Nothing is so fatal to the progress of the human mind as to suppose ....... that there are no new worlds to conquer. (Humphrey Davy, English engineer and physicist, public lecture 1810)

Soil and in particular its microbial diversity remains largely an unexplored world. A few researchers have provided insights into the outer edges of this world but it remains mostly unknown and inhabited by a huge diversity of organisms whose biology is open to speculation. Yet it is this world and its inhabitants which arguably hold many of the properties which will enable mankind to surmount the huge problems resulting from a burgeoning population and diminishing land supply. Increasing food production in parallel with conserving and protecting our environment while allowing producers adequate financial returns are the primary challenges facing agricultural science research in the twenty-first century. These factors of food production, environmental protection and producers’ profit form a triangle which defines agrarian sustainability. Sustainably raising crop production will only be achieved by gaining far greater understanding of the physics and chemistry of the soil environment in which roots grow and the impact of benign and pathogenic microbes on them. It is at least as important that we understand the world beneath our feet as we do the Earth’s atmosphere and oceans and those of neighbouring planets. Increasing the benefits obtained from soil microbes must be linked with cautious care for the world which they inhabit. Ill-judged and ignorant exploitation has lead to, and continues leading to, devastated land where the soil is degraded into lifeless dust-bowls where structure, texture and biological activity are lost and salinity rises. The very nature of soils has slowed their study until recently. Now the tools of molecular biology are offering powerful new ways of unravelling complex relationships and simplifying interactions.

This Book provides an insight into the developing knowledge of soil microbes and points to ways by which they can be utilised in support of agronomically and environmentally sustainable crop production. This context is introduced in the first chapter which sets out the parameters of sustainable production. It is succeeded by analyses of microbiology in natural, unfarmed soil defining the baselines from which agriculture has modified soil resources. Chapters describing nutrient cycling and the development of soil organic matter clearly demonstrate the impact of mankind’s activities and means by which these may be tailored to achieve sustainable
objectives. Detailed studies of beneficial and pathogenic soil- and root-borne microbes follow identifying the continuous interactions between plants and the organisms with which they co-exist. Outcomes of this co-existence can be either immensely valuable in terms of raising crop health and productivity or totally disastrous leading to disease and death. Husbandry practices affect the balance between these outcomes. Gradually the significance of the way in which land-use interacts with crop production and the potential for its manipulation to raise sustainable yields is being extending into mainstream crop production. This philosophy is not new but had been ignored and side-lined for at least the latter part of the twentieth century by crop production methods based almost solely on approaches which have targeted the plant as opposed to the soil. Crop agronomy using a soil-based approach demands as a priority the revision of plant breeders’ targets. A result should be new cultivars tailored to attain maximum yields and quality in harmony with beneficial soil-borne microbes. This approach will enable crop producers to make far greater use of integrated systems for the control of pests and pathogens. Biological control used with cultivars fitted for increased productivity growing in soil managed by husbandry systems which enhance beneficial microbial populations could deliver the sustainable yield enhancements needed by population growth. Greater understanding and manipulation of the soil environment must include knowledge of the aerial environment and the manner by which it is changing. Both environments interact and influence each other consequently consideration must be given to the impact of global climate change both directly and indirectly on soil microbial populations. Changes to air temperature, precipitation and wind will have direct and substantial effects on soil borne microbes. Evidence for this is already apparent in the movements of aggressive pathogenic species in to previously un-colonised regions. Ultimately, increasing crop productivity and caring for the soil environment can only be considered to be fully sustainable if farmers and growers are able to maintain viable and successful businesses. Soil is the first resource which suffers from lack of care where economic sustainability is absent. Ensuring adequate incomes for soil users is integral and essential for the achievement of sustainability in both crop production and environmental care and conservation. Science and its practitioners can, given the necessary resources, open up and more fully explore soils for the greater benefit of mankind and the Earth’s environment and its natural biodiversity. It is the task of politicians to understand the opportunities which this offers and ensure that the general public, the tax-payers, recognise why financial resources should be applied to the crucial task of acquiring knowledge of the microbes in soil. Regrettably, for at least the past generation there has been a worldwide failure by politicians and their advisors to provide adequately for studies of the agricultural and soil sciences. Unless this situation is reversed in the very short-term none of the opportunities outlined in this Book will be realised. That will exacerbate the famines which afflict mankind and continue the destruction of the Earth’s soil, its environment and its inhabitants.

This Book was conceived as a contribution towards the international debate on population growth, food insecurity and the conservation of biodiversity. Gradually there is a recognition that soils demand as much attention as the atmosphere as an
integral part of the biosphere. It has been written by an international team of researchers recruited from around the world. Substantial effort, expert knowledge and energy have brought this project to fruition for which the Editors Geoffrey R. Dixon and Emma L. Tilston sincerely thank each member of the team of authors. All have been prepared to devote considerable time to fulfilling this task and have shared with the Editors the joys and frustrations inherent in writing such a Book. We thank all of them for the care with which they have submitted excellently authoritative manuscripts. The Editors have been supported by many family and friends. Particular thanks go to Mrs Kathy Dixon who with much patience and good humour aids and accepts her husband’s literary activities. Both Editors have made much use of the facilities in the Library and our respective Departments (Horticulture and Landscape and Soil Science) at the University of Reading for which we offer very grateful thanks and acknowledgement. Authors have offered acknowledgements at the ends of their Chapters.

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