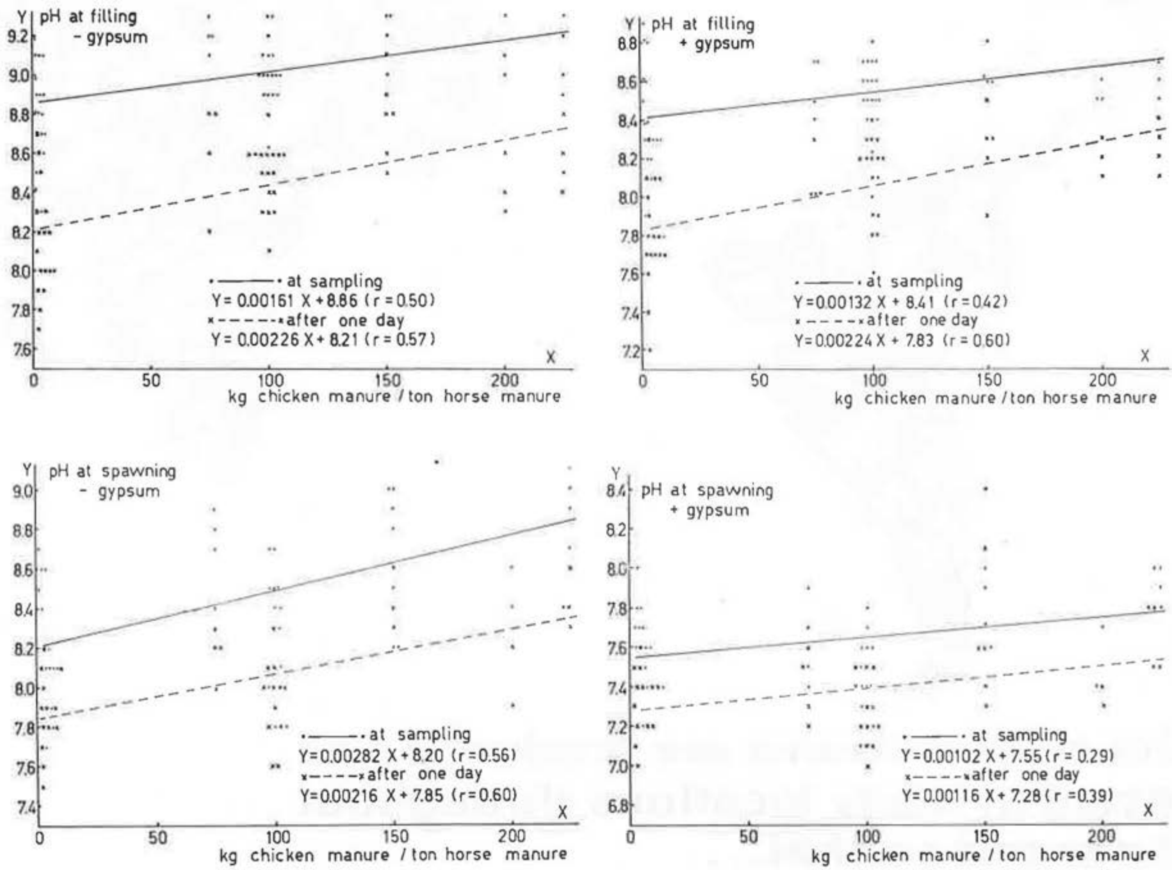

Fig. 4. Relationship between the amount of chicken manure added per 1000 kg. of horse manure and the pH at filling and at spawning, with and without gypsum, determined at sampling time and after one day

Table 2 gives the N content at filling and the NH_4 content, now converted as NH_4–N at filling, as derived from Table 1. Besides, the data are expressed as percentages of the organic matter in order to eliminate the influence of gypsum on the ash content. For this purpose the ash content is used as calculated in Table 3. Now it is clear that through the addition of gypsum the N content as well as the NH_4–N content increases. Therefore the sum of both, i.e. N-total, is slightly higher with gypsum than without gypsum. In the presence of gypsum less N and NH_4 disappear from the compost than in its absence.

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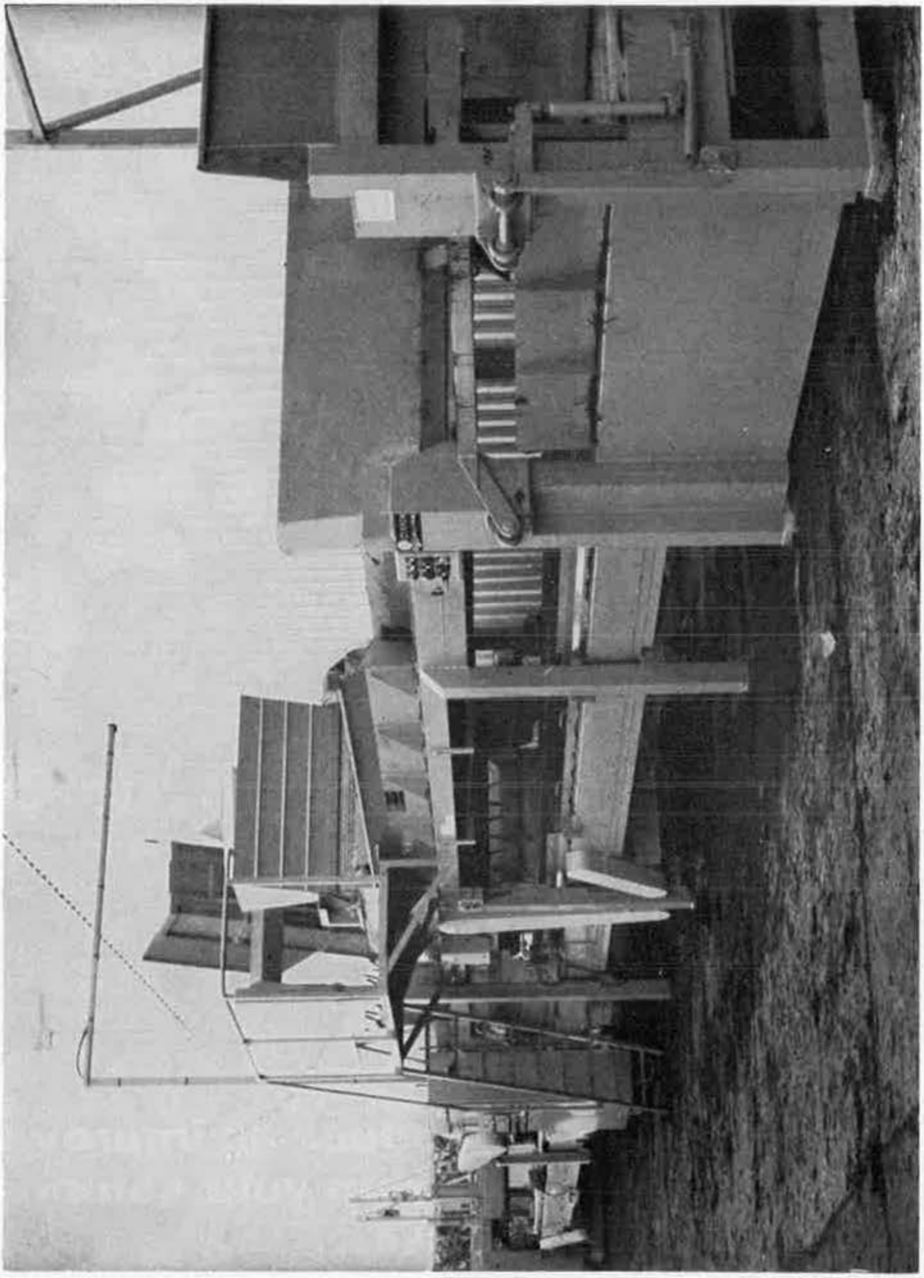

