Novel Strategies for the Control of Fungal Crop Disease

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I have a presentation for you which is based on a major Framework Five project which looked at improving the agronomy of organic potato production. Framework Five is a European Union (EU) research funding program which finished in 2002, but some of the projects under that program are still ongoing, so we are in the third year at the moment but we have quite a few results, and those results are basically the core of this presentation. The program was focused on finding strategies to eliminate and/or minimize late blight (*Phytophthora infestans*) in potato production without the use of copper (Cu). The EU is keen to remove Cu from its list of permitted organic farming inputs.

But before I start, I would like to tell you a little bit about where I'm coming from, and then at the end I would also like to give you some data from tomato production–another filamentous crop–which might give a hint where one should go at the major upcoming disease program in potato production, which is *Rhizoctonia*. *Rhizoctonia* is an increasing problem throughout Europe. I think we've made big strides toward managing *Phytophthora* better through this project. The whole project is under the umbrella of funding from the European Commission, who I would at this point gratefully acknowledge. They have been really good to organic farming, much better with respect to their support for organic farming than a lot of national governments in Europe.

I'm a bit of a split personality; I hold a chair at Newcastle University, but I do a lot of my organic farming-focused research in the area of potato and vegetable production through an organization called the Stockbridge Technology Centre. Both of these organizations are based right in the centre of the United Kingdom (UK). Stockbridge Technology Centre is close to York in Yorkshire and the organic farming centre of Newcastle University, which is based at Nafferton Farm, a university farm near Newcastle.

Here are some pictures, starting with Nafferton Experimental Farm. It's a 360-hectare typical Northumberland estate with a cereals and oilseed business and the main business of a dairy herd of about 160 dairy cattle, and we produce beef from the dairy offshoot–relatively low-quality beef. Since we have converted half the farm to organic production, the other half remains conventional. We also have a vegetable and potato business, and the organic vegetables made about two-thirds of the profits last year. The potato didn't. There was an overproduction in the UK last year, and I will explain a little bit about that later. Part of the deal of going to Newcastle (I lived in Aberdeen before) was that we would get the fairly old-fashioned offices and the laboratory on the farm, believing that PhD students and researchers should actually learn their trade in the background of an active farming business. If you only come out to the farm to your field trials to do your assessments, you don't really get much knowledge about the framework that you're working in, and that is one of the really dangerous processes that has happened in agricultural research in general, in my opinion. People that do farming research do not know about farming anymore. Now, for those researchers among you that don't fall into that category, I apologize, but that is one of the big problems at the moment. We even make them live on the farm. They're often quite happy because the cottages we provide are really nice and really inexpensive. The offices and the laboratory are based in that building. Stockbridge Technology Centre, as I said, is further down in Yorkshire. That's where most of the horticultural and a large proportion of the potato research happens. It used to be part of the Horticultural Research Institute, the government institute for horticultural research. The government basically allowed the horticultural research to become a molecular biology research centre, thereby not producing any benefits to the industry anymore. They wanted to close this unit down, and we made a business plan and bought it from DEFRA (Department for Environment, Food & Rural Affairs) as a consortium of farmers–big horticultural farmers. We are now making about £100,000 profit on a £2,000,000 turnover. So research can be done profitably; you just have to get the industry involved in managing it.

Here we have excellent glasshouse facilities, really the type of Dutch glass that the commercial producers use. The best glass has gone into the organic glasshouse unit, which consists of 16 identical 4 x 4 independent-controlled units. But, having said that, most of our research goes on within commercial companies, and this is a setup of the Tesco producer base (Tesco is one of the big supermarkets–the biggest supermarket– in the UK, also the supermarket which has the highest range–about 1000 products–and the highest turnover in organic foods). We have been working very closely with the Tesco producer base on developing larger-scale organic production systems. Most of our research and most of our research associates are actually based on these production units throughout the UK. They usually work on a specific commodity within the context of an organic rotation, and so we have people working on carrots and brassicas up in Scotland. You have a fantastic microclimate for growing carrots here for the early market. They're stored over winter with straw on top. The temperatures don't go low enough to cause damage, and they don't go high enough for them to sprout. So you can store carrots here until April in the soil and then compete with the new French crop early in the season in May and April. It's big business, and it's early potato country up here as well.

You can see that throughout the country we have industry collaborators with whom we work on composting and copper production, potato production, allium, brassicas, cereals, oilseeds, tomatoes, and cucumbers, and now, as well, lettuce, pigs, and top and soft fruit. We actually don't work on top fruit in the UK; we only work on soft fruit. The only area where we don't have funding is top fruit in the UK, and we do that in Germany instead. Protective crops are at the Stockbridge Technology Centre. So that is a sort of corporate introduction to the setup that I'm working in, and that brings me to the topic of the talk, which is on fungal diseases in organic production.

If you look at the fungal diseases that are major problems in Europe at the moment, we have one clear major problem, which is late blight. It is pretty much the same since that particular disease came over from the Americas 250 years ago. It is still the major problem in both organic and conventional production. In conventional production we have a serious problem with pesticide resistance, so the EU was not just funding this program from an organic point of view; they knew that this is an emerging problem that comes up for conventional farming as well. They put a fairly large budget into this project–about €3,000,000–because they knew there would be some support for conventional production out of it as well. In Europe late blight can be soilborne via volunteer potatoes. We're not as lucky as Canada is in having a proper frost ever year. We do have a major problem with volunteers producing the initial inoculum in a lot of areas which are main potato production areas, and it can obviously be airborne, and sanitary measures are not good enough to completely prevent that. Spores from early crops, gardens, potato dumps, and so on are a major inoculum source. In addition, we have another problem that is coming up, and that is *Rhizoctonia*. Until about 2 or 3 years ago *Rhizoctonia* wasn't such a big problem in organic production, but it is suddenly appearing to cause a lot of rejections. This may be partially because the supermarkets are getting more picky, but it is also in my opinion due to the fact that we have to increasingly use organically-produced seeds, and not all seed producers are completely up to that yet. Now, that's a controversial statement, but that is my impression. We obviously have an array of other diseases, but they don't cause anywhere near as much commercial damage as the top two. So that's a background.

