Mapping the crop of the future

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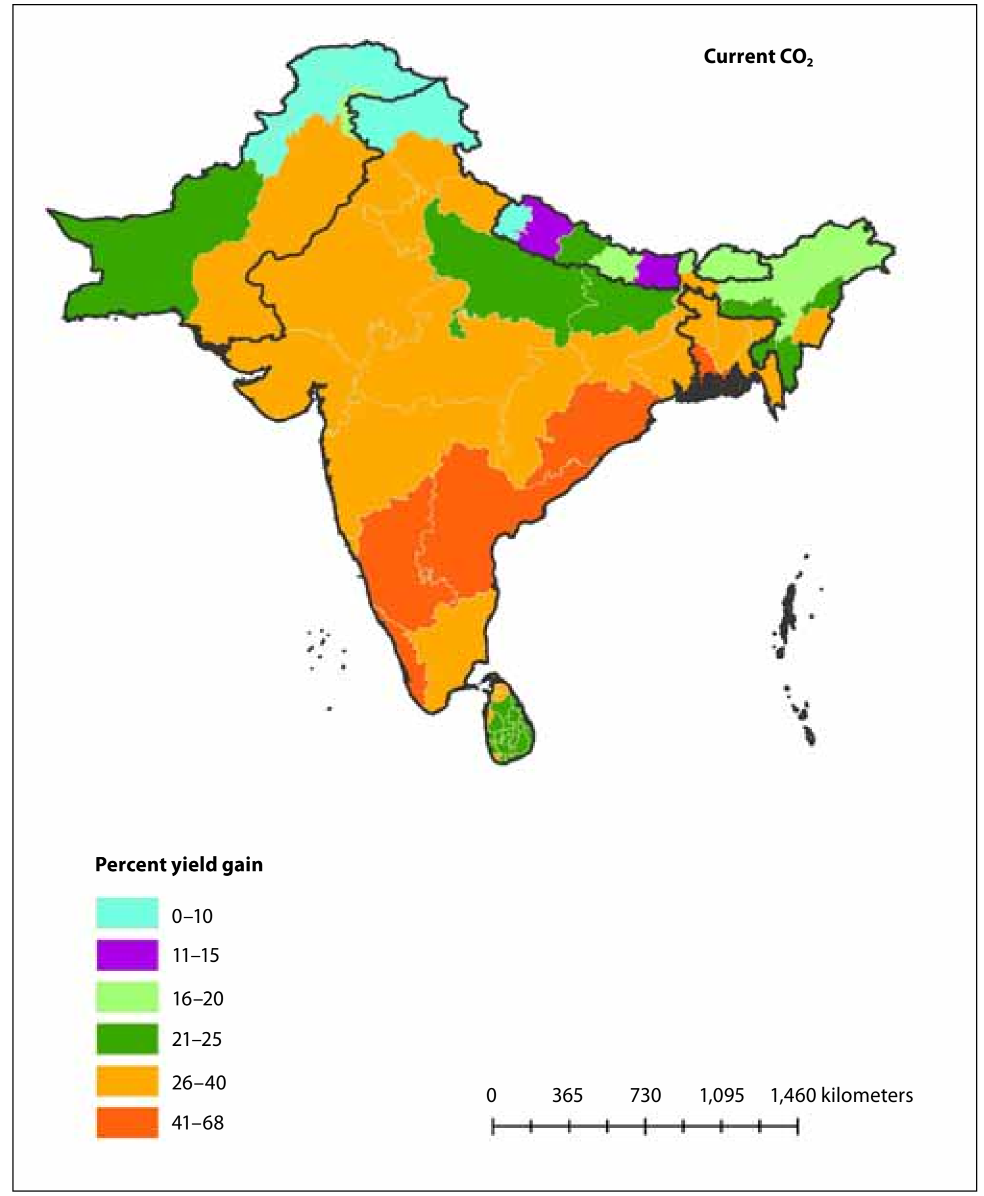

Fig. 1. Recent yield gain of C_4 rice at current CO_2.