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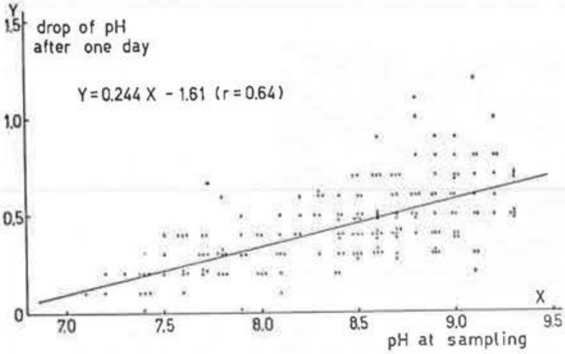


Fig. 5. Relationship between the pH at sampling time and the drop of pH after one day

Gypsum, NH_4 and yield

The NH_4 content of the compost at filling is a good measure of the quantity of nitrogen (e.g. chicken manure) added during the composting process. In Fig. 6 the yield of all experiments is plotted against the NH_4 content of the compost at filling. The yields are expressed in kg. per m^2 and not converted as percentage yield as occurred in a previous series of trials (Gerrits, 1977). So the variation between the different experiments still exists. In spite of this a good parabolic relationship between the percentage NH_4 and the yield was established. The parabola with gypsum closely resembles the one published before (Gerrits, 1977). In any experiment there was always a very significant interaction between the percentage NH_4 and gypsum, i.e. in a poor compost with a low NH_4 content gypsum does not effect yield whereas the effect of gypsum becomes more important as the NH_4 content increases. The results of the individual trials are combined in the two curves in Fig. 6 and give a clear picture of the effect of gypsum. According to the graphs no mushrooms are produced at a NH_4 content of 0.75 % without gypsum, whereas the yield with gypsum still amounts to about

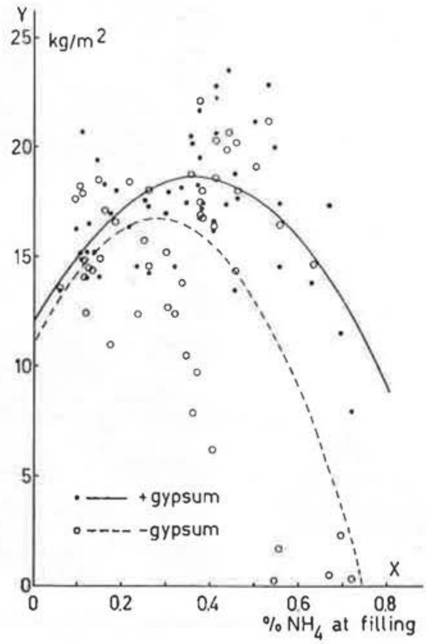


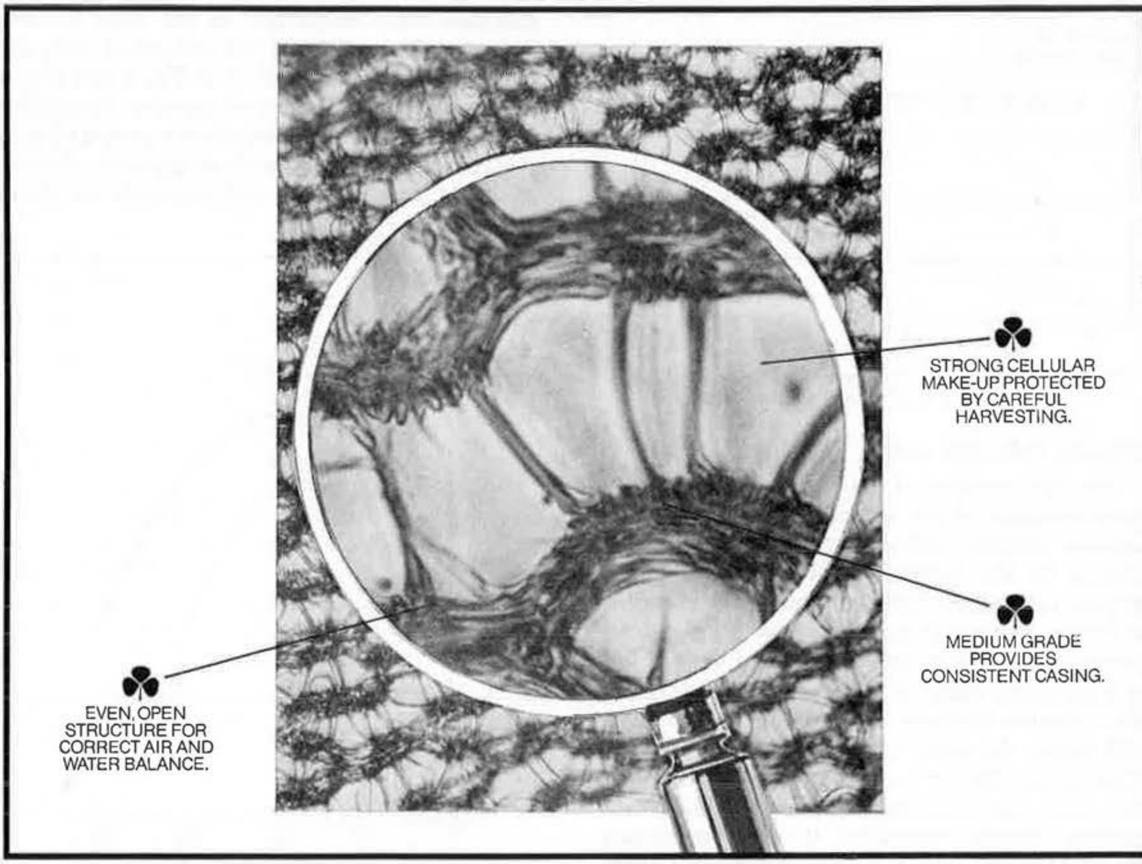
Fig. 6. Relationship between the % NH_4 at filling and the yield in kg./m^2 with and without gypsum. The regression equations are:

+ gypsum $Y = -50.92 X^2 + 37.19 X + 11.91$

− gypsum $Y = -73.88 X^2 + 41.07 X + 11.04$

Table 3. Some average data (determined or calculated) for compost with and without gypsum

	Without gypsum	With gypsum
Determined		
kg. chicken manure/1000 kg. horse manure	85	85
kg. compost/1000 kg. horse manure	1070	1119
% moisture (at filling)	73.2	71.4
% loss in dry matter during composting	29.4	26.4
% ash (estimation)	—	30
Calculated		
kg. dry matter (at filling)	287	320
kg. dry matter (start)	406	435
kg. loss in dry matter	119	115
kg. ash (at filling)	71	96
% ash (at filling)	24.7	30
kg. dry matter per m^2	26.8	28.6
kg. organic matter per m^2	20.2	20.0



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11 kg. per m²! If chicken manure is used, extra water is added to the compost in most cases to achieve an equivalent moisture content in compost with and without chicken manure. The amount of water is not adjusted for gypsum. This resulted in an average moisture content of the compost at filling of 73.2 % without gypsum and 71.4 % with gypsum. The experimental plots were filled with 100 kg. compost per m^2 throughout. Therefore the plots without gypsum contain less dry matter per m^2 than plots with gypsum. However, because the ash content increases with gypsum, the amount of organic matter per m^2 is the same in both cases. Data used for this argument are shown in Table 3. For this reason no correction of the moisture content is applied in the calculation of the parabolas in Fig. 6.

Yield per week

Edwards (1949) established that the addition of gypsum influences the sequence of yield per week (flush). With gypsum his yields were better in the early weeks than in later ones. Table 4 shows the average weekly yield of all experiments with and without gypsum. These yields are also expressed as percentage of the total yield. The data show clearly that in those experiments the sequence of cropping is not affected by gypsum. The average increase in yield with gypsum is equally spread over all cropping weeks.

Influence of supplementation with soya bean meal

In six trials the compost was supplemented with 1 kg. of soya bean meal per m^2 just before casing (Sinden & Schisler, 1962; Gerrits, 1972a, 1976b). It was already known that the increase in yield after supplementation is not always the same and that sometimes there is no effect at all. Figure 7 shows that the percentage NH_4 of the compost together with the use of gypsum can explain much of the variability in the results. In the individual experiments strong interactions could be demonstrated between NH_4, gypsum and supplementation. In order to get a clear survey of the situation parabolas were calculated from the experimental data in the same way as indicated in Fig. 6. Corresponding curves agree well with each other.

Referring to Fig. 7 the following remarks can be made. If gypsum is present in the compost an increase in yield of 4 kg. per m^2 is obtained by supplementing 1 kg. of soya bean meal per m^2 in a compost with a low NH_4 content. With an increasing NH_4 content the effect of supplementation decreases. At an optimum NH_4 content of 0.35 % the effect is still over 3 kg. per m^2. Beyond this the effect decreases to turn at a NH_4 content of 0.6–0.7 % from positive to negative. The position of this turning-point has not to be considered as absolute, but this can vary from trial to trial according to the circumstances. On average, however, it gives a good indication. A combination of compost with 100 kg. of chicken manure as used in practice and supplementation with soya bean meal gives the best results, whereas the risks remain limited. If compost without gypsum is supplemented, there is only some positive effect if the NH_4 content is very low. Even from a NH_4 content of 0.3 % upwards (i.e. lower than the optimum with gypsum) the effect will be negative. Consequently gypsum has also a highly stabilizing influence on the result if supplementation with soya bean meal is practised.

Quantity of gypsum

In the experiments discussed so far 25 kg. of gypsum per 1000 kg. of horse manure was used throughout. In some experiments other quantities were used as well in order to check the optimum amount of gypsum. The result is shown in Table 5. These data show no influence of the amount of gypsum on the NH_4 content at filling and at spawning. There is a definite influence on the pH. With 25 kg. the pH is lower

Table 4. Yield per week with and without gypsum in kg./m² and in % (average yield from all experiments)

		W 1	W 2	W 3	W 4	W 5	total
− gypsum	(kg./m²)	3.3	5.3	3.0	1.6	1.1	14.3
	(%)	23	37	21	11	8	100
+ gypsum	(kg./m²)	3.9	6.7	3.9	2.2	1.4	18.1
	(%)	22	37	22	12	7	100

than with 10 kg. This difference is more explicit at spawning than at filling. With more than 25 kg. gypsum there is no further decrease of the pH. The difference between 10 and 25 kg. is probably brought about by a greater difficulty in distributing small quantities in the compost. Theoretically as little as 10 kg. should be an overdose (Edwards, 1974).

In the yield the difference between 10 and 25 kg. of gypsum is only manifested if the compost is supplemented with soya bean meal. This indicates that under certain circumstances 25 kg. is better than 10 kg. Therefore 25 kg. of gypsum is recommended as a standard. With more than 25 kg. of gypsum the yield does not increase any more. (This last statement has to be considered in relation to the decreasing moisture content and increasing ash content, if the quantity of gypsum added increases.)

Time of adding gypsum

In five experiments the time the gypsum and chicken manure were added was varied. In these experiments there were also treatments without gypsum or chicken manure, whereas in other treatments 200 kg. of chicken manure were used. On the whole the conclusions drawn from the experimental data agreed with those derived from Fig. 6. In Table 6 only variants with gypsum are shown, always with 100 kg. of chicken manure added at day 0.