Now, to acknowledge the partners in this EU program. We had partners from 8 different European countries, and in some countries we had more than one partner. Our partners are Newcastle University, Elm Farm Research Centre, and Stockbridge Technology Centre in the UK; The Institute of Organic Agriculture and the Research Station for Agroecology in Switzerland; INRA (Institut National de la Recherche Agronomique), the Groupe de Recherche Agriculture Biologique (GRAB) that's an organic farming-focused research organization in France; University of Kassel, the Biologische Bundesanstalt in Darmstadt in Germany; the Danish Institute of Agricultural Science; the Norwegian Centre for Ecological Agriculture; and then three organizations in Holland. If you do anything with EU funding, you want to have the Dutch involved because they are incredibly politically connected to European funding. So three Dutch institutions were involved–Louis Bolk Instituut; Plant Research International; and the Agricultural Economics Research Institute, Lei. The Dutch are obviously incredibly good at growing potatoes as well as doing research on potatoes.

You will all be familiar with this, but it is quite important when working on *Phytophthora* to really see the two main problems with it. The two main problems are that it can attack both the foliage and the tubers, and the foliar blight can strike very quickly, and under European conditions it can cause up to 40-60% damage and yield loss compared to uninfected crops. In a lot of trials it is very difficult to have uninfected controls–it's that prevalent, even if you use any pesticide available. Also, the spores are washed down from infected stems and foliage to infect the tubers. So it's generally considered not to move through the plant; it's moving as spores through the soil to the tubers. Tuber blight is the result if the spores get through the soil to the tubers and infecting them, making them unmarketable. They also provide wounds for secondary rots, which can spread very rapidly during storage.

The main rationale for this program initially was the desire by organic farming organizations and also the European Union to remove copper (Cu) fungicides from organic production. There is also a move in general to remove Cu fungicides from horticultural crop production in Europe. Cu is a type of fungicide that is used in conventional production but also one of the few pesticides that is still permitted in organic production in some European countries. In particular, organic farmers who have direct-sales markets are very concerned about still using it because they say, "Our customers know exactly what we do, and they don't like us to use a spray. They don't care about academic arguments about Cu not being any problem with respect to human health or the environment in potato production. They just don't like us to go with a sprayer onto the crop". The bigger producers are less concerned. They would actually like to keep Cu in the system. I say that there might actually be a rationale for that in potato production but not, however, in intensive horticultural production of annual crops such as grapevine production or apple production where it is used every year, year after year, and where there are clear environmental reasons to replace it. It accumulates in the soil and causes soil toxicity. Under the current regulations (until the December 31, 2005) we can still use 8 kg of Cu per hectare (ha) in some European countries. Denmark and Holland have no permission for Cu fungicides anymore because they didn't give permission for Cu fungicides under their normal pesticide regulations. It wasn't an organic-specific legislation; they banned Cu outright in agriculture production. EU regulations stipulate that from January 1, 2006 on, we are only allowed to use 6 kg/ha/year. One outcome that we had from the project very quickly was that we tried to get away with 6 kg and it was no problem. In all the trials where we did it, we got the same controls with frequent applications of about 1 kg/ha up to 6 times as we got with much higher doses going up to 20 kg/ha. So, when used as oxychloride, we can get quite good control with 6 kg/ha. But we have to be prepared for further reductions, and a complete ban is actually expected by quite a few organic farming organizations.

Now what do we do about it? Our trials came up with one very clear strategy that works, and a lot of other strategies that don't work. The one strategy that clearly does work is the breeding and selection for resistant varieties that can be grown under organic farming conditions. Not every resistance that has been developed for conventional production systems of high nitrogen (N) input also expressed themselves in our organic farming trials. There were some varieties which have excellent resistance under high N input, but those resistances don't work in the organic matter-based fertility management systems in organic farming. But those were few. In general, we found that those which had good resistance in conventional farming systems also held their resistance in organic production. But a few varieties that gave extremely good resistance in organic production systems also had clear signs that they had much better scavenging abilities and produced particularly good yields. One group of varieties that did that is the most important group of varieties, a group of varieties called Sarpo from Hungary. In all our trials they gave the best foliar blight resistance by far. I'll show you some data, but first I want to make one conclusion: The best way to prepare for late blight is to have a nationally sponsored, continuously updating blight resistance breeding program. Even the more horizontal resistances will eventually break down, as our results and other results in Europe have clearly shown. Even if you go for multi-gene and the horizontal resistances or mixtures of R-gene based on horizontal resistances, they will eventually be overcome by the pathogen. It takes longer if you have horizontal resistances, and you may have 5-6 years instead of the 1 or 2 years or 2 or 3 years with the R-genes. But eventually they both break down. So really the most important thing that is required is a government-sponsored and supported resistance breeding program that continuously introgresses new resistances into potatoes. That is my opinion.

Let me give you the evidence. What we did in these variety-selection-focused trials in Europe was as follows: In Europe everybody has a different preference for potatoes. That's the biggest problem in doing something like this. The UK people, the people in England, want their potatoes completely pale, and they like very large baking potatoes. The Swiss like to make rösti, and so you have to have something that is really sticky and holds together if you make it into flakes. The Germans want only yellow potatoes, and a large proportion of Germans like them relatively mealy, the sort of thing which dissolves on your tongue. Obviously, the Hungarians like their potatoes to fall apart when they make goulash. So everybody has different culinary requirements for their potatoes. There was no point in trying to select potato varieties for just Europe. That would have been complete, utter madness because we would have come up with basically an average potato that nobody would have wanted.

So what we did was, in order to still be able to compare things with respect to blight resistance, we included in all the trials two project-wide reference varieties, and these were Bintje, which is something that, believe it or not, there is still a market for–an organic market. It's a very, very, very susceptible variety originally bred in Holland. Then we had Sante in there. Sante is grown in a lot of countries, not necessarily consumed in a lot of European countries, but it's grown in a lot of countries, usually for export markets in northern Europe. And Sante, until recently, was considered to be the most resistant variety that gave very high yields in main crop potato production in organic farming systems. So that is the sort of thing that everybody in Germany and Holland and the UK recommended. That is what the agricultural advisors recommended people should plant if they wanted to have a bumper main crop. Then we used two local reference varieties. These were varieties which were in the particular country; in this case we're talking about Switzerland. So this is our variety combination in Switzerland, which under Swiss conditions was grown by a lot of farmers. There we again chose one variety that was at the susceptible end and one variety that was at the resistant end, and then we included the new genotypes, the ones which nobody really grew yet, but which have been put forward by either breeders or test stations, etc. as the sort of varieties which can satisfy the taste and consistency and colour and appearance requests of the local consumers and at the same time were put forward as particularly blight resistant. What we came up with basically in all of the 5 countries was some varieties which were more blight resistant and gave higher yields. So by looking at just selecting the right type of varieties for a particular area in Germany out of the existing gene pool, we were able to select new varieties.

