Chapter 1
Soil Microbial Resources and Agricultural Policies

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Abstract The current systems of food production used in Europe and North America have been hugely successful in increasing the yields of arable crops and in reducing the proportion of household budgets devoted to food. Despite this, intensive agricultural systems have had adverse effects on the environment, and the resulting diet has been linked to current health issues. Both the EU and the USA Government have subsidised production. The income derived from subsides has often exceeded that from farming. Such subsidies are unsustainable. Farming must become more market orientated. Past attempts have largely related to attempts to increase yields and reduce costs. The introduction of genetically modified crops is an example of this approach. An alternative has been to increase income from farming by producing products selling at a premium price. Recently, the public have come to question how food is produced and the consequences of particular methodologies. Questions related to the ethical values inherent in systems are increasingly raised. Future agriculture will be more eco-efficient. Against this background, the role of mycorrhizal fungi should be enhanced. These issues are examined here.

1.1 Introduction

The proceedings of the 5th International Conference on Mycorrhiza (Anon 2006) indicate that at the current time several lines of research are being followed. There are studies aimed at documenting the genome of the fungi and related work to understand molecular communications between fungi, host plants and other micro-organisms. There are studies which aim to understand how the association works to promote the success of the plant partner. There are an increasing number of studies

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aimed at understanding the ecology of the fungal plant association (see Chapter 12 by Wolfe et al.) and, derived from this interest, in inoculating agricultural and horticultural crops with arbuscular mycorrhizal fungi (AMF) so as to promote performance. With the exception of the last of these areas, research is justified on the basis of its contribution to our fundamental understanding of symbiotic relationships between fungi and plants and of the structure and functioning of soil communities. The success of inoculation technology depends on its potential to improve current agricultural practices. However, whether any of this research is put into practice, and the amount of funding which may be made available for even the most fundamental of the research areas, will depend on factors mainly unrelated to mycorrhizal fungi.

The ability for progress in any area of science to have a significant effect on the economics of the area it seeks to influence or even on practice within the technologies to which it relates is far from linear (Kealey 1996). Firstly, the science must deliver real understanding and the ability for that understanding to be developed into either a new technology or product or to result in a significant gain in the delivery of current objectives. In the context of agriculture or horticulture, this would normally be seen as an increase in yield or product quality or in the ability to carry out an action more easily. Secondly, the science must enhance the direction of travel of a particular set of technologies and, as a result, aid a saving in costs or render a key activity doable. It will contribute most if it is able to reduce costs in a major part of the cost structure of the industry or if it enhances the practicality of a distinct approach to production. Thirdly, it must also work with the prevailing political model. In the context of agriculture in Europe it must sit comfortably with the rules of the Common Agricultural Policy (CAP) and the environmental norms of the EU as enacted in the Water Framework Directive (WFD). Fourthly, it must also be considered to be ethical, safe and necessary if it is to be acceptable to society.

Most reviews of progress in particular areas of science and on their potential impact deal primarily with the first of these factors. Issues related to the second are often used as justification within the case for carrying out research in that particular area of science, although analysis of financial impact, after the completion of the research, is seldom carried out in a rigorous manner. The potential for system change is currently topical. Until relatively recently it has been assumed that the political process and the public will always support technological advances if they are apparently safe and if they seem likely to result in cost saving. For much of the twentieth century this was the case. Towards the end of the century, attempts to introduce agricultural biotechnological products, such as genetically modified (GM) crops (Bruce and Bruce 1998; Marsh 2003), indicated that there had been a major change in the mood of the public, at least in Europe. This indicated that public acceptance of technological advances could not be automatically assumed. It became clear that the views of those who did research and the creators of new technological products were likely to be driven by different considerations to the users of products and those who purchase foods (Bruce and Bruce 1998).

The resistance of the public to GM crops is currently a factor in attempts to introduce nanotechnology to agriculture.

This chapter examines the extent to which political and economic influences, changes in farming practice and ethical issues will influence the potential role and contribution to agriculture and related industries of soil microbes in general and AMF in particular in the coming decade.