The time gypsum was added showed no significant effect on yield in any of the experiments. Neither has the time any effect on the NH_4 content and the pH at filling. Only the absence

Table 5. Influence of the quantity of gypsum in kg./1000 kg. of fresh horse manure. The gypsum is applied on day 4 and 100 kg. of chicken manure is used throughout

Exp. No.	Gypsum kg./1000 kg. manure	At filling			At spawning		Yield kg/m²	
		% moisture	NH_4(%)	pH	NH_4(%)	pH	− soya	+ soya
325	0	72.9	0.43	8.8	—	—	—	20.7
	25	73.5	0.45	8.3	—	—	—	23.6
	50	69.9	0.44	8.4	—	—	—	22.5
	75	69.0	0.40	8.4	—	—	—	23.3
433	0	72.2	0.22	8.8	0.03	8.2	18.1	18.0
	10	73.0	0.25	8.4	0.04	7.8	17.3	19.7
	25	70.3	0.30	8.3	0.02	7.2	17.3	21.2
443	0	74.4	0.31	8.7	0.03	8.0	15.2	19.6
	10	71.9	0.26	8.3	0.03	7.5	16.0	19.3
	25	70.4	0.29	8.2	0.03	7.2	17.0	20.4

Table 6. Influence of the time of application of gypsum (25 kg. per 1000 kg. of horse manure) on yield (kg./m²) and % NH_4 at filling (100 kg. of chicken manure is added throughout on day 0)

Exp.		Without gypsum	With gypsum					
			−4	−2	0	2	4	7
354/355	kg./m²	6.2	—	—	17.2	—	16.6	17.3
	% NH_4	0.42	—	—	0.38	—	0.39	0.37
468	kg./m²	19.9	—	—	21.0	—	17.4	—
	% NH_4	0.37	—	—	0.50	—	0.50	—
495	kg./m²	18.8	—	—	20.7	—	20.5	20.9
	% NH_4	0.32	—	—	0.40	—	0.39	0.35
543	kg./m²	20.1	21.8	—	21.8	—	21.8	—
	% NH_4	0.23	0.42	—	0.26	—	0.23	—
551	kg./m²	14.4	—	18.5	16.9	17.9	—	—
	% NH_4	0.53	—	0.60	0.59	0.49	—	—

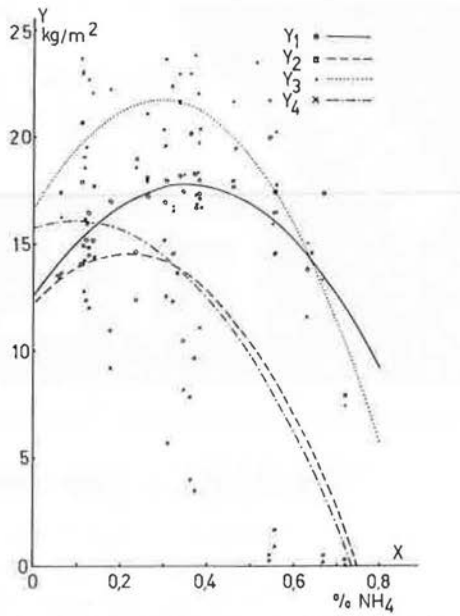

Fig. 7. Relationship between the % NH_4 at filling and the yield in kg./m² with and without gypsum and with and without supplementation with soya bean meal. The regression equations are:

Y_1: + gypsum − soya: $Y = -42.04\,X^2 + 29.62\,X + 12.63$

Y_2: − gypsum − soya: $Y = -50.81\,X^2 + 21.81\,X + 12.29$

Y_3: + gypsum + soya: $Y = -61.17\,X^2 + 35.53\,X + 16.63$

Y_4: − gypsum + soya: $Y = -37.99\,X^2 + 7.05\,X + 15.77$

or presence of gypsum shows variable effects on yield depending on the type of manure used. As far as the quantity of chicken manure is concerned the following can be noted. Compost with chicken manure usually heats better than without chicken manure. It does not matter when chicken manure is added. The NH_4 content at filling increases slightly in proportion as the chicken manure is added later. Ammonia then has a shorter period of time in which to disappear. Only if the chicken manure is added the day before filling (day 7) does the uncontrolled variation between the replicates increase strongly, indicating less efficient distribution resulting in more variable yields. In this case the activity of the compost during peak-heating is higher, and this is likely to be related to the higher NH_4 content.

To get a good crop the chicken manure and gypsum cannot be given too early, but for practical reasons it may be desirable to add chicken manure only after watering the fresh manure, and gypsum at the first or second turning. If chicken manure and gypsum are added rather late a less homogeneous compost will be the result.

Discussion

The pH of a compost is highly dependent on the time interval between sampling and determination. The pH of the samples decreases more at a high pH value than at a low one, suggesting a relationship with a loss of ammonia. However, no obvious drop of the ammonia content could be shown with decreasing pH. Probably there are other possible explanations for this drop in pH such as the establishment of a new $NH_4^+ \leftrightarrows + H^+$ equilibrium in the samples after cooling down.

The drop in pH during peak-heating probably is mainly caused by the disappearance of ammonia either by ventilating the mushroom houses or its incorporation by micro-organisms. The first possibility seems to be the more important one.

The pH of the compost also decreases with the addition of gypsum. The quantity of ammonia under specific circumstances present as free NH_3 depends on the pH. This is accurately known for a solution of NH_4^+ ions in water, e.g. at 25°C. (Fig. 8). It is doubtful how far such a curve applies to a complex medium like compost. As a result of the high salt concentration in the compost the curve could move as a whole to the right or to the left or be less steep. Also the temperature has a strong influence on the dissociation of NH_4^+ ions (Srinath & Loehr, 1974). However, Fig. 8 gives a general picture of what happens to ammonia in the compost. The more chicken manure or other N source is added to the compost, the higher will be the NH_4 content and the lower the 'available' C:N ratio. At the same time the pH of the compost increases and in addition the $NH_4^+ \leftrightarrows NH_3 + H^+$ equilibrium moves to the right. Therefore more NH_3 disappears and the pH falls. Some sort of equilibrium arises at a certain NH_4 content and a certain pH. If the pH decreases further by adding gypsum the equilibrium just mentioned moves to the left. As a result less ammonia is present as free NH_3. Figure 8 shows that the dissociation of NH_4^+ ions is considerably influenced by pH values between 8 and 9. These values normally occur in compost. Building on

thoughts developed by van Dijk (1971) a (hypothetical) explanation of the action of gypsum can be summarized schematically as follows:

$$
\begin{array}{lcl}
 & & \qquad NH_3 + H^+ \\
 & & \qquad\quad \upharpoonleft\downharpoonright \\
[RH_n]\cdot(NH_4)_m & \rightleftharpoons & [RH_n]^{-m} + m\,NH_4^+ \\
\qquad I & & \quad II \\
 & & \quad\downarrow + Ca^{++} \\
 & & [RH_{n-1}\cdot Ca]^{-m+1} + H^+ \\
 & & \quad III
\end{array}
$$