Just to show you again how this compares. At the bottom here I've given you as an indication of the level of blight resistance– the time it takes in days between the first symptoms of blight and 75% defoliation. So with Bintje, you can see that within a week you don't have any foliage left. Nicola, which was a local standard, doesn't take that much longer. With Sante, a more resistant variety, it takes 3 weeks, and Naturella and Eden more than 30 days. You don't need more than 30 days in a lot of European countries because you know if you protect the foliage for about 3 to 4 weeks, you would burn off anyway just to start the curing of the tubers. So it's 3 or 4 weeks that we usually want to get out of any resistance. Anything more is usually considered over the top. We got them out of Naturella and Eden, and you can see that there was a significant, maybe quite a substantial, increase in yield with these new varieties, and in the taste evaluations and the supermarket scoring they were perfectly fine. They were judged as being equal to the current culinary standards. We did that in every country, and in every country we got a pretty similar result. By just looking at what is there, we can guarantee up to 50% increase in yield based on just appropriate variety selection. That is one of the most important results from this study. That is the way to tackle late blight in the future. It gives control for late blight. Nothing else we tried gave control of late blight. It gave us higher yields. Quite a lot of things that we did, agronomic strategy-wise particularly, gave us higher yield by the time the late blight came, but it didn't have any control on late blight.

Just to elaborate a little bit, I want to show you some more data from the UK trials just to show you how these resistances express themselves when you have a look at the individual data. So what you do in these late blight trials is you assess the amount of foliar blight, or the amount of foliage removed by the fungus, at regular intervals. In our case, when the weather was really wet, we went in there basically every day and every two days and recorded a sort of blight development pattern.

These have quite typical blight development patterns for Bintje. This is Bintje without Cu, so you can see within a week the fungus destroys the foliage. This is in an average blight year. It's not even a blight year which has the sort of conditions that you would have classified as very high blight pressure. If you use Cu you get about a week more with a reasonable amount of foliage, or a little bit less than a week more. If you look at Sante, and remember Sante was our standard resistant variety, it's actually not that good anymore. If this variety trial would have happened 5 years ago, the "without Cu treatment" results would have been somewhere like that. So even in varieties like Sante which have, apart from 1 or 2 R-genes, also an underlying horizontal multi-gene resistance, we see an increase in susceptibility because the fungus is getting adapted more aggressively towards the variety.

This is a general pattern that has been happening in Europe, even in those varieties post 1970s when everybody stopped breeding for R-gene resistances, single-gene resistances. Even the varieties developed then which had a mixture of both R-genes and more horizontal tolerances eventually will break down. We do have the second mating type now in Europe as well, and we do expect that these sort of things similar to pesticide resistances will develop faster. So, again, we need a continuous breeding program which continuously introgresses new resistances into potatoes. If you compare that to a variety that was bred in Hungary under low-input conditions because potato production during the communist era in eastern Europe was one of low input. People didn't use a lot of N fertilizer. These were selected from very, very broad introgressions of wide varieties from South America in the 1960s. They were then back-crossed for about 10 or 12 years to get the culinary characteristics back into them, and they were then selected for specific types of potato. So these were bred over a 30-year period, and they provided tolerance. We did see some very small lesions already here, although the lesions did not expand rapidly right until the end of the growing season. We would have normally defoliated a crop around day 26 here. So they provide good resistance until the end of the growing season. And as you can see, the Cu doesn't have any impact. You don't need Cu for these types of varieties. These are main crop varieties. Please remember that.

There is one interesting thing I want to point to. Look at the yields again. What I've done here is again I've expressed this data as a percent additional yield in Cu-treated plants or plots. So with Bintje you have about 20% more yield through Cu; with Nicola and Cara even a bit more, about 30%. But the interesting thing is that these are the resistant varieties, one coming off of a Scottish breeding program and two coming off the breeding programs in Hungary. The interesting thing is that we had one variety which, in two consecutive field trials, always gave significantly lower yields with Cu. But we had two varieties which basically didn't have any foliar blight right until the time when we destroy the foliage anyway, which gave significantly higher yields than the ones which had not been treated with Cu. So we are wondering why that is. Does the Cu actually give a direct fertility effect on these varieties? Remember that in the UK we quite often work on soils which are low in Cu. During the grass phase our grass doesn't have enough Cu to avoid deficiencies in the livestock, so this is low-Cu soil. Do we have a situation where some varieties actually require the Cu for maximum yield? We don't know, and the fact that one of the varieties which came out of the same breeding program showed exactly the opposite, which leaves us a little bit stranded as to explaining it. But it's worthwhile looking into that because it doesn't make sense that these have a significantly higher yield even though they didn't really have much disease symptoms by the end of the season when we defoliated. So there are often questions, as usual, but the thing to remember is that with Cu we only got a 10% to 30% increase in yield with most varieties. Selecting the right varieties gave us 50% more yield, so that is a very successful strategy.

Now we going through a few things which didn't work. The thing that didn't really work, if you approach it commercially, are the sort of diversification strategies which organic farming and low-input farming sometimes has used quite successfully in other crops. We didn't get any significant increase in yields or significant control of late blight when we grew potatoes in alternating rows of different varieties; it didn't work. The only thing that we got with certain combinations was a reduction in yield. Variety mixtures were investigated by Elm Farm, and they really mixed anything with everything. There were an amazing number of different combinations, and they were not able to find mixtures which gave a higher yield or which overall gave a reduction in blight epidemic development. It simply didn't work. The growing of barrier crops, especially wheat, between beds of potatoes was investigated, particularly by Kassel University. We did get a slight reduction in threat of blight. In Germany there are 2 different types of blight development. In the areas where you have volunteers, it starts at one particular spot and then spreads ragingly. In an area like Germany where you do get frost, you have the blight coming in from one end of the field and then going through the field. What they found in Germany was that the spread through the fields was slightly reduced, but there was no yield effect. Of course many of us wondered whether these types of approaches would be commercially viable anyway because if you grow mixtures you have difficulty selling them to anyone. In Europe you basically cannot sell mixtures, and going in there and sorting them out, well, the labour costs of that would just be prohibitive even if it did work in the field.

