



Grower Summary

M 56

**Understanding Mushroom
Nutrition: Project aimed at
improving yield, substrate
efficiency and utilisation and
flavour**

Final 2015

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Before using all pesticides check the approval status and conditions of use.

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Further information

If you would like a copy of the full report, please email the AHDB Horticulture office (hort.info.@ahdb.org.uk), quoting your AHDB Horticulture number, alternatively contact AHDB Horticulture at the address below.

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Project Title:	Understanding Mushroom Nutrition: Project aimed at improving yield, substrate efficiency and utilisation and flavour
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GROWER SUMMARY

Headline

- Mushroom yields increased 11.5% by addition of protein-based supplements at 1.5% (ProMycel Gold, Champfood E, MCSustradd and Natural Gold (a lipid-protein blend) to phase 3 composts
- The increased mushroom yield is worth 6.4 times the cost of supplement (at 1.5%)
- Protein-based supplements increased mushroom cap density and so improved texture and picking rates
- Supplementation did not affect mushroom flavour.

Background

The nutrition from compost is a key factor for the successful mushroom growth. A range of different nutritional supplements are available to the mushroom industry, some reported to correct possible nutrient deficiencies in compost and others reported to have 'hormonal' effects by stimulating extra growth. At the start of this project there was little objective knowledge on the effects of these supplements in phase 3 compost on mushroom yield, quality and metabolism. This project evaluated the effects of four different types of compost supplement (protein-based, lipid-protein blend, carboxylic acid-based and mineral micronutrients) applied to two different phase 3 composts (horse manure-based and straw-based). Mushroom yield was measured as weight of mushrooms harvested. Mushroom quality was measured as mushroom colour, density (related to texture), percentage dry weight and mushroom flavour. Examining the effects of supplements on flavour is a novel and important component of the project as flavour is key to consumer acceptance, so it is important to know whether there are positive or negative effects from supplements.

Because different supplements have reported to have different modes of action (correcting deficiencies of different nutrients or hormonal) this project also examined the biology of the *A. bisporus* mycelia growing in different nutrient conditions to develop our understanding on mushroom nutrition. This work involved measuring gene expression using microarray technology.

The four supplement types under evaluation are available as commercial products:

- Protein-based (largely from soy) – three products tested (ProMycel Gold, Champfood E, MCSustradd)
- A blend of lipid and protein-based product (Natural Gold)
- A carboxylic acid-based product (MycroNutrient)

- Mineral micronutrients, a mix of calcium, magnesium, sulphur, boron, copper, iron, manganese, molybdenum and zinc salts (Micromax)

Summary

This project examined supplementation of phase 3 compost: a review of current usage, crop experimentation to identify possible benefits to yield and quality, and laboratory analysis to examine how supplements may affect the physiology of the mycelium.

Compost supplementation is practiced throughout Europe. There are a range of product types (protein, lipid/protein blend, carboxylic acids and mineral micronutrients) and different suppliers. However, there is little objective knowledge on how effective these products are; most information is provided by the suppliers. The normal rate of use is 1.5% (for protein-based supplements) on white strains but there is reduced use of supplements for brown strains.

The four protein-based supplements (ProMycel Gold, Champfood E, MCSustradd and Natural Gold) produced an average increase in mushroom yield of 11.5% on white strain A15. No differences were found between these supplements. This equates to a 6.4 times multiplier in terms of cost benefit [£1 spent on supplement produces £6.40 of extra mushrooms]. No increase in yield was detected by supplementation with carboxylic acids and mineral micronutrients. The carboxylic acids product (MycroNutrient) is marketed as a 'Casing Supplement'; it was included in these experiments for completeness. Previous reports from USA have suggested that composts may be deficient in mineral micronutrients, the evidence from these experiments suggest that the composts used (produced in Britain and The Netherlands) are not mineral deficient.