The organic matter-ammonium complex I can be considered as a salt of a weak acid (the anion II still carrying dissociable H^+ ions) and the weak base NH_4OH. The NH_4^+ ion is in equilibrium with NH_3 and H^+. NH_3 is volatile. The higher the concentration of NH_4^+ ions and the higher the pH is, the more NH_3 volatilizes. Ca^{++} ions of the well ionized $CaSO_4$ (salt of a strong acid and a strong base) have a much greater affinity for II than NH_4 ions and can even 'displace' (part of the) H^+ ions which are still bound. Moreover this gives rise to III and free H^+ ions (decrease of pH), influencing the NH_4–NH_3 equilibrium, so that less NH_3 volatilizes. Indeed Table 2 confirmed a smaller N loss after adding gypsum. $CaCO_3$ has no effect on pH. Some experiments in which various N levels were combined with various moisture contents indicated that less ammonia disappears from a wet compost than from a dry one. Probably more factors influence the ultimate NH_4 content of the compost such as a high ambient temperature during composting resulting in reduced ventilation of the compost pile (chimney effect) and therefore leading to a high NH_4 content. A possible effect of the quantity of chicken manure, with or without gypsum, on the microflora has not been checked.

Sometimes thermotolerant ink caps do occur. They are stimulated either by a combination of absence of gypsum and relatively low temperatures during conditioning, or by an overdose or late application of chicken manure.

At the time Pizer (1937, 1938) studied the function of gypsum, a much heavier type of manure was used with relatively more droppings but less additives. A long composting time in heaps of 5–6 m. wide turned only once a week often resulted in greasy compost. In this situation the primary function of gypsum undoubtedly was improvement of the structure and

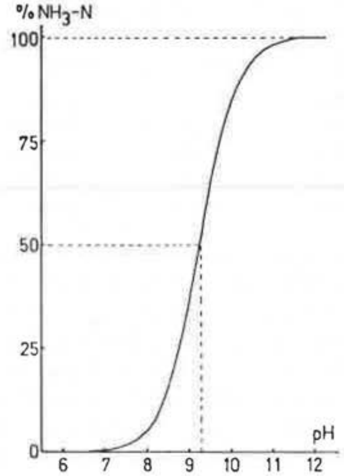

Fig. 8. Effect of pH on the fraction of undissociated ammonia in a solution of ammonia in water

aeration of the compost, because gypsum prevents greasiness.

Nowadays the heaps are narrower (1.8–2.0 m.), and the manure contains more straw giving rise to a better structure and aeration. Therefore the influence of gypsum on pH and NH_3 content is more pronounced than it was in the past. In a rich manure (poor in straw), that is relatively wet and with a high NH_4 content, the beneficial effect of gypsum will be a combination of effects on pH and structure. A high NH_4 content is associated with a high N content, and this latter with a low C:N ratio. This can be achieved by adding a considerable quantity of N or by a prolonged composting time. The last procedure leads to damage of structure. that can partly be counteracted by gypsum. If the C:N ratio is low and the structure right, then the effect of gypsum on pH is more important than the prevention of greasiness. The use of gypsum has been an enormous step forward in getting compost with a consistent yield.

Stoller (1962) described the influence of NH_3 on the growth of mushroom mycelium. He noticed good growth at a pH of 7.3–7.6, at a lower pH the growth was even faster. The NH_3 content at a pH of 7.3–7.6 was about 0.005%. As early as 1945 Stoller showed that the pH is not a good measure for ammonia. If Fig. 8 can be assumed to be applicable to compost and if 0.005% (w/w) is a safe level of NH_3 in the compost, the following combinations of pH and

NH_4^+ lead to favourable conditions for the mushroom mycelium.

pH	NH_4^+ (%)	NH_3 (%)
7.50	0.29	0.0051
7.75	0.16	0.0049
8.00	0.09	0.0048
8.25	0.06	0.0055
8.50	0.03	0.0045

The mushroom is sensitive to NH_3, not to NH_4^+. The behaviour of freshwater fish in relation to ammonia is comparable with the mushroom (Anonymous, 1973). The mycelium grows well at pH values between 6.0 and 8.5 (Pizer, 1950; Treschow, 1944). This means that neither low levels of NH_4 with a high pH, nor a moderate amount of NH_4 with a low pH, is harmful. Only a combination of a high pH with high NH_4 is harmful because this results in a high level of NH_3 in the compost.

The best method to check if the compost is ready for spawning is not to determine the pH but to use a red litmus paper or a colorimetric absorption tube and a bellows pump as supplied by Dräger Limited, Lübeck, West Germany (Kenny, 1975). A red litmus paper reacts on volatile bases such as NH_3. For the measurement it is important to put the compost in a plastic bag to let the NH_3 in the compost equilibrate with the air above. In further trials the effect of very low pH values in combination with high NH_4 levels will be checked. For this purpose materials will be added to the compost that have a strong pH decreasing effect.

Acknowledgements

The author thanks Dr. R. C. Ross of Country Kitchen Foods for correcting the English text and Dr. H. van Dijk and drs. H. G. van Faassen from the Institute of Soil Fertility for their help in finding an explanation for the action of gypsum and for their critical comments on the manuscript.

REFERENCES

Anonymous, 1973. Water quality criteria for European freshwater fish. Report on ammonia and inland fisheries. *Water Res.*, 7: 1011–22. Pergamon Press.

Bech, K. & C. Riber Rasmussen, 1968. Further investigation on organic and inorganic supplementation of mushroom compost. *Mushroom Science*, 7: 329–42. Pudoc, Wageningen.

Dijk, H. van, 1971. Cation binding of humic acids. *Geoderma*, 5: 53–67.

Edwards, R. L., 1949. Cropping experiments. *A. Rep. Mushroom Res. Stn. (Yaxley, Peterborough)*, 1946–48: 11–43.

Edwards, R. L., 1974. Why do we add gypsum to mushroom compost? *Mushroom J.*, 16: 150–53.