That brings us to agronomic strategies. We were initially looking at these to find out whether we can reduce blight development. A lot of these things have been studied before. We studied these with new varieties in the context of organic farming. With a lot of these we did not get a reduction in blight development, but what we did quite often get was higher yields if we did the right thing underneath the foliage by the time the blight came. So these are worthwhile looking at.

These were the different strategies that we looked at: We looked at improving fertility management in organic production, pre-sprouting or chitting, plant density, and planting dates (always try to optimize it for the new set of varieties). We looked at defoliation methods–do we get away with just chopping, or do we get more tuber blight if we just chop compared to burning? Organic farming doesn't want to use a lot of energy, so using a green burner is making potato production above the level of conventional energy use, which kills off with acid. We were trying to find out whether we can get away with defoliation methods that are more acceptable, and we had to look at volunteer control. An interesting result from that was obviously if you remove the volunteers you get less inoculant source of blight; that was foregone. But what we really wanted to look at here is whether we can get away from having to rotavate a couple of times to remove the potato volunteers or whether we can use pigs after harvest–move pigs into the field after harvest and let them remove the volunteers. That actually worked. In fact, they removed them so fast that in the first trial the pigs all escaped in search of more food. So if you have pigs and if you have a good herdsman who can manage this... Remember, there are problems with putting pigs into a field that is bare after the potato harvest when it's wet in autumn. You need a really good herdsman to do it, but if you can do it and if you can manage it, it's an excellent way of removing volunteers. Obviously in Canada you don't need it, but in the UK and in Holland it is actually a good thing to do, and people are doing that now.

We also looked at irrigation methods, especially in the southern European production areas. This was done in France, and again we found that the farmers in southern France use much too much water on the potatoes. When we compared potato applications according to monitoring (there are little water measurement sticks in the soil), we found that they use twice as much water as they really needed, and that obviously is an enormous expense in a place like southern France. But by using too much water, they obviously had more blight as well. So by switching to the right type of water management based on water monitoring, we got a substantial reduction in late blight, better quality potatoes, and also higher yields. By switching from overhead to drip irrigation you eliminate late blight, but not everybody can afford the investment.

That brings us to fertility management, and that is again another area where the yield of potato production can be substantially increased. We initially did that with this particular workpackage because there is evidence from conventional production which shows that if you give excessive N to your potato crops, they become more susceptible to late blight. That is fairly well established. But does this hold for organic production systems? Basically, up to the input levels that are permitted now in organic farming in Europe, which is about 170 kg of N put in as manure or compost or any type of input that is permitted, it doesn't hold. We never got any difference in blight development whatever fertility treatment we used. But we did get substantial differences in yield.

What I've done here again is something really unscientific. I've put in the data from one trial, which is basically the variety trial which shows you the disease development in Sante with and without Cu, and then I superimposed on that the results we got from a range of different manure treatments with respect to blight. You can see that independent of what type of fertility input we used, and fertility input level we used up to the maximum permitted, we didn't really get a significant reduction in blight at all. But what we did get, as I said before, were significant differences in yield–and they really were quite astonishing–when we switched from manure to compost. In manure we very rarely got a typical dose-response curve, with increasing input increasing yield. The manure in our relatively light soils where potatoes are grown in the UK didn't give much of a yield impact at all. Remember that most potatoes in the UK are grown straight after grass clover with an addition of manure input, as much as the farmer can afford, because it's the potatoes which are the main cash crop. So he invests all his fertility into that particular crop. It isn't a problem in that type of fertility management resulting in more blight, but if the manure is composted and the compost which was used in this case was a compost to which a certain amount of clay was added during composting, you get a significant increase in yield and the economics of this work out.

Compost turners are written off within a 4-year period of time and after that, with a compost turner lasting for about 10 years, you're just talking profit. So it is valuable to compost the manure. This is the type of composting I'm talking about. It's an aerobic windrow composting system–one of these compost turners which basically regularly throws the compost in the air, aerates it, and then lays it down again in a nice windrow. Under our conditions we have to cover it because otherwise we get rain into it, and if it gets too moist the aerobic conditions turn to anaerobic conditions, and we get major nitrogen losses from the compost.

What didn't work in fertility management? There was data from tomato production which showed that if you up the potassium inputs, you get more protection against foliar diseases. Our Swiss colleagues felt that one way to protect more against late blight was to add additional potassium (K) in the form of potassium sulfate, which, as you know, is a permitted input. But we actually did meet a derogation because we couldn't really justify adding more K on the basis of nutrition. So it was a purely experimental setup. But the fact was that adding more K, although not significant, always gave lower yields than the same treatment with the N in form of manure, compost only. So we didn't get any control of blight, and we didn't get any increase of yield. If anything, we probably overall got a reduction of yield. But over a set of about 6 or 7 trials we got about 50% more yield out of the compost at the highest input level than out of the same amount of N added as manure. Apart from one season, and that was a season when it was dry in England (it's rarely dry in England), the yields were exactly the same whether you used manure or compost. This makes sense if you realize that in compost all the N is released via mineralization. So if something happens that reduces the mineralization in the soil, the N supply from the input will be more affected than the N supply from this input, which has a lot of readily available N in it already. So if it gets too dry, your compost gets close to your manure. When we eliminated the microbial activity, the mineralization activity, in the soil completely in the pot trial, we got exactly the opposite result. So if you do the same experiment in a sand culture (in a sand culture you basically don't have any microbial activity apart from the one that you add to the compost as a manure), you have exactly the opposite effect. So your compost is basically giving a very low yield and your manure gives a very high yield. The most important thing is when you go over to using compost as your principal fertility input, you have to make sure that your microbes are active. As you know, the longer a soil is in organic management, the higher the soil biological activity gets. Longtime trials in Switzerland have clearly shown that. But it also means that under those conditions, if you don't irrigate you're likely to have problems in getting the effect.

One interesting thing about these trials was that we also got an increase in dry matter in the potatoes which were fertilized with the compost, and that, again, was significant in at least two seasons. That is different from when you push yields in conventional systems with higher N inputs, because there you always get a diluting effect when you push the yields. And that, to us, was a very interesting result as well, and we're not completely sure why yet. But the next program that we're doing for the European Union is looking exactly at the impact of different fertility management systems on quality of crops as a main focus. So you can see here that at 85 kg N input with compost you have about 1% more dry matter. with potatoes you can get too much dry matter as well, but for Sante you actually want them at 19% rather than 18%, or ideally, at 20%. If you go any higher then they wouldn't like them anymore.

