

expressed by one senior visitor who said, "In general I'm more happy here than with other labs at the same stage."

High energy physicists, even the lucky ones who win time on the Batavia machine, must come to terms

with lower funding up and down the line these days. Their reduced circumstances—extending to life-styles—are suggested by comparisons between the old days, when even a graduate student might have had a rental car at his disposal during visits to the accelerator

and now, when the individual food allowance may be \$3 a day (\$4 when an experiment is running).

As the same visitor put it, "We're living in different style. It's not an optimal style for doing physics, but we're getting it done."—JOHN WALSH

Green Revolution: Creators Still Quite Hopeful on World Food

No Western technology has more intimately influenced the life of the Asian peasant than the science of plant breeding. Farmers from Turkey to the Philippines last year sowed 39 million acres of wheat and an equal area of rice with the high-yield strains developed in research institutes created by the Rockefeller and Ford foundations. The process of replacing traditional varieties of crops is a phenomenon only 10 years old and has engendered not just increased yields but the hope that some-

thing can be done to assist peasant agriculture out of its age-old rut of no-change conservatism.

Yet the green revolution, as it is known, has attracted a crescendo of criticism. Some consider the new seeds serve to make the rich farmers richer and the poor poorer, others that the green revolution is a myth, or only successful when there is an abundance of water and fertilizer. The jump in oil prices and worldwide shortages of fertilizer have not improved the immediate prospects for green revolution agriculture.

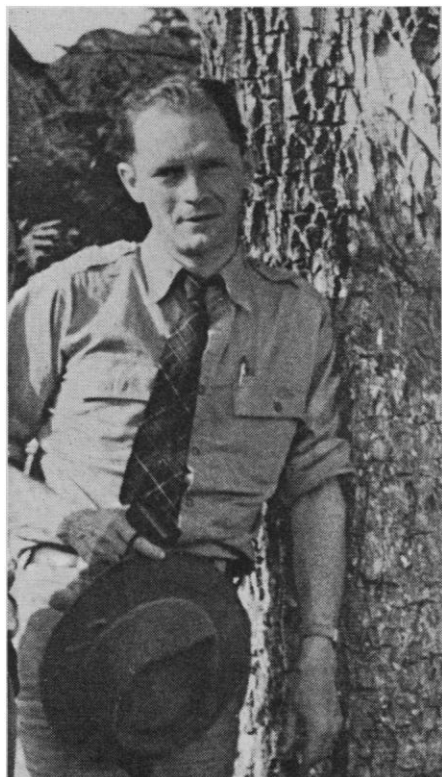
How do the creators of the green revolution feel about the process they have launched? Many have contributed but four people have particularly aided the genesis of the new varieties: J. George Harrar, first director of the Rockefeller Foundation's agricultural research program in Mexico; Edwin J. Wellhausen, the program's corn breeder and Harrar's successor as director; Norman E. Borlaug, a forester who became the wheat breeder; and Robert F. Chandler, a soil scientist who, after work in Mexico, set up a similar institute in the Philippines which has done for rice what the Mexican program has done for wheat.

Interviewed recently both Harrar and Chandler were zestful in rebutting the critics of the green revolution, their only regret being that the new seeds had not been more widely adopted. In Asia as a whole 35 percent of the total wheat area and 20 percent of the rice area were planted with the high-yield varieties in the 1972-73 season. For Harrar, this is not enough: "I feel very frustrated. It's said that if you build a better mousetrap the world will beat a path to your doorstep. We

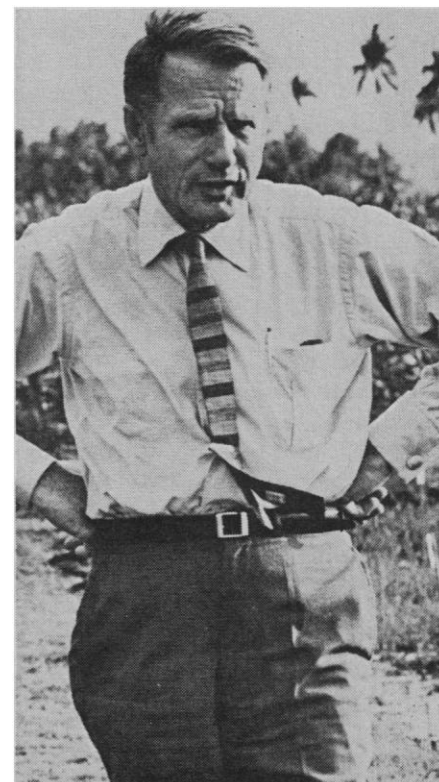
built a better mousetrap, but people didn't come."

Harrar, now retired as president of the Rockefeller Foundation, blames the leadership of developing countries for buying "fighter planes instead of fertilizer." Some political leaders think the green revolution has accomplished its job, he complains. But so far it has only showed the way. It hasn't failed, as the critics allege, but it has not begun to reach its potential.

For Chandler, too, the major problem with the green revolution is why it hasn't been more widely adopted. Chandler retired in 1972 from the International Rice Research Institute (IRRI) that he had set up in the Philippines, but within a month of his retirement had arrived in Taiwan to create a second institute, the Asian Vegetable Research and Development Center. The center already has the world's



J. George Harrar, now president emeritus of the Rockefeller Foundation, in the early days of the Mexican agricultural research program, about 1944. [Photo: Rockefeller Foundation]



Robert F. Chandler, now head of the Asian Vegetable Research and Development Center, during his directorship (1960-1972) of the International Rice Research Institute. [Photo: Rockefeller Foundation]

largest collection of tomatoes and also possesses germ-plasm banks of soybeans, mung beans, sweet potatoes, white potatoes, and Chinese cabbage.

