PART 4

MANAGING THE CROP

The first three parts of this book have focused on crop plants and genetic resources. Of course, agriculture consists of crops being grown in an environment, by farmers and using natural resources. The best crop variety that is short of nutrients or water will come nowhere close to expressing its potential yield. Likewise, the best agronomic practices cannot change the genetic limitations of a variety. Recognising that there are positive and negative feedback loops among varieties, the environment and agronomic practices, it is instructive, not to say more manageable, to treat each area independently while essentially holding the others constant.

Rather than work through advances in crop management practices, such as precision agriculture, weed control, tillage, fertiliser and water management, Chapter 14 takes the approach of examining where crop yields are significantly falling short of their potential. Actual farm yields that are significantly less than potential yield essentially reflect an overall deficiency in crop management and areas with greatest gaps are also those with most severe poverty. This chapter separates the world into six groups with respect to yield gaps. Focusing on sub-Saharan Africa (SSA), it is clear that major failures at a several levels explain the serious production problems throughout virtually the entire continent. Although there are many reasons for the yield gaps across Africa, and these of course differ across countries, there is no inherent biophysical reason for them. The gaps are clearly reversible, as argued in Chapter 25, and a range of policy interventions are being put in place to achieve the reversal are summarised in Chapter 24.

Water is a major determinant of how agriculture is practised. For high-value crops especially, there have been significant advances in water delivery methods such as drip irrigation and in wealthy countries some row crops benefit from overhead and sprinkler irrigation. Nonetheless, large areas of the world are dependent on rainfall for most or all of their agricultural water. At best farmers in these regions can draw on some kind on supplemental irrigation that is delivered in largely the same manner as it has been for thousands of years. It is true that modern dams are larger, canals longer, pumps more powerful and wells deeper than ever before in human history, but, they are still dams, canals, pumps and wells.

Chapter 18 provides a fascinating look at how irrigation has expanded over recent decades across the world, the impact on major food grain production and the policy drivers behind this expansion. A shift from major dam development peaking in the 1980s in Asia, to the wide availability of pumps servicing shallow tube wells have supported steady production growth in Asia and formed a key component of the 'Green Revolution'. However, deterioration of irrigated lands, dropping water tables, poor governance, and corruption all threaten these gains. Regardless, a look at major regions of the developing world illustrates that countries, while jealous of their access to it, have shown an impressive willingness to treat water as a regional resource. They have established multilateral mechanisms to deal with water disputes and allocations, and these have continued to function even during times of terrible warfare among parties.

As we have seen in Part 2, and as is reflected in a rapidly growing body of scientific literature, microbes are now seen as major contributors to human health and make up a significant portion of our own bodies (at least in terms of numbers of cells in our body). There is also an emerging consensus that the same can be said for the soil. Although it may be a stretch to claim that the soil is 'alive', the way in which plants take up their nutrients is greatly influenced by the microbial make-up of agricultural soils. Chapter 15 examines in some historical detail our understanding of the microbial constituents of flooded, oxygen-poor (anaerobic) soils, how they interact with the rice plant (the major crop grown under these conditions) and influence soil chemistry and nutrient uptake. The chapter advances a particularly intriguing prospect of engineering plants to accept nitrogen-fixing microbes, and the anaerobic conditions in flooded rice paddies are excellent environments for this.

Greenhouse gas emissions from agriculture have attracted attention of the global community of climate researchers and policy makers. Nitrogen fertiliser production and rice production have been seen as a major global source of methane. Improper use of nitrogen fertiliser is also a source of NO_x gasses. However, it is certain that soil microorganisms are key players in the carbon and nitrogen budgets of our soils.

Crops not only provide human sustenance, they are also attractive food sources for a large number of other species. Farmers reasonably classify as pests those species that damage the crop and reduce yields. It is equally reasonable that marginally educated farmers will see any non-crop species in a field as a threat to their crops. It is only relatively recently that farmers and plant breeders have had tools to proactively manage pests in their fields. Breeding resistant varieties has been a major success across many crops, as mentioned in several chapters. This has been most striking in dealing with microbial pathogens (viruses, bacteria, fungi and, to some extent, nematodes). A notable frustration in developing resistance to pathogens has been their ability in many cases to overcome that resistance and render varieties susceptible to damage again. Chapter 16 elegantly summarises what we understand of the intricate relationships between host plants and their pathogens that leads to resistance breakdown. This deep understanding suggests approaches to manipulate the genetics and physiology of crops to effectively and perhaps permanently eliminate losses from some key crop pathogens. It is probably not surprising to the attentive reader that there are major policy issues around our ability to implement control strategies. In addition to those around the transgenic approaches foreshadowed in Chapter 10, there are major regulatory constraints to research in terms of limiting scientists very ability to even work with the pathogens of concern.

Insect pests (and their arthropod allies such as mites) have presented even more challenges to controlling losses. Their relationships with crop plants may be considered to be one of herbivores, as compared with the intimate physiological relationship between

pathogenic microbe and host. Modern agriculture has seen the advent of a myriad of toxic compounds applied to crops in attempts to kill pests. Early chemicals were broadly toxic to arthropods and vertebrates and typically were applied to entire fields. In the latter half of the 20th century a major insight into controlling insect pests was to view their presence essentially an ecological question of species balance in fields. Early broad-spectrum pesticides applied indiscriminately severely disrupted the balance of species in fields and in many cases ended up exacerbating pest problems rather than alleviating them. Chapter 17 presents an excellent summary of this understanding as a case study of the rice-insecticide case, focusing on Indonesia. This is particularly illuminating because at the beginning of the Green Revolution in rice in the late 1960s virtually nothing was known of rice field ecology in the tropics. What little was known of temperate rice field ecology was mostly limited to East Asia and of pre-World War II vintage written in Japanese.

The story of how ecological understanding of rice fields intersected with improved pest management certainly supports the case for investing in research. It is also clear that access to key policy makers in critical to changing government policies such that vested interests profiting from short-term misuse of pesticides can be neutralised. Unfortunately, personality-dependent policies imposed under a 'strong man' regime run the risk of not surviving the strong man. This certainly appeared to be the case in Indonesia. It is noteworthy that pesticide policies in the Philippines were developed through a more institutional process over roughly the same timeframes and have withstood numerous changes at the top of the government.