Gerrits, J. P. G., 1970. Inorganic and organic supplementation of mushroom compost. *Mushroom Grow. Ass. Bull.*, 251: 489–508.

Gerrits, J. P. G., 1972a. Praktische mogelijkheden van bijvoeden van champignoncompost. *de Champignoncultuur*, 16: 257–73.

Gerrits, J. P. G., 1972b. The influence of water in mushroom compost. *Mushroom Science*, 8: 43–57.

Gerrits, J. P. G., 1974. Development of a synthetic compost for mushroom growing based on wheat straw and chicken manure. *Neth. J. agric. Sci.*, 22: 175–94.

Gerrits, J. P. G., 1976a. Die Funktion organischer und anorganischer Zusätze im Champignonkompost, speziell hinsichtlich der Ammoniak-Konzentration. *Der Champignon*, 175: 21–28; 176: 9–20.

Gerrits, J. P. G., 1976b. Welke resultaten zijn met bijvoeden te bereiken? *de Champignoncultuur*, 20: 279–95.

Gerrits, J. P. G., 1977. The supplementation of horse manure compost and synthetic compost with chicken manure and other nitrogen sources. *Mushroom Science*, 9 (Part 2), 77–98.

Kenny, A., 1975. Determination of ammonia in mushroom compost. *Mushroom J.*, 30: 196–98.

Kligman, A. M., 1950. Handbook of mushroom culture. Business Press Inc., Lancaster, Pennsylvania.

Lemke, G., 1963. Champignonkultur auf nicht kompostiertem Strohsubstrat mit 'Startdüngung'. *Dt. Gartenbauw.*, 11: 167–68.

Pizer, N. H., 1937. Investigations into the environment and nutrition of the cultivated mushroom, *Psalliota campestris*. I. *J. agric. Sci.*, 27: 349–76.

Pizer, N. H. & J. Thompson, 1938. Investigation into the environment and nutrition of the cultivated mushroom, *Psalliota campestris*. II. *J. agric. Sci.*, 28: 604–17.

Pizer, N. H., 1950. Horse manure composts. *Mushroom Science*, 1: 46–51.

Riber Rasmussen, C., 1967. Combination of sulphate of ammonia, calcium carbonate, superphosphate and gypsum, and their influence on outside composting and cropping yield. *Mushroom Science*, 6: 307–27. Pudoc, Wageningen.

Sinden, J. W. & L. C. Schisler, 1962. Nutrient supplementation of mushroom compost at casing. *Mushroom Science*, 5: 267–80.

Srinath, E. G. & R. C. Loehr, 1974. Ammonia desorption by diffused aeration. *J. Water Poll. Centr. Fed.*, 46: 1939–57.

Stoller, B. B., 1945. Experiments in mushroom culture. Ph.D. thesis. University of Wisconsin.

Stoller, B. B. (1962). Ammonia in compost, Part 2. *Mushroom Digest*, 1962, (3): 49–53.

Treschow, C., 1944. The nutrition of the cultivated mushroom. *Dansk bot. Ark.*, 11: 1–180.

MUSHROOMS FOR WEST GERMANY

Imports of *canned* mushrooms by West Germany continue to rise. In the first five months of this year they reached 47,499 tonnes compared with 41,803 tonnes in the same period last year. Most of the increase came from South Korea.

The Dutch sent 16,024 tonnes compared with 14,385 tonnes in the same period in 1977. They also sent 300 tonnes of *fresh* mushrooms, compared with 202; but their principal market for fresh mushrooms remains Belgium, although the total slipped to 1,001 tonnes from 1,096 tonnes in the relevant period. RLE

NOT EXACTLY HELPFUL!

One authority has suggested that 'taking everything into consideration, mushrooms may be considered slightly superior in nutritional value to such vegetables as the cauliflower'. To which the GCRI expert Peter Flegg responds that 'it might be added that, in terms of its protein content, the mushroom is also slightly inferior to the brussels sprout!'

West Sussex Gazette, 17th August 1978

NEW THILOT TURNER MANUFACTURED IN YORKSHIRE

A new T604 Thilot Compost Turner manufactured by Monomech Developments Ltd. of South Kirkby, Yorkshire, has been delivered to James A. Gooding Ltd. at Yaxley, Peterborough.

This machine has all the latest modifications as developed at the Dutch composting yards at CNC, Ottersum, particularly in the use of a direct-drive 20 h.p. motor to the pick-up drum, thereby avoiding the use of long-drive 'V' belts which were a source of trouble. The machine is also fitted with hydraulic drive to main axle, giving infinitely variable drive from zero to 2,130 ft./hr.

Capable of handling 40 to 60 tons of compost per hour in a stack 1.80 to 2.00 metres wide (adjustable) and 1.80 to 2.00 metres high, the T604 has a working length of 9.80 metres and weighs approximately 6,500 kg.

In the accompanying photograph John Young, the maintenance engineer at Yaxley, is seen examining the machine.

AGRICULTURAL WAGES UP 100% IN FOUR YEARS

The minimum wage rates for regular whole-time men (20 years and over) for recent years have been as follows:

	Appointment Grade I £	Appointment Grade II £	Craftsmen £	Ordinary £
From January 22, 1974	28.34	26.16	25.00	21.80 for a 40 hour week
January 20, 1975	37.05	34.20	31.35	28.50 for a 40 hour week
July 21, 1975	39.65	36.60	33.55	30.50 for a 40 hour week
January 20, 1976	45.65	42.60	39.55	36.50 for a 40 hour week
January 20, 1977	48.15	45.10	42.05	39.00 for a 40 hour week
January 20, 1978	55.90	51.60	47.30	43.00 for a 40 hour week

Equal pay for women in all grades was introduced on 29 December 1975. *Ministry of Agriculture*

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Copies of literature cited are available from the MGA office, Science Reference Library, or Dr. R. L. Edwards, **AS INDICATED**. See *Journal* No. 47, Nov. 1976, page 378.

SRL — Science Reference Library.

MGA — Mushroom Growers' Association.

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Reference number
Title
Author
Name of Journal, volume (number), pages.

Failure to do this gives them additional work which is unnecessary and they may have to call for more expert assistance.