The effects of supplements on a range of mushroom quality attributes (mushroom colour, texture (density), flavour and dry matter content) were investigated. Protein-based supplements improved mushroom density by 5.5%, which directly relates to mushroom texture and also picking rates (more fresh weight picked per mushroom of the same size). The use of supplements produced only minor or no differences in the other quality attributes. Two protein supplements (ProMycel Gold and McSubstradd) did make the mushrooms more yellow coloured, this is probably below the threshold of consumer detection and the overall whiteness (L value) was unaffected. However, the small effects of supplements on mushroom yellowness

were affected by compost type and flush number and it is therefore difficult to be sure of an overall trend.

One protein-based supplement was found to increase the yield of the brown strain, Heirloom. This is of interest to growers of 'browns' as they are considered by some to be unresponsive to supplements.

The compost type was found to influence mushroom quality but not yield: horse-manure-based composts produced more dense mushrooms while straw-based compost produced whiter mushrooms.

Gene expression analysis was carried out on the mycelium growing in the differently supplemented composts to try to identify how the extra yields are achieved. The composts of the first flush showed that only one gene had different expression levels in the protein supplemented compost compared with the non-supplemented compost. This was a surprise and may be because the mycelium has sufficient capacity in terms of enzymes produced to deal with the extra protein provided. A larger number of genes had changed expression levels in the lipid/protein treatment compared with the non-supplemented treatment. The up-regulated genes were largely concerned with nitrogen metabolism while many of the down-regulated genes had lipid metabolism functions. This is evidence that the lipid/protein supplement does change the metabolism of the mycelium. However, the yield increase of the lipid/protein supplement was the same as the protein alone supplement.

Financial Benefits

The financial benefits of supplementing phase 3 compost with protein supplement (at 1.5%) to improve yields have been calculated as: that for every £1 spent on protein supplement £6.4 of extra mushrooms are produced.

For this calculation Brendan Burns (of Sylvan Inc) kindly provided figures for realistic approximate costs of supplements and compost and wholesale price of mushrooms.

- Price of protein supplement £400/tonne
- Price of Phase 3 compost £145/tonne
- Price of mushrooms (ex-farm i.e. harvested and packed) £1.40 to £1.50/kg
- Net Price of mushrooms (excluding harvesting and packing) £0.90/kg

From Experiments 2 and 3:

Mushroom yield	(No supplementation)	363 kg/tonne compost
Mushroom yield	(Average of the 4 protein supplements)	405.8 kg/tonne compost
Increase in yield due to protein supplements	(405.8 - 363)	42.825 kg/tonne compost

Value of supplementation (increased mushroom yield X net price of mushrooms)

i.e. (42.825 X £0.90) **£38.54**

Cost of supplement (at 1.5% rate i.e. 15 kg/tonne compost or 0.015tonne of supplement)

(0.015 tonne supplement X £400/tonne) **£6**

£6 spent of supplement yields an extra £38.54 of mushrooms

Therefore, the multiplier of supplement use is £38.54/£6 = 6.4 times

An additional cost of using supplements may be the additional cooling requirement (electricity cost), particular during the summer.

Action Points

- Protein-based supplements offer such clear benefits without negative issues (other than potential over-heating of compost) that their use should be regularly reviewed. In our experiments the four protein-based supplements gave similar increases to yield and we were unable to distinguish between them. They are of course different products and the choice between them may be more than price but also the degree of temperature spike, possible benefits specific to individual farms/composts and the other components present in the supplement. For instance, Natural Gold is a lipid/protein blend and other supplements contain mineral trace elements, rape (lipids) and polysaccharides
- There is the possibility that the supplement inclusion rate of 1.5% could be slightly raised for further increases in yield if the danger of overheating compost can be controlled
- The gene expression laboratory experiment as part of this project gives good grounds to believe that supplementation with lipids offers future possibilities of further yield improvements. Growers are recommended to 'keep a watching eye' on this

- The one negative attribute of protein-based supplement was the slight increased yellowing of mushrooms. It is not believed that this is a problem although growers are recommended that they again 'keep a watching eye' in case yellowing should ever become a significant quality issue
- Growers of brown strains are recommended to trial protein-based supplements