SECTION 5

The Effects on Rice Yields in Hokkaido

5.1. Introduction

We have seen that cool summer damage can have a significant impact on Japanese rice production, especially in the northern regions of Hokkaido and Tohoku, which produce more than a third of the national output. In this section we use a dynamic model to simulate the growth and yield of the rice crop in Hokkaido under some of the climatic scenarios described in Section 2. Results from these experiments will subsequently be used to substantiate further experimental results in the next section of this report.

The model developed here is a process-oriented dynamic model that can be used to predict the growth and yield of rice under altered climatic conditions, in contrast to empirical–statistical rice models which cannot be extrapolated with much confidence beyond the range of data upon which they were constructed (for example, *see* Sections 3 and 4, this report; Matsuda, 1960; Hanyu *et al.*, 1966; Kudo, 1975; Munakata, 1976). Since the model is dynamic, it may also be applied to a real time prediction of the growth and yield of rice under changing weather conditions, providing timely information that is useful both for crop management and policy determinations.

5.2. The Model

The *SI*mulation *M*odel for *RI*ce-*W*eather relationships (SIMRIW) was constructed on the basis of the general principle that the grain yield Y_G forms a specific component of the total dry matter production W_t of a crop:

$$Y_G = hW_t \tag{5.1}$$

in which h is the harvest index.

M. L. Parry et al. (eds.), *The Impact of Climatic Variations on Agriculture*

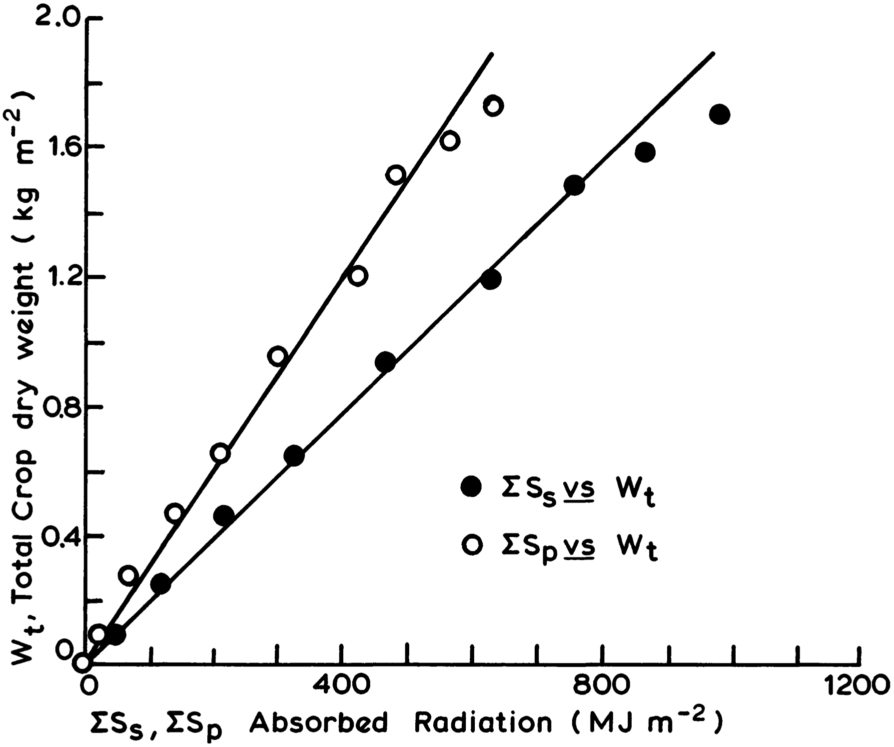

Figure 5.1. Relation between total crop dry weight (W_t) at different times during growth and absorbed shortwave radiation (S_s) or PAR (S_p) cumulated over time for "Nipponbare" rice grown at Tsukuba, Ibaraki prefecture (Horie and Sakuratani, 1985).

It has been shown that crop dry matter production is proportional to the photosynthetically active radiation (PAR) or the shortwave radiation absorbed by a crop canopy (Shibles and Weber, 1966; Monteith, 1977; Gallagher and Biscoe, 1978). Horie and Sakuratani (1985) showed that this is also true in rice and that the proportional constant, the conversion efficiency from the radiation to biomass, is constant until the middle of the ripening stage and thereafter it decreases curvilinearly (*Figure 5.1*). Moreover, they concluded from both simulations and experiments that the conversion efficiency is practically unaffected by climatic conditions in a wide range of environments.

SIMRIW is based on this general principle as follows:

$$\frac{\mathrm{d}W_t}{\mathrm{d}t} = c_s I_s \tag{5.2}$$

where c_s is the conversion efficiency from the absorbed shortwave radiation to the rice biomass (g/MJ), and I_s the absorbed radiation per unit time. Since the time constant of rice growth after transplanting into the field (the reciprocal of the relative growth rate) is more than 5 days, it is sufficiently accurate to