MGA can supply **only** copies of papers **marked MGA in the List**, and Dr. Edwards **only those marked RLE.**

The field of interest covered by a paper is indicated as follows:

- **C. Commercial, economic**
- **P. Practical growing**
- **R. Scientific, research, experimental**

R. The fungus flora of compost during mycelium colonization by *Agaricus brunnescens.*
C. L. Fergus, 1978
Mycologia, **70** (3), 636–44 SRL

R. Glycogen in spores and mycelium of *Agaricus bisporus.*
J. Lendenmann, D. Rast, 1978
Trans. Br. Mycol. Soc., **71** (1), 146–48 SRL

R. Cultivation of European button mushroom in Orissa.
G. C. Smith, B. N. Mohapatra, B. Patnaik, 1977
Science and Culture, **43** (11), 501–02
From Orissa University of Agriculture and Technology, Orissa, India.

R. Shiitake: a fungus with health-giving properties.
A. Carnevali, 1978 (in Italian)
Informatiore di Ortoflorofrutticoltura, **19** (2), 13–19
SRL

R. Studies on the chemical composition of oyster mushroom.
I. Kostadinov, S. Stefanov, 1977 (in Bulgarian, English summary)
Gradinarska i Lozarska Nauka, **14** (5), 110–12
From Opitna Stantsiya po Gradinarstvo, Negovan, Sofia, Bulgaria.

P. Casing soil and compost substrates used in the artificial culture of *Agaricus bisporus* the cultivated mushroom.
W. A. Hayes, T. R. Shandilya, 1977
Indian J. Mycology and Plant Pathology, **7** (1), 5–10
From Himachal Pradesh University, Solan, India.

PR. Perfection of a biological control method with a predacious hyphomycete: *Arthrobotrys robusta*, antipolis strain (Royal 300).
J.-C. Cayrol, J.-P. Frankowski, A. Lanièce, G. d'Hardemare, and J.-P. Talon, 1978 (in French)
Pepiniéristes, Horticulteurs, Maraichers, **184**, 23–30
SRL

R. Evaluation of the botulism hazard in fresh mushrooms wrapped in commercial polyvinylchloride film.
D. A. Kautter, T. Lilly, Jr., and R. Lynt, 1978
J. Food Protection, **41** (2), 120–21 SRL

R. Determination of heat produced by agricultural produce, by means of an adiabatic calorimeter.
W. Verbeek, J. W. Rudolphij, 1977 (in Dutch)
Koeltechniek-Klimaatregeling, **70** (11), 177–81
including mushrooms: relevant to storage, cooling, etc.

P. Cultural studies on mushrooms 1974–76.
J. D. Bowden and P. G. Allen, 1978
Exp. Horticulture, **30**, 66–75 SRL

PR. Control of Sciarids *Lycoriella auripila* in mushroom cultures (*Agaricus bisporus*) by diflubenzuron in the casing soil.
P. Kalberer and E. Vogel, 1978
Z. für Pflanzenkrankheiten und Pflanzenschutz, **85** (6), 328
From Station Fédérale de Recherches, CH-8820 Wädenswil, Switzerland.

R. Automated spectrophotometric determination of O-diphenoloxidase activity in common mushroom (*Agaricus bisporus* L).
P. Varoquaux, J. Sarris and G. Albagnac, 1977
Annales de Technologie Agricole, **26** (4), 461–84 SRL

R. Effects of antioxidants and heat in O-diphenol-oxidase of common mushroom (*Agaricus bisporus* L).
P. Varoquaux, J. Sarris and G. Albagnac, 1977
Annales de Technologie Agricole, **26** (4), 485 SRL

R. Mycelial growth of the cultivated mushroom and related problems.
J. M. Olivier and J. Guillaumes, 1978 (in French)
Bull. Fed. Nat. Synd. Agric. des Cultivateurs de Champignons, **14**, 1407–20 MGA

R. Technical and economic factors in the use of compost activators based on soluble carbohydrates.
W. A. Hayes, 1978 (in French)
Bull. Fed. Nat. Synd. Agric. des Cultivateurs de Champignons, **14**, 1420–24 MGA

PR. Important factors in pasteurization.
M. H. A. Geurts, J. P. G. Gerrits, 1978 (in Dutch)
De Champignoncultuur, **22** (6), 183–99 MGA

P. From casing to first flush with *Agaricus bisporus*.
J. van de Geijn, 1978 (in Dutch)
De Champignoncultuur, **22** (6), 203–07 MGA

PR. New strain of *Agaricus bitorquis*, Horst K46.
Anon., 1978 (in Dutch)
Groenten en Fruit, **34** (8), 57 RLE
H. R. Visscher, 1978
De Champignoncultuur, **22** (6), 181–83 MGA

P. Mechanical harvesting for the tray system.
Anon., 1978 (in Dutch)
Groenten en Fruit, 34 (6), 66–67 RLE

P. Mechanical harvesting on tray farms.
P. Rongen, 1978 (in German)
Der Champignon, **204**, 25–27 MGA
These two articles describe the same farm and equipment.

P. Simplification of mechanical compost handling in bulk.
Anon., 1978 (in German)
Der Champignon, **204**, 23–24 MGA

Annual Reports: The following Annual Reports include references to research on mushrooms:
Hong Kong, Director of Agriculture and Fisheries 1976/77.
India, Central Food Technological Research Institute, Mysore, 1975. Economics.
Netherlands, Sprenger Instituut, Wageningen 1976. Transport and storage.

What next?

'The cultivated mushroom has appeared under a number of names in the literature, with the correct one still the subject of some disagreement', writes **David Malloch**, of the University of Toronto, in *Mycologia* **68,** 1976. 'I must point out that, since *Agaricus brunnescens* Peck is the oldest name for the species of the cultivated mushroom, it must be accepted according to the rules of priority as the correct name for the species.'

NEW CHAIRMAN FOR EASTERN AREA

Squadron-Leader Peter Hearne is the new chairman of the Eastern Area of mushroom growers, following the resignation of Geoff Ganney. **Barry Hughes** is vice-chairman. The elections were held at a well-attended Area Meeting in Ipswich in September.

Peter Flegg surveyed the work of GCRI, explaining not only the strength but also the weaknesses and delays inherent in a Governmental system controlling the research programmes and finance. His talk stimulated animated discussion in which everyone wanted to participate.

A new research student was to start work in October on *Verticillium* but Flegg emphasised that the true function of GCRI was research and that the development or application of its findings was essentially the responsibility of ADAS through the various Experimental Horticulture Stations, Lee Valley and Fairfield having a special interest in mushrooms.

Sam J. Agnew of the Agricultural Training Board outlined the training and educational facilities available to growers. He made the point that, in an industry which is so labour-intensive, efficient management of staff workers is essential; the ATB runs a special four-day course to help train manager-supervisors to get the best out of their staff, and grants towards the cost of attendance could be claimed.