In Washington for a recent meeting, Chandler denied that the present fertilizer shortage would leave farmers worse off than before they had the new seeds. The very basis of the green revolution is that the high-yield plants are designed to be responsive to fertilizer. But they have other properties bred into them, such as resistance to disease, which give them the edge over traditional varieties, even in the absence of fertilizer, says Chandler. For example IR-8, the first improved strain of rice developed at IRRI, was resistant to the green leafhopper and to blast but was susceptible to almost everything else. IR-26, the variety released by IRRI for planting last November, is a prodigiously healthy plant possessed with strong or moderate resistance to most of the ills that rice is heir to, including blast, blight, leaf streak, grassy stunt, tungro, the green leafhopper, the brown plant hopper, and the stem borer. "So many times the press has come out with statements that it would be better to go back to the old varieties. This is not true. Even without fertilizer the high-yielding varieties will yield more," Chandler says.

American agriculture is very energy-intensive. Does it make sense to export such a style of agriculture in the form of the green revolution to developing countries which cannot easily afford energy? Only parts of it are exported, Chandler notes, chiefly the reliance on fertilizer. There is not much mechanization in Asia, except in the Punjab, which is a special case.

Both Chandler and Harrar deny the accusation that the green revolution is socially disruptive. According to Chandler, there is some evidence in the Punjab that rich farmers have bought out the poorer, but by and large this has not happened in Southeast Asia. Surveys show that the same people are farming the land now as were farming it before the green revolution.

In Harrar's view the chief social effect of the green revolution has been to show that agriculture doesn't have to be a degrading way of life, the desperate failure that in the past has made people in developing countries flock in droves to the cities. It may be that the best farmers see the benefit of the green revolution first and go after it. "But it is not true that the poor

	Diseases						Insects			Soil problems			
	Lodging	Blast	Bacterial blight	Bacterial leaf streak	Grassy stunt	Tungro	Green leaf-hopper	Brown plant-hopper	Stem borer	Alkali injury	Salt injury	Iron toxicity	Reduction product
IR8	R	MR	S	S	S	S	R	S	MS	S	MR	S	MR
IR5	MR	S	S	MS	S	S	R	S	S	S	MR	S	MS
IR20	MR	MR	R	MR	S	R	R	S	MS	S	MR	R	MR
IR22	R	S	R	MS	S	S	S	S	S	S	S	MR	MR
IR24	R	S	S	MR	S	MR	R	S	S	MR	MR	MR	MS
IR26	MR	MR	R	MR	MR	R	R	R	MR	MR	MR	R	MR

Rice varieties released by IRRI each year are continually improved in their genetic endowment. IR-8 was the first variety released, IR-26 the most recent. R, resistant; MR, moderately resistant; MS, moderately susceptible; S, susceptible. [From IRRI Research Highlights for 1973]

get poorer. There is a trickle-down effect."

Those who write most negatively about the green revolution, affirms Harrar, know the least. "The easiest thing in the world is to criticize someone else. I say, 'Look, show me a better way. What is the alternative?' These supercritics have not got an answer." Chandler too believes the basic approach of the green revolution is the sound and only way to go. He would follow the same scientific strategy as before if starting IRRI over again.

Chandler and Harrar are both upbeat about the world food situation because they understand how far the new crops are from attaining their full potential. Yet even they hedge their optimism with if's and but's. "We have got to intensify our efforts if we are going to make it," says Chandler. "For certain situations I might be more discouraged than I was 5 to 10 years ago—it's discouraging to see how overpopulated areas such as Bangladesh are going to come out of it—but for the situation as a whole, I really do believe that if people make an effort they can double food production."

Harrar's vision of the future includes famine as well as sufficiency. "I am getting a resurgence of cautious optimism on the basis of a stark picture of the future," he says. Developing nations will cease to neglect agriculture, he believes, but because they are getting scarer, not smarter. "The road to the future is going to be strewn with the collective effects of earlier mistakes. We will see localized or even more widespread famines, because we can't turn the situation around that fast." Nor does Harrar consider that the present constrained world food supply is only a temporary adversity. "People say there will be food surpluses. I don't believe it. Our problem has been that we live from crisis to crisis.

This is a crisis that is here to stay."

The green revolution has now been institutionalized in a network of research organizations that cover all the major crops and regions of the developing world. IRRI and the Mexican corn and wheat center, CIMMYT, have been joined by CIP (International Potato Center) in Peru, ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) in Hyderabad, India, CIAT (International Center for Tropical Agriculture) in Colombia, and IITA (International Institute of Tropical Agriculture) in Nigeria. The centers are funded by the Consultative Group, an international group of donors chaired by the World Bank and including the Rockefeller and Ford foundations, which were the original supporters of CIMMYT and IRRI. These centers can be expected to continue the momentum of the green revolution and extend it to other crops besides wheat and rice.

Whatever the merits of the critics' arguments (to be examined in a subsequent article) the green revolution is what will keep the wolf from the door while world population continues its 2 percent a year explosion. But even the creators of the green revolution seem to have lost the shine of their earlier optimism. Borlaug believes that food shortages will become severe enough by the end of this decade to cause political instability in countries such as Bangladesh, India, Egypt, and Indonesia. Harrar speaks of famines before the corner is turned. And Chandler thinks that "the only really hopeful thing is that yields are so low now there is plenty of room for improvement." If even the creators of the green revolution have doubts that agricultural productivity can keep pace with population growth, the race may fairly be said to look like a close call.

—NICHOLAS WADE