I'm going to give you some data which underpins the points I've made about soil biological activity being important, and some biological activity being related to previous management of the soil. This is the data from the Swiss long-term study into the effect of different fertility management regimes on soil biological activity, and you can see that soil biological activity after 16 years of management was lowest in unfertilized soil, second lowest in the mineral-fertilized soil, and a little bit higher in a conventionally managed soil which got both manure and mineral fertilizers (actually, manure at exactly the same level as this organic system). So the additional mineral fertilizers reduced soil biological activity. One treatment was a standard organic (biological organics, they called in it Switzerland) treatment where manure was used and the other was a system where farmyard manure-based compost was used, a biodynamic system. Biodynamic farmers have always been into composting their manure, at least turning it several times and, as you know, if you go towards composts, you need that biological activity because otherwise nothing mineralizes the N that you add.

The next agronomic strategy that we looked at was pre-sprouting. We did about 6 trials throughout Europe, and in none of these trials we had any effect on blight development, so pre-sprouting didn't give any positive effect on blight development. When the epidemic came, the pre-sprouted potatoes were wiped out in exactly the same way as the ones which hadn't been pre-sprouted. Here's some data now from Germany which indicates that under extremely high blight pressure, it's actually the pre-sprouted potatoes that defoliate faster because they are at a physiologically more vulnerable state by the time the blight hits. In our trials there was no difference, but there's some indication from Germany that it can switch toward the pre-sprouted ones being faster defoliated. But what we did get was a clear yield effect, as expected, off the pre-sprouting. In all these trials we used non-chitted controls. We used partially pre-sprouted potatoes which had just a sort of rosette formed, and the idea was that if we do that, we can still machine-plant. Not everybody has a semi-automatic planter, and not everybody has acreage small enough that he can cope with a semi-automatic planter being used. We also used fully-chitted, which you need specific machinery for, of course, not to break them off during planting. These were the sort of results we got. We always got a yield effect with the fully-chitted only. The partial-chitted ones never showed a significant increase in yield. So the idea of partially chitting them in order to be able to machine-plant chitted potatoes was not really working out, whereas you did have a yield effect with fully-chitted potatoes as might have been expected. The only varieties where we didn't get a significant yield effect were the so-called determinant varieties, the ones which have a very specific number of branches that form, and then they don't form any more branches. Some potatoes continue growing branches depending on where they are in the season. But with the determinant potatoes we never got a significant yield effect when we chitted.

The next set of trials again within the program on agronomy was one where we tried to find out whether by just chopping rather than burning, we still had sufficient control on tuber blight development. As you know, you defoliate for two reasons: You defoliate to start curing the potatoes and setting of the skin, but you also defoliate to prevent spores getting through the soil onto the tuber to prevent tuber blight. The strategies we tested were chopping or flailing, burning, and then a combination of the two. With some varieties like Cara, farmers have to quite often do both because they have such a volume of foliage that just burning doesn't work. We did these different types of defoliation treatments in the background or at 10% or 35% foliar blight development. So the question was--do we actually need to defoliate early in order to prevent tuber blight? Or in other words, are the Dutch right in insisting that organic crops are defoliated at 5% only. In Holland if you are a potato grower you have to defoliate if blight reaches 5% of the total foliage. We did it with and without irrigation prior to defoliation. The question was: Is it dangerous to defoliate when it has just rained? There was no difference in tuber blight development between the defoliation methods, but the controls, the ones where we didn't defoliate, were obviously getting significant tuber blight, and there was no difference in tuber blight development between crops defoliated at 10% or 30% foliar infection level. So letting the blight develop a little bit more, in our trials, didn't seem to have any impact on tuber blight development. In fact, in a lot of other trials where we defoliated at 70% or 90%, we got virtually no tuber blight because we were working with varieties that were fairly resistant to tuber blight. Maybe, as some of my colleagues suggested, in an organic soil the transfer of spores through the soils is actually hampered by the biological activity, a point we still have to prove. We have no evidence for that whatsoever. There was no difference in tuber blight between crops irrigated before defoliation and those not irrigated. Tuber blight was always very low in these crops. But remember, these were done with varieties that were relatively resistant. But, as expected, the earlier defoliation gave a significant decrease in yield, so if we defoliated at 10% we had significantly lower yields.

Those were a couple of agronomics strategies which definitely had a yield effect but didn't do anything to control blight. Now we're back to some treatments or some approaches which don't work., and the things which don't work are basically all alternative treatments that we've tried, and I can tell you we've tried a lot. We tried millions of different treatments. We've tried compost extracts, we tried plant and seaweed extracts, and not just one. Anything that anybody could come up with, we've had in our trials in Switzerland, in Germany, in Holland, in Denmark, in the UK. Some of the biological control agents gave some activity in the lab, but was always a lot less than even the Cu control. And remember, Cu is not the most active pesticide around. The trouble is, none of them are commercially available, and getting them into commercial practice would take forever. Rhubarb extract actually works, but you have to grow a field of rhubarb to produce enough extract to treat a hectare of potatoes. So it was a nice idea, but it didn't work. We've tried everything on compost extracts - different composting methods, different composting extraction dates or extracting the compost at different times. We've tried compost made from manure, compost made from manure plus clay, compost made from green waste, compost made from household waste; you name it, we've had it in there. Apart from some bioassays that the Danes did, which came up with some really interesting results and which can be published, none of the field trials showed any effect of compost extracts, and we couldn't relate these trial results in the fields at all.

But just to give you an idea of what they did find in their laboratory tests, here it is. It was interesting and it sort of contradicts what people have always said about compost extracts. What you've got here is an infected control, untreated, and then the results you've obtained with extracts from 43-day-old compost, 57-day-old compost, and 81-day-old compost. You can see that the Cu control obviously controlled. Then you have horse manure, cow slurry, and cow litter. Those were sort of controls. The horse manure compost gave good control, and so did the cow slurry extract and the cow litter extract. As you let the compost mature, the level of control decreased, so it's a very young compost that gives you the best control in leaf assays. That's when you spray your *Phytophthora* on a leaf and then put some compost extract on top of it. In the 81-day-old compost they compared autoclaved compost extracts with the pure extracts, and the autoclaved one always did better, so somehow the activity didn't seem to relate to the biological activity in the compost extract, but must do something chemical, they've concluded.