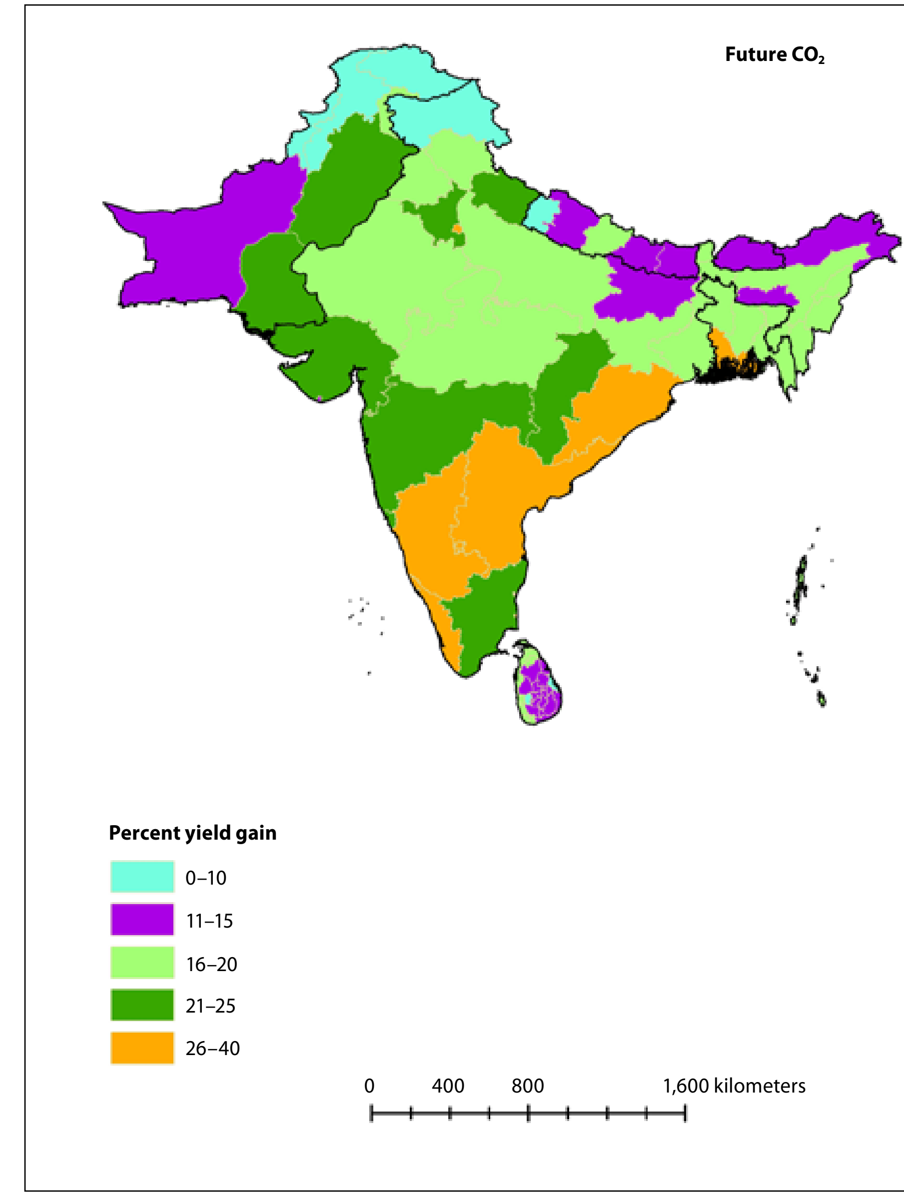

Fig. 2. Recent yield gain of C_4 rice by 2035-40.

* The results are expressed as averages of three future climate scenarios and weighted averages of rice pixels in each state/province.

By 2035, the world will require more than 100 million tons of additional rice when the population surpasses 8.5 billion. To meet this global demand, the International Rice Research Institute (IRRI), through the International C_4 Rice Consortium, is developing C_4 rice, a new kind of rice equipped with a more powerful "engine" for transforming carbon dioxide (CO_2) and solar energy into food.

C_4 plants such as maize and sorghum have more efficient photosynthesis than C_3 plants. The photosynthesis in C_3 plants such as rice is not as efficient because of a wasteful process called photorespiration that takes place in the mesophyll cells of leaves. In C_4 photosynthesis, CO_2 is concentrated in the bundle sheath cells where photorespiration is negligible.

Scientists are now attempting to introduce C_4 photosynthesis, including the required changes in the leaf structure, into rice. The good thing about C_4 rice is that it can thrive under high temperature caused by global warming, and with a decreasing fertilizer and water supply.

C_4 rice varieties may be available to farmers in another 15 years. By 2035, farmers could adopt them in irrigated areas.

So, in the future, how much will the yield gain of C_4 rice be in South Asia, where many rice consumers live? To help answer this question, we used ORYZA2000, a rice growth simulation model, combined with the C_3 and C_4 photosynthetic modules from GECROS.

In one simulation set, we assumed that 220 kg of nitrogen was applied per hectare of rice area, and we used spatial soil data and weather from three climate scenarios between 2035 and 2040 with corresponding increases in atmospheric CO_2 (Fig. 2). The other simulation set used the current CO_2 of 400 ppm (Fig. 1).

At the current CO_2, the yield gains of C_4 rice can be more than 40% in Kerala, Odisha, Andhra Pradesh, and Karnataka in India and in Khulna Province in Bangladesh. But, at higher CO_2 level in anticipation of climate change, yield gains are lower. The reason for this is that CO_2 concentration is already high in the bundle sheath cells of C_4 rice so it won't be able to take much advantage of the increase in atmospheric CO_2. Even with this setback, the virtual C_4 rice still yields an impressive additional 26–40% in Andhra Pradesh, Karnataka, Odisha, and Kerala in India, and in Barisal and Khulna provinces in Bangladesh.

Yield gains across South Asia will vary because of the interaction between soils and climate. Generally, the yield gain of C_4 rice will average 32% at current CO_2. At higher CO_2, on the other hand, the average yield gain will be 21%.

These initial results suggest that appropriate location-specific C_4 rice cultivars, fertilizer doses, and management options will further improve these yield gains. This clearly shows the importance of the development and deployment of C_4 cultivars for global rice production to keep up with increased rice demand.

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