pressures for conformity irresistable. "The nail that sticks out gets hammered down," is a Japanese aphorism.

It is not yet clear, though, that any of these factors constitute serious impediments to innovation. After all, little in the way of innovation in the United States can be traced to basic academic research, and research directors in U.S. companies do not necessarily place high value on doctorate-bearing employees.

While the Japanese are not known for the kind of original work that produces Nobel prize winners, there are many ways in which they have proven themselves to be innovative—in their resourceful marketing strategies, institutional adaptations, improvements on imported technologies, and rapid deployment of new technologies. Although many of the grand concepts underlying development—such as economies of scale—have also been borrowed from the West, they have been molded to fit the culture in such a way as to appear to be uniquely Japanese.

Whether the formula that has proved so successful so far will now catapult Japan into an era of more radical innovation is open to speculation. But there is little reason to suppose that the country is going to rest on her laurels. The export trade is lifeblood to Japan which has so little in the way of indigenous natural resources. For the country to thrive she must make optimal use of science and technology.

Japan's success is no mere surface phenomenon; it springs from the nature of her society and the hazardous conditions of her existence. Clearly there is no simple recipe that can be followed wholesale in the West. Because of the very different structure of American society and the conflicting demands made on government, the United States cannot hope to emulate their comprehensive approach to economic development or the close working relationship that exists between Japanese government and industry. But just as the Japanese once learned so much from the United States, it may now be this country's turn to consider which elements of the Japanese experience could be adapted to set its own economy on a happier course.

—CONSTANCE HOLDEN

What to Do When the Well Runs Dry

In western Kansas, depletion of the Ogallala aquifer is forcing a change in growing corn by irrigation

In western Kansas, the summer of 1980 will be remembered for the intense heat that struck by the time the corn was pollinating and caused sharply reduced yields. For some farmers in the driest part of this dry region the summer also brought home warnings that the water is running out.

In much of the western third of Kansas a prosperous feed grain economy depends on irrigation water from the great underground reservoir of the Ogallala aquifer. Now, signs of depletion are on the increase.

In the town of Leoti in west central Kansas, for example, wells that had been pumping water at the rate of 500 gallons a minute were this summer down to 300. The municipal water system for the town of over 2000 lost pressure and hours of water use had to be severely restricted.

Leoti Mayor Skip Harkness says, "The aquifer in this whole part of the state is deteriorating. We'll have enough water for a while, but we can't meet peak demand." Leoti recently increased its water storage capacity and faces the expensive prospect of going farther afield to buy water rights, sink new wells, and pipe water in. But the decline of the water table is inexorable and that reality faces the whole region.

For a century or more, farmers assumed that western Kansas was too dry and too hot to grow anything but wheat and feed grains that require much less water than corn. For the last two decades, however, western Kansas has been a highly productive outpost of the corn belt. The feat of growing corn in this semiarid region was made possible by heavy irrigation with water drawn from the Ogallala which underlies parts of the high plains states from Texas to Wyoming.

The national significance of this irrigation agriculture is suggested by the fact that 40 percent of grain-fed beef sent to market in the United States are fattened in an area of six high plains states dependent on the Ogallala.*

The situation varies from place to place according to the thickness of the aquifer and the local history of water use. But engineering studies indicate that underground water in the region may be depleted in 3 to 20 years.

In extreme cases in Texas, exhaustion of the aquifer has resulted in the land going back to sagebrush. What lies ahead for most of western Kansas is not a reversion to buffalo grass and scrub but a transition from irrigated corn agriculture to the raising of less water-intensive crops and, perhaps ultimately, to dryland farming of wheat and grain sorghums.

The transition could be abrupt and traumatic if farmers keep pumping, so to speak, to the last drop. If they husband water supplies for irrigation and make the most of options for different crops and new farming techniques, the change will be more manageable.

Crucial in the period of adjustment will be the alliance between farmers and the state's agricultural research establishment, based on the agricultural experiment station at Kansas State University (KSU), and the extension service's county agents. Also essential will be a degree of planning and cooperation among farmers that will in some ways run counter to traditions of self-reliance and individualism on the old frontier.

Even at best, however, the impact will be heavy on the expanded economic infrastructure created by the corn economy. The availability of corn and other feed grains in the region encouraged establishment of large feedlots where great numbers of cattle are fattened. In recent years meat-packing companies have invested heavily in slaughtering and packing facilities close to the feedlots. This is not to mention the wide range of businesses and services needed to support intensive raising of corn by irrigation.

For individual farmers, raising irrigated corn has been more profitable than any alternative crop. The shift away from irrigated corn growing will cut total production and inevitably reduce farm

*Texas, New Mexico, Oklahoma, Colorado, Kansas, and Nebraska.

0036-8075/80/1114-0754$00.75/0

income and land prices and also affect general employment and tax revenues in the region.

For some farmers, the extreme heat of the past summer hastened the move away from "total" irrigation of corn. In areas of declining groundwater levels, particularly in west central Kansas, the costs of irrigation have made raising corn this way a marginal proposition. When all-out irrigation of corn becomes too expensive, the preferred option for many farmers in western Kansas will be so-called limited irrigation of corn or grain sorghum.