But as I said before, when we tried all this stuff in the field we didn't get any activity whatsoever, and in some cases the compost extract actually accelerated disease development. Here are a few figures from field trials, which also cover a couple of other "wonder drugs", as we started calling them, because everybody came up with some new ones every year and they never really worked for us. Again, you've got a Cu control which worked, and at this stage we were working with only 6 kg/ha; then chitin, which we'd successfully used for root disease control in tomatoes; silica, which biodynamic farmers had put forward; brassica extract, which again we'd used successfully to control soilborne diseases in tomatoes; seaweed extract; a greenwaste compost; fresh compost from manure; and a mature compost from manure. You can see that there is no difference in the blight development curve compared to the untreated control, no significant difference whatsoever. We've repeated it in different countries, and it just didn't work.

Where does that leave us with respect to treatment? Well, the only active treatment that we have is Cu, and in our trials the Cu always increased the available Cu concentrations by about 100%, but only for about one season. Thereafter, you couldn't detect any difference in available soil Cu levels between Cu-sprayed and non-Cu-sprayed crops. So where does that leave us? Well, in perennial crops, accumulation of Cu in soils to phytotoxic levels has been proven. In organic production units that happens faster because organic producers don't have the synthetic pesticides available. But in perennial crops we actually have some alternative treatments that can cope with scab in apple and downy mildew in grapevine, which are the principal diseases for which Cu is used. In annual crops, particularly potato, there is no accumulation to phytotoxic levels. In fact, the 6 kg we add once every 6 years to a potato crop, probably helps to remediate the Cu deficiency that we have in a lot of soils and which does seriously affect our livestock production systems. In annual crops we have currently no alternative treatment; we haven't come up with one. We will test another year. We've got another list of wonder drugs to test for this year.

I think this would be a good point to sort of open up for questions before I go into the next bit.

Q: I have a couple of quick questions about compost extract. Are you talking about a foliar spray?

A: Yes.

Q: If you are flail-mowing your potatoes, did you find that it was better to do it when conditions were wet? I do it, and it seems like in dry conditions it tends to leave some potatoes exposed through blowing soil.

A: We did it both under wet conditions where we've just irrigated and under dry conditions. Under both conditions we didn't get any tuber blight apart from the ones where we didn't flail at all. So we had basically total control with respect to tuber blight.

Q: Did you see any difference in terms of exposure to potato size?

A: We didn't look, to be honest.

Q: Just a comment. Some years in Canada when we get a lot of snowfall early; there's no frost goes in the ground. Some years we have oodles of volunteer potatoes. So you had thought that we were free of that problem. We do have it some years, and we do have different strains of late blight. One of our problems is we're not really permitted to do trials outside with late blight to do efficacy trials. So then we're dependent on other areas to get efficacy on some of these new fungicides. Trying to deal with late blight is quite a challenge for everyone.

A: In the variety trials we had to innoculate, and for one simple reason: If you don't innoculate with a strain mixture that covers all known R-genes, you're not sure in your variety trial whether you are having a variety that just lacks the right type of fungal community in your area and is much more vulnerable to resistance development compared to one which has a definite horizontal resistance. So we did two things to try to avoid the problem of selecting for varieties with new R-genes–we inoculated with a combination of strains which was supplied by the Scottish Agricultural Office so that we could say "Well, at least there is no R-gene in there that is known". The other thing we did is recorded slow lesion development because slow lesion development was used by us as an indication that we have a tolerance rather than a complete resistance, which we didn't want to select for because that's what was done in the past and they never last longer than 2 or 3 years. So the varieties that we eventually selected were slow lesion developers. They might have R-genes in there as well, and the R-gene might have contributed to it. But we have as much safety as we can get with respect to selecting for the type of resistance we were after.

Q: How do you innoculate outside without having the local farmers take you to task?

A: Well, luckily, Northumberland is an area where blight always comes late - it's the latest, and it's an area where no potatoes are grown now because for water regulation it's easier to grow potatoes just across the Scottish border. So water is difficult to get to in England, but very easy to get to and inexpensive in Scotland, so all potato production has crossed the border. So where we were, there was nobody to complain because nobody grew potatoes.

Q: Are you aware of the compost tea production by Dr. Elaine Ingham? Are you going to make experiments with that compost tea program which may be different from the compost extract?

A: We even bought a machine to do exactly the same type of extraction from America. We flew in one of the compost extractors that was recommended, and we did get compost extracts working against quite a few foliar diseases under protective conditions in tomato and cucumber production. We have very good results, and quite a few of our farmers now use it to control mildew and *Botrytis*. But it did not work against *Phytophthora*, and we tried a lot of different recipes.

Q: I had a question about Sarpo, the variety from Hungary. How long has it been around?

A: That's a very good question because obviously we have done trials over 3 years to be able to say that it's tolerant rather than resistant; short-term rather than long-term. We can't really do on 3 years' trials. But we actually had the Sarpo varieties grown the UK now for about 8 years, year after year, in demonstration plots, and although the demonstration plots were not near to where we were–they were in Wales and western Scotland under much higher blight pressure–we basically in those 8 years have not seen any reduction in blight resistance in those varieties and similarly in the Lady Balfour and the Eve Balfour, which are Greenvale-owned varieties bred at the Scottish Crop Research Institute. They have been around for about 5 or 6 years, and again they are slow blighters. They have not shown any increase in susceptibility over 5 or 6 years. So we already show that they have a greater longevity than the typical R-gene-related variety. I'm absolutely sure that it will eventually break. With potato we have to face the reality that we have to have a continuous breeding program which introgresses new resistances. Maybe after 10 years we can come back to the same resistances. But we have to have that continuous breeding program because it's really the only thing that can give us more control of blight with the alternative treatments not working and with the aversion of Cu probably going to put it out of business at some stage.

Q: Can you give us some examples of some of the mechanisms that help resistance?

A: Well, we tested 2 things. We did some microscopic examinations of the Sarpo varieties and we made some extracts from the leaves which we concentrated to various concentrations. And in either of those investigations we couldn't really come up with anything that could be an explanation for the resistance. So with the extracts--the watery and alcoholic and whatever extracts we made, we never found some sort of direct antifungal activity in the potato leaves themselves. Basically at the moment we know what might not be involved in the resistance, but we don't know what constitutes a resistance, I'm afraid. In short, we don't know.