1.2 The Current State of European Agriculture

1.2.1 The Common Agricultural Policy

For most of the twentieth century, in most European countries, agriculture has been subsidised by Governments, latterly via the Common Agricultural Policy (CAP) (Plum 1998). The basis of subsidy has varied. For much of the period, payments were tied to the production of certain crops or resulted from the willingness of the EU to purchase (intervention) crops at prices which were above the cost of production (North 1987; Atkinson 1990). As a result, production was related to the rules of the CAP rather than being geared to the needs of the consumers. The impact of the CAP, together with decreases in the market prices of major commodities during the 1990s, meant that for farming in a country like Scotland, income from the direct products of farming, e.g. grain or milk, represented, on average, only one-third of the total income of the farming business. The remaining two-thirds of income came from the CAP and related sources. An additional consequence of subsidies was that for many commodities the cost of production was above farm gate prices. For example, milk production costs in 2006 were 19.5 p/l against a selling price of 18 p/l, beef production £2/kg against a selling price of £1.9 and oat production £100/t against a selling price of £70/t (NFU Scotland 2006). The survival of farming with prices at these levels was only possible because of the existence of the CAP (DEFRA 2006). Over the same period, the US Farm Bill had a similar effect on production in the USA. In the UK, the competitive nature of the multiple retailers and the low direct prices received by producers meant that the proportion of household incomes spent on food, <10%, fell to an all-time low (DEFRA 2006; Hampson 2006). The value of primary production in UK decreased to 1.7% of gross domestic product (GDP) although the whole agri-food sector represented 7.7% of GDP. This situation was generally perceived to be unsustainable (Buckwell 1998; Anon 2002). In 2005, the CAP was reformed with the replacement of the whole series of production subsidies by a single farm payment which was given irrespective of the farming enterprises being undertaken. The payment requires farming to be continued and a series of environmental goals to be met. At the same time, the EU saw its largest single enlargement (Marsh 2005).

1.2.2 CAP Reform

The combined effect of the above is that the CAP is due for reform in 2013 (see also Sect. 1.7) with the expectation that the level of subsidy will decrease, perhaps by 50% (Fischer Boel 2007). These changes have resulted in a significant awareness within European agriculture of the need to change, and hence in more interest in novel activities and novel methods than has existed for some time. Were support from the CAP to decrease to 50% of current levels this would increase the significance of income derived from farming. This would need to increase significantly to preserve current average incomes. Increases in farming incomes will need to come from a reduction in costs or from improvements in quality; there is insufficient scope to increase yields to the extent needed to replace lost income. This presents options for soil micro-organisms to be part of a radical reform of farming practice and to increase their impact.

1.3 The Current Farming Model and Its Consequences

1.3.1 The Conventional Model

Agriculture, post-1945, changed so as to increase its emphasis on maximising yields through the optimised/maximised use of nitrogen fertilisers. Pesticides were used to protect these high nitrogen crops from the adverse impact of pests and diseases (Martin 1998). Agriculture moved away from a model where crop rotation, which recycled nutrients between crop and stock enterprises and used biological processes such as nitrogen fixation by legumes, was the norm. It moved to a system which saw the principle role of soil as physically supporting the plant so that it could absorb fertiliser-applied nutrients (Conford 2001). The use of varieties in which the partitioning of assimilates into grain, rather than into vegetative elements such as straw, resulted in the predominance of shorter varieties of cereals which needed herbicides to permit them to compete with weeds. Overall, the combination of cheap fertiliser, a continual stream of new pesticides and increasingly high-yielding varieties of cereals increased average yields to record levels; average yields increased by 1–2% each year for most of the period 1975–2000 (Atkinson 1990).

1.3.2 The Environmental Impact of Agriculture

Production carried out in this way and with these inputs was not without its costs in relation to biodiversity of wildlife and soil and environmental quality (Nortcliff 2006). This has become a factor of increasing importance and now is integral to the design of farming systems. Pretty et al. (2000) estimated that in the UK alone the externalities of agriculture, the real costs not being born by those who incurred them, totalled around £2.3 bn/year. This resulted from negative impacts on water, air, soil and biodiversity. For example, they estimated the cost of cleaning water from contamination with fertiliser and pesticides alone was £231 m/year. A hectare of farmed land which might produce £700 of income for cereals would incur a cost of £250 in respect of environmental damage.

1.3.3 Pesticide Concerns

In addition to their environmental impact, conventional farming methods became associated with concerns over the frequency with which pesticide residues were found in food products. This has become significant for many European consumers. The presence of pesticides in food is related to the farming system used. In a study of apple production in the USA, Baker et al. (2002), found pesticide residues in 82% of fruit from conventional production compared to 49% in fruit from farms using integrated pest management (IPM) and 23% from farms which were using organic production. For vegetable production, the comparable figures were 65%, 45% and 23%, respectively. For vegetables, when residues of materials which were currently not permitted for use on any crop were removed from the analysis, the figures decreased to 61%, 44% and 9%, respectively. For fruit, removing such residues had little effect on the analysis. The high frequency of presence in organic production indicated the prevalence of long-lasting contamination from materials applied many years ago, and the possible contamination of production by applications to conventional systems.

1.4 Alternatives to the Current Agricultural Model

1.4.1 Ways of Reducing Environmental Impact

Concerns about the impact of current agricultural systems on wildlife and the environment, and about the presence of pesticide residues in foods, have led to calls for changes to the way farming is practised so as to achieve reductions in pesticide use and a reduced impact of agriculture on the environment (Baillier et al. 1997; Bax 2002). It has resulted in an increase in the proportion of the market being supplied by production which does not rely, or rely as heavily, on the use of pesticides, such as organic farming (Conford 2001). Organic farming is the most extreme version of a system which aims to use natural processes and cycles as the basis of nutrient supply to crops and for the protection of crops from the adverse impact of other organisms. At the present time, such systems produce yields of the main agricultural commodities which are significantly below those http://www.springer.com/978-3-540-87977-0

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