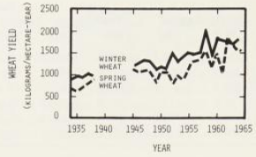

Figure 4-33 Historical wheat yields in the United States
Source: Georg Borgstrom, *Too Many: A Story of Earth's Limitations*, rev. ed. (New York: Macmillan Publishing Co., 1970), p. 46. (Copyright © 1969, 1971 by Georg Borgstrom. Copyright © 1969 by Macmillan Publishing Co., Inc.)

a typical yield in traditional agricultural societies. On the other hand, average land yields as high as 5,000–6,000 vegetable-equivalent kilograms per hectare-year may become attainable over large areas of arable land with exceedingly high levels of agricultural inputs per hectare AIPH. Thus the land yield multiplier from capital LYMC may increase preindustrial land yields around the world by a factor of about ten at very high values of AIPH (such yields are rare today but may become possible in the future). This upper limit of LYMC is of special significance; together with the limit of potentially arable land PALT, it defines the maximum value of global food production assumed in World3.

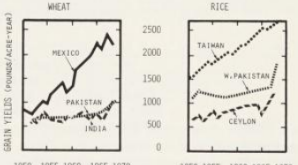

Figure 4-34 Yield "take-off" for wheat and rice
Source: Lester R. Brown, *Seeds of Change: The Green Revolution and Development in the 1970's* (New York: Praeger Publishers, 1970), pp. 37, 39. Copyright © 1970 by Praeger Publishers, Inc. Excerpted and reprinted by permission.

Why should we assume that there is any necessary limit to the yield increases attainable from adding capital inputs to the agricultural production function? From a biological point of view, there does seem to be an upper limit to the efficiency with which the photosynthetic process can fix incoming solar energy into vegetable matter edible to man. From an economic point of view, the diminishing marginal returns to agricultural inputs are already evident. The next few paragraphs discuss the present trends toward diminishing returns for several agricultural inputs: fertilizer, pesticides, new seed, and mechanization.

The use of fertilizer in various countries of the world and its relationship to land yield have already been shown in Figure 4-6. Since an increase in fertilizer use normally is accompanied by other improvements (better seeds, more pesticides, and better cultivation techniques), the graph should not be interpreted as more than a general demonstration of the relation between yield and fertilizer use. Decreasing marginal returns to both fertilizer and pesticide use are demonstrated more clearly by Figures 4-35 and 4-36. In addition, the data on which the graphs are based demonstrate a nearly perfect proportionality between fertilizer and pesticide use per hectare (PSAC 1967, vol. 3, pp. 140–143).

Figure 4-36 may give a misleading impression of the ability of pesticides *alone* to increase yields. In looking at the steep curve of the figure, it should be noted that the heavy use of pesticides is almost always accompanied by the heavy use of other inputs. Although global crop losses due to pests are large (Figures 4-37 and 4-38), perhaps of the order of 20 percent, even infinite expenditures on pesticides cannot do more than recover this 20 percent loss, that is, increase food production by one-fifth. Diminishing returns to pesticide use must occur fairly quickly as pesticide use increases.

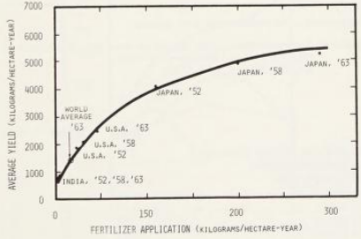

Figure 4-35 Yield and fertilizer use
Source: PSAC 1967, vol. 3, p. 143.