The upcoming fungal disease in organic production has been *Rhizoctonia*, and our working hypothesis is that this is due to the fact that we have to increasingly use organic seed. About 40% of the crop in the UK is now grown from organic seed, and it's really since that had been introduced that we had a gradual increase in *Rhizoctonia* rejected potato loads. Now that is quite a controversial statement, but if you know the biology of *Rhizoctonia*, you know that in organic farming we already use other factors which encourage it. We do use organic matter inputs. We do have high organic-matter-containing soils. So we already did that in the past, prior to organic seed use. So the only thing that has changed over the last 3 or 4 years while we had an increase in *Rhizoctonia* was really the push toward organic seed. You only have to look at some organic seed loads and you can see *Rhizoctonia*. So it's not a completely stupid hypothesis. So what do we do about that? That is our future program, and it is only starting this year and it's looking at how we can improve organic seed production and how we can possibly find treatments, ideally seed treatments, to avoid producing *Rhizoctonia*-infected crops from mildly infected seed. Obviously we have the other diseases and there are some contradictions there. The Sarpo varieties are incredibly virus resistant, and that's probably the reason why they won't get into business in the UK; no seed producer really wants to produce virus-resistant seed, because once you have virus resistant seed you have to go back to the seed merchant less often because you can use your own seed longer. That is a real problem because for once we would have a set of genotypes that have both virus resistance and blight resistance. So we're not really working on these other areas--viruses, scab, *Erwinia*--because really in order to make headway there we need political action, particularly with respect to the viruses, if we want to use the best approaches available.

Q: Do the countries in your trials utilize flush-through seed systems where the seed cannot be saved in the system so long before it gets flushed out?

A: That's what we have. But the reason for having those is so that viruses don't accumulate.

Q: But it's not solely viruses that appear. Viruses are one aspect of it, but it's also other soilborne diseases that can be carried over, which can be big problems. So the viruses are only one component of it.

A: But they are the one component which make you change seed first. It takes longer to accumulate most of the other diseases and it...

Q: I guess what I'm getting at is the systems are in place. I know in Canada your seed, whether it stays clean or not, has to drop a class a year, and just because it went in clean of viruses, I can't keep my seed longer.

A: But those systems were introduced in order to make sure that the seeds that are used by farmers remain clean within the current context of conditions. As long as you don't have virus-resistant plants, that is a very sensible thing to do. As soon as you have virus-resistant plants, you can allow another 2 years of safe seed use. The very people who could introduce those sort of varieties can't be interested in doing that. That's all I'm saying. So I absolutely agree that those systems are there and they are legal, but because those systems are there, there's no market for virus-resistant seed. They would give you no benefit because there would be no point in saving your seed because you couldn't use them in the next year anyway.

Q: That's my point. That's the way the system's set up now. You've got to change the system to bring those varieties across.

A: Absolutely. That's my point.

The principal approaches that we want to use were developed and are now successfully used in intensive horticultural production systems under glass. We are now going to investigate them with respect to *Rhizoctonia*, and I understand I might be able to learn something later on that issue because it's already happening. So I will be sitting here with open ears. But what we basically have spent the last 6 years doing, and parallel to all potato work, is finding new approaches to the control of corky root rot and *Verticillium* in organic tomato production and, to a lesser extent, also in organic cucumber production. These soilborne diseases are serious problems. Juan Rodriguez did all the work, and he did this work in a commercial company in Somerset in southern England. Basically, what we were faced with when we first started on organic glasshouse production was an industry that steamed the soil every year, then put chicken manure down, then grew a tomato crop, and then went through the same cycle again. So it was everything organic shouldn't be–it was a monoculture, water-soluble fertilizer was used, and the soil biological activity was killed off annually. We didn't want that because we felt that it wouldn't be credible to sell to the consumer in the long run, and it's also incredibly expensive. Soil steaming is an incredibly expensive exercise, and chicken pellets are quite expensive as well. So we looked at different types of approaches to getting away from steaming, and the one methodology that did work was the use of so-called suppressive composts. If you use the right type of starting materials and the right type of compost, compost raw materials, and the right type of composting procedure, you can come up with a material that is naturally suppressive to the disease, and it works in horticultural systems. It really works. We got the same level of control if we added compost as we did with manure.

Let me explain these results a little bit. That is your steamed control, and the blue bars are your overall yield. This is in soils which for 20 years did not have a tomato growing in it, and the fungus was still there. This was soil in a glasshouse which 20 years ago had tomatoes grown in soil, then went into hydroponics, and then went back into soil. In the first season you already have enough disease to let you end up with only half the root system. If you grow them for another season you don't have a yield at all because they're killed off early in the season, and you have a reduction of yield. If in year 1 you use manure, then the additional fertility available through the manure, the relative available fertility of the manure, allows the plant to compensate for the smaller root system, so you still get a decent yield. But only in year 1. It year 2 there is basically so much disease that you have the plants killed early on, about midseason. If you use a suppressive compost you basically get the same yield and root system levels, and if you base your production system on compost you can maintain healthy roots for 4 years, and that's as long as we've done it now. This is 4 years out of production. Now, you can get the same level of protection by using grafted plants in tomato production. But grafted plants are not an option in potatoes. The one strategy we're going to have a look at is using these type of composts. We know that composts give us higher yield anyway. Maybe the right type of compost also give us control of *Rhizoctonia*, especially when we use it not just the one year when we plant the potatoes, but regularly before we plant the potatoes.

The other thing that we found works is if we use chitin and brassica wastes as a soil amendment. We're not going to use chitin and brassica waste as a soil amendment; we're going to try and use that as a seed treatment with potatoes. But our plan is to basically translate what we've found with these type of treatments in tomato production to *Rhizoctonia* in potatoes.

On the second most important one, I can only give you the plans; I can't give you the results. But what I would like to alert you to at the end of my presentation is the next European framework. The next European funding framework for research, the so-called Sixth Framework Programme, more or less the same consortium that has worked on potato blight, has been selected to provide the research and development support at the EU level for organic and low-input farming. So there's only one big research program for supporting agricultural food production–the agronomy end of food production–and that's our program. It started on March 1st and it's called "Improving Quality and Safety and Reduction of Costs in the European Organic and Low-Input Food Supply Chains". The interesting thing is we've competed in this program with everybody else who wanted to work on integrated farming, on GM-based farming, and while 1 or 2 integrated farming projects have made the scientific threshold, none of the GM-based programs even got over the scientific threshold. And it's the organic farming-based program that the EU has selected as providing the main input into research for agricultural food production over the next 5 years. Under this scheme we will do more work answering some of the questions that have remained under this blight program, in particular in the areas of foliar and seedborne disease control and also fertility management. It has a total budget of €18,000,000 excluding the industrial partner inputs, and it has 31 partners, 5 of which are core partners. It's basically based on organizations who have been involved in Framework Four and Framework Five projects, and it continues these in a sort of integrated way. These are the type of projects that form the knowledge base for the new Framework Six Programme. So the program includes components on marketing and consumer research, obviously, components on agronomy, but also components on quality assurance.

