Chapter 11
A Modeling Approach to Simulate Effects of Intercropping and Interspecific Competition in Arable Crops

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ABSTRACT

Interspecific competition between species influences their individual growth and performance. Neighborhood effects become especially important in intercropping systems, and modeling approaches could be a useful tool to simulate plant growth under different environmental conditions to help identify appropriate combinations of different crops while managing competition. This study gives an overview of different competition models and their underlying modeling approaches. To model intercropping in terms of neighbouring effects in the context of field boundary cultivation, a new model approach was developed and integrated into the DSSAT model. The results indicate the possibility of simulating general competition and beneficial effects due to different incoming solar radiation and soil temperature in a winter wheat/maize intercropping system. Considering more than the competition factors is important, that is, sunlight, due to changed solar radiation alone not explaining yield differences in all cases. For example, intercropped maize could compensate low radiation due to its high radiation use efficiency. Wheat benefited from the increased solar radiation, but even more from the increased soil temperature.

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INTRODUCTION

Intercropping, defined as growing two or more crops simultaneously on the same field (Federer, 1993), is widespread all over the world. Especially in smallholder farming like in Africa (e.g., Malawi: 80 – 90% of soybean cultivation), India (17% of arable land) or China (25% of arable land), intercropping is a common cropping system. In times of climate change, rising food prices, shortage of arable land and food in third world countries and countries with a rapidly increasing population, adjusted traditional cropping systems become more and more important. Farmers tend to utilize every square centimetre of available arable land for production and for diversification of their families diet. Besides, there is a so-called unconscious intercropping: Because fields and farm size are very small (0.1 – 2 ha), the sum of field borders can be considered as intercropping in a larger scale (Figure 1).

Competition results not only in a survival of the fittest, but also in an optimal use of ecological niches. Agriculture can utilize interspecific competition in order to adjust cropping systems. Some attempts have been made to investigate and improve the various forms of intercropping. An increasing number of these research efforts, especially during the 1990’s, were done by modeling studies in order to simulate interspecific competition. Most models dealing with interspecific competition are common crop grow or crop/weed models extended with a submodel or additional algorithms. In most cases, modeling a cereal-cereal interaction, the crops of choice are a cereal-legume mixture as on one hand, this crop combination is a common and widespread intercropping system due to the advantages of nitrogen supply by the legume and on the other hand, these species are already included in most crop growth models.

Nevertheless, intercropping has always been considered as a secluded cropping system within one field so far. But in African and Asian countries, where intercropping is widespread, the system can be extended to a much larger scale: common on-field intercropping goes along with small field size on average, low mechanization level and hence, small field boundary distances. For example in China, where the average farm size is around 0.1 ha, small fields alternate as stripes with different crops grown on it and turn-

Figure 1. In China, the average field size is very small and fields alternate as stripes with different crops grown on it, turning field boundaries into a kind of unconscious intercropping at a larger scale (A, B). For illustration, field boundaries are marked with white lines (A) and field length and width are between 5 to 20 m.
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