Another area of extreme importance was the efficient use of heat, for which the Board also ran courses, training those handling heating systems to achieve the greatest efficiency and economy in the use of fuel. These and other courses, e.g. electrical installation and maintenance and engineering, could be held either on the farm or at a suitably local centre.

DNL

INTERPRETATION OF ORGANOLEPTIC SYMPTOMS IN A GOOD COMPOST*

Pierre Guiochon

Organoleptics. These are what we call the characteristics which are impressed on our senses, particularly sight, smell and touch.

Mushroom growers have always used these signs to assess the composts from the raw material to the end of the crop.

The inspection of a compost in production, or even a part of a compost, is rich in education; it confirms the phenomena which have been produced and fixes in some way a guide to many of them.

But the organoleptical examination is even more interesting when it concerns the effect of fermentation. It seemed to me useful to review the investigations into the symptoms which can help us in our growing during this period.

A. OUTSIDE COMPOSTING

Sight

This is certainly one of the senses which helps us the most. But one must know how to look and compare.

Fresh manure is or is not strawy or short, dry or wet, fresh or spoilt. Is the stack too big, high enough? Is the watering adequate? You may say that this is childish. Not so — I have seen watering lances on a large mushroom farm with the nozzles of the hose giving only one quarter of their normal dose. The time given to watering therefore was false and the manure will be too dry. If the mushroom grower had had his eyes open he ought to have noticed this.

On the contrary if the water runs out in floods under the heaps then the manure is washed out. Nevertheless the watering is allowed to continue!

Let us get down to turning. By looking we can appreciate the state of the breakdown of the straws. Are they fermented? Too hard? Blackened? Still bright? Are the edges well tucked in? Has the anaerobic condition useful before composting been produced? The livid yellow colour will tell us this before the smell.

Again it is our sight which tells us, during turning, whether the width and the height of the stacks are right — also the good distribution of the nitrogenous elements and fertilizers; the correction of insufficiently moist parts — the compressing of the edges.

And the temperature? Do not let us forget to go every morning and evening and look at the thermometers. Has one thought to put them in correctly and at the right places so as not to have to move them and not to walk on the stack (which stifles it).

Now to turning again. The attentive and practised eye apreciates immediately the diminishing width, the additives to be perfectly spread, the thermometer temperatures spaced every three metres, so as to watch the regularity of the fermentation; we will come back later under the heading 'Smell' to the very bad anaerobic condition at this stage (and future stages) but already the look and low temperatures show an oxygen deficiency. The colour should be dark brown, nearly black. The straw is still brilliant although flabby and colloidal (it is the anaerobic condition which dulls them).

Smell

This is perhaps not as extensive but just as important.

First of all it is necessary, especially if the manure was fresh, that we should smell at turning some of that disagreeable and revolting odour of 'pig manure' only useful before turning for the rapid breakdown of the shiny yellow straws; especially when they have come from the short straw wheat varieties which are fashionable at present.

After turning, this is no longer necessary, because the two or three following weeks, according to the technique employed, will be necessary to get rid of any trace of anaerobic conditions.

On the contrary a slight smell of ammonia should float on the steam which emanates from the turning. This is a good sign as it means that the ammonia fermentations are taking place. However, a too strong smell is bad for nutrition.

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*Reproduced with permission from the *Bulletin de la Federation Nationale des Syndicats Agricoles des Cultivateurs de Champignons*. The translation was made for us by Raymond Thompson.

A sensitive sense of smell should be able to detect the fermentation evolving.

At the highest temperature the sense of smell should allow us to analyse the physico chemical combustion of the sugars and the complex celluloses which from 165°F release the characteristic odours of burnt sugar.

Touch

Hands (we do not mind certain contacts when they are necessary) tell us about important points. The breakdown of the straw is made apparent by screwing up a handful of compost between the hands. Straw yields more or less easily under the stress of this method — experts appreciate the state of the composting at the rupture.

Touching also allows one to appreciate the colloidal state of the compost. This appreciation can even allow one to judge the difference between the colloidal state and the greasy state when filling into boxes. In fact it is the difference between touching glycerine and butter. The colloidal touch disappears easily in contact with water — the greasy is more tenacious.

The colloids which concern us, called molecular colloids, or micelles moleculaires, are organic bodies generally proteinic in aqueous emulsion. They are impervious to air but have the quality of being flocculated or coagulated by certain neutral salts such as carbonate of lime (or limestone) and above all calcium sulphate (gypsum). The aerobic fermentation transforms them into stable proteinic matter, having lost any slimy characteristics.

B. PASTEURIZATION

Sight

As aerobic fermentation settles in the compost, other fermentations disappear progressively. One must be curious enough to enter the house and see the evolution of the compost. It looks dimmer and white dots appear more and more numerous formed by colonies of thermophile and actinomycete bacteria. At the end when the temperature drops a white bluish down shows — it is visible on the surface. This mould called Monotospora (Heat Mould) appears only when the straw breakdown is complete and pasteurization finished.

Smell

Smell is very useful both during and after pasteurization.

At the exit vent of the peak-heat house it is normal to smell ammonia for the first two days. This stale smell if it persists would indicate a difficult pasteurization. If the ammonia smell persists after pasteurization it shows as insufficiency or a lack of air or more rarely an excess of nitrogen.

On the contrary a good smell — of course — slightly soapy and 'sui generis' is a good note but still not sufficient for a good 'average'.

Touch

This is possibly the best indication at the end of pasteurization. One takes first of all a small handful of compost and presses strongly with clenched fist. Normally juice should not show or only be light (clear). If the liquid appears light brown, the compost is too wet but well flocculated.

If the beads are dark there remain untransformed colloids.

A fistful of compost pressed tightly in the hand which remains compressed when the hand is opened indicates a heavy compost too compact; probably greasy and adhesive.

Now let us take one or two pinches of compost between the thumb and the index and rub them once — this will show, if it is rough, and will definitely reassure us as to the disappearance of the colloidal state; if it is sticky and tight, even dry, it is probable that a section of the compost has not been entirely transformed by the aerobic fermentation; perhaps there remains an anaerobic part there still.

Hearing

Even hearing is used by some people. By pressing several times near your ear a handful of compost at the end of pasteurization, the fact of hearing the noise of pressing and depressing shows too much humidity.

One could continue the catalogue of effects on all our senses of all the phenomena which are produced during the cultural cycle, but let us stop there.

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