Here is where the partners are based. The core partners are University of Newcastle; Stockbridge Technology Centre; DARCOF (Danish Research Centre for Organic Farming), the Danish organic farming institute; the Louis Bolk Instituut, the Dutch institute for applied animal research; and the Organic Farming Institute in Switzerland. The university partners are all over Europe and Asia, so we have partners in Israel, on Crete, in Italy, in Poland, and in Czechoslovakia. We are more or less in every European country but Belgium, believe it or not–the people who give us the money haven't got their own partner in there. We have companies throughout Europe, including Turkey, involved. There is a project board, and then there are subproject coordination teams which focus on the different components of the program, which are consumer studies, nutritional studies, really trying to answer the question, "If you use organic agronomic methods, do you get an improved nutritional and sensory value into your crops and livestock products?". The two subprojects which focus on an improvement in the agronomy of crop and livestock production systems will work very much on potatoes again. We want to elaborate on how we have to grow potatoes to get higher quality, higher nutritional, and higher sensory quality into potatoes in the background, obviously, of the agronomic aspect that we need. There are also processing studies, and a program which looks at developing quality assurance systems for organic and low-input farming, and horizontal activities which do environmental and sustainability impact assessments. They will also do cost-benefit analysis on the new strategies developed here, and they will have components of training and dissemination.

In each of those subprojects we have different workpackages. These are the ones on crop production: Improving soil management; improving seed and seedling health, which doesn't just focus on seed treatment–it also focuses on agronomic strategies to stop seedborne diseases from developing in the field. We have one which looks at improving fertility management–how we can optimize fertility supply from organic-matter-based input systems; how we can get most of the N in the manure into the crop rather than lose it. One program is for ready-to-eat-type crops, lettuce, particularly; minimizing enteric pathogen transfer risk, and finally, a workpackage which looks at integrative crop protections–how we can combine various types of strategies to protect the crop.

That was just to show you where we're moving now, and how we're following up on some of the results that we got in the Blight MOP project.

Q: I'd like to ask you a question about your compost. First of all, when you're making compost for potato production, do you have any specific goals in mind when you make that compost, and what were you looking at for an end product as far as a C:N ratio for the potatoes? Did you also prepare biodynamic tea of this homemade compost?

A: The C:N ratios I have to look up. We grow potatoes on very light soils in the UK, and where we did the trials we had very, very light soils. So one objective with making the compost, in addition to obviously converting all the fertility into non-water-soluble N, was losing as little N as possible during composting. The third objective was to increase the cation exchange capacity within that compost; that's why we added the clay. The clay was preselected to have a high cation exchange capacity. So we actually had to carry it in from some distance because the nearest local ones both had a very low one. We turned according to temperature and CO_2 measurements, because in the initial stages of the composting it's important to get the nitrate fires working as fast as possible to get the ammonia converted to nitrate so that you don't have volatilisation of ammonia. For that, we add about 15% of old compost because we know there are loads of nitrophiles in there, but as a raw product–the stuff that comes out of the cow, and the straw–it has very little nitrification activity in there, whereas old compost mixed with soil has. So that's the first stage. In the first stage we want to get the ammonia to nitrate. The reason why we put the foil on top is that is breathable, so it lets the CO_2 out but it doesn't let water in. Once you've got the ammonia converted to nitrate, and there's nitrate in there already, you have to avoid the nitrate being washed out of your compost heap. You get quite a lot if you leave it open; you get quite a lot of nitrate washed out in the first 1 or 2 weeks of the composting process. The third thing that we monitor is temperature. It's not so important in compost for potatoes with respect for eliminating enterics, but it is quite important with the compost we make for other horticultural crops. We stipulate now in the Tesco producer group that they have to have a compost passport for crops such as lettuce, carrots, etc. which shows that the temperature has been above 60° for 2 days so that we basically had a heating-up process for long enough, for at least one turn, that the whole heap got enough temperature to kill off the enterics. We stipulated that it has to have cooled down again, to below 25° and there are certain measurements that you take to make sure there aren't any inhibitors in there. They all come in a pack that Sandberger supplies (I don't have the details with me) which makes sure that you don't have any inhibitor accumulation. This is going away from the trials, particularly where we integrate putrescible waste–green waste or household waste–into the compost. We don't have experience with raw material; we'll have to make sure that there isn't accumulation of any inhibitors, and that's what the test provides. Anyway, we stipulate that at the end it is below 25° simply to make sure that it has matured to a stage where any new enterics introduced into it can't develop. That's a sort of second barrier; once your compost has matured and you have bird droppings going onto it and so on–we tested this, actually–it's very difficult for them to develop because it's not the sort of stuff that comes out of the gut anymore; it's something that is much closer to soil–low in readily available carbohydrates and so on. So enterics can't develop on it anymore. That's basically the process we follow with all the field crops. For some of the very specialized horticultural crops, we developed in-vessel systems because there we need compost that has a very rapid nutrient release pattern, and there we go for more N compared to C. We add amendments to that at the end as well to get the N even higher.

Q: Could you please tell us what kind and what quantities of brassica residues that you use for *Rhizoctonia* suppression?

A: We used 5%, 10% and 40% of fresh brassica inputs, then we repeated that with dried brassica matter that was ground down very finely and basically represented the same amount that we had put in as fresh residues.

Q: Would that just be cabbage leaves? Would you have used canola to fertilize potato crops?

A: We tried both in the horticultural systems. We had a cabbage producer, a packhouse for brassicas, so there was waste from cabbages, broccoli, and cauliflower–the green bits of the cauliflower. They were all mixed up. That was one brassica input. Then we used basically canola straw as well. The canola didn't work; the green brassica waste from the packhouse did work.

Q: Did the packhouse have organic as well as...

A: No, it was a conventional packhouse.

Q: Does it matter?

A: It does matter. We want to use it commercially; we can only use waste from an organic packhouse. But during the trials we used basically a packhouse that was packing conventional. We got a derogation to do that on a trial basis.