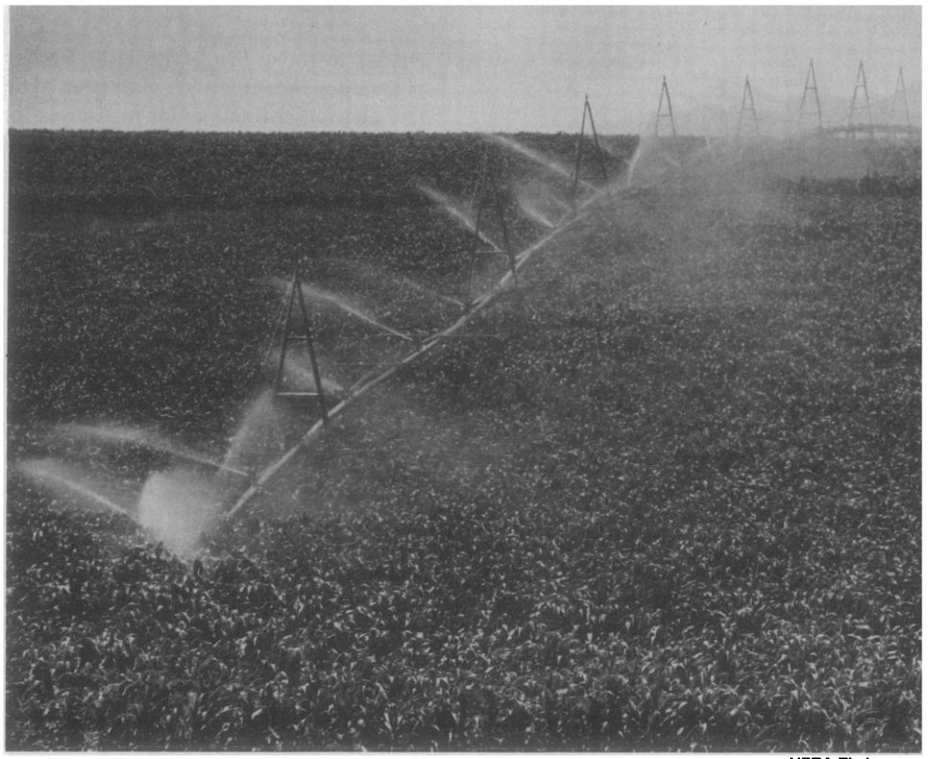
This is where research comes in. For example, corn's need for water varies during the growing season. It is particularly vulnerable to "water stress" during the tasseling or pollination stage. A study by L. R. Stone, an expert in soil physics at Kansas State, and colleagues showed that depletion of soil moisture to the wilting stage for 6 to 8 days during pollination reduced grain yield by 50 percent. Other research showed that single-shot irrigation during the growing season is most effective if timed with early silk emergence on the plant. Good yields can be obtained under limited irrigation with half to two-thirds as much water as with total irrigation.

Many farmers have successfully made the transition already. One example is George Armantrout who farms in the Scott City area where the water table is dropping. Armantrout is regarded at KSU as something of a trailblazer, but he insists that his operation is "not a product of ingenuity. We were victims of circumstance."

Armantrout started out raising grain sorghum under full irrigation. He says everyone's goal in those days was to achieve "maximum yields" by combining water, fertilizer, seed, and other inputs as necessary. "Water was regarded as unlimited." Armantrout moved into raising fully irrigated corn in the early 1960's.

In the early 1970's, even before fuel costs soared, Armantrout was forced to reappraise his operation. The output of three main wells that had been producing 4000 gallons of water a minute dropped to 800. His reaction? "Scared," says Armantrout. "When we plotted the drawdown we could see it was going to end up at zero."

He had a big investment in an irrigation system and says he "had to try something to get the money back." That something was limited irrigation of grain sorghum. In agronomic terms, says Armantrout, "Corn is kind of a Ferrari. Grain sorghum is kind of a jeep. Corn won't take [water] stress. Grain sorghum is pretty forgiving, it takes stress pretty well."



USDA Photo

Irrigating midwestern corn

Armantrout says he was influenced in making the shift by the work of agricultural scientist Ian Stuart, who Armantrout consulted at the University of California, Davis. Stuart had showed how grain sorghum uses moisture stored deep in the soil. In the case of the soil and growing season in his area, says Armantrout, that meant a root zone 6 feet deep. The aim is to apply no more water than the plant needs or the soil will retain. A major advantage in western Kansas is the character of much of the soil—deep loams with remarkable water-holding properties. "Think of it as a sponge," he says. Since, as Armantrout observes, "The plants don't know when the water is put into the soil," irrigation can be done virtually throughout the year. Applying water in winter months, for example, minimizes surface evaporation. In limited irrigation, "one has to know exactly what the moisture level of the soil is," says Armantrout, but farmers have learned to do that, in some cases by turning to high technology measurement equipment.

In profit and loss terms, the shift to limited irrigation has also been encouraging. The costs of inputs required to raise fully irrigated corn, particularly of fuel for pumps, are now so high that his balance sheet favors grain sorghum, says Armantrout. The aim now is to achieve the highest yield per inch of water, he says. Those who sought the old goal of maximum yield irregardless were "hanging the beacon on the wrong rock."

The benefits of research and its applications are an accepted feature of the agricultural scene in Kansas. Data from the experiment station branch at Tribune in the dry west central area show that average corn yields in the area rose from 33 bushels per acre in the 1950's to 91 bushels in the 1960's. Between 1968 and 1971 corn yields went to 152 bushels an acre in "first-year performance" testing.

While farmers are ready to listen to researchers to meet emerging conditions, they are, above all, pragmatists. They do not read the latest scientific papers nor are they influenced by lectures on theory. What does impress them is demonstration projects that succeed under local conditions. "Once technology is proven, it is adopted fairly rapidly," says Danny Rogers of the northwest area extension office.

The hard fact remains, however, that even the best management can only delay the depletion of the aquifer. The Ogallala, named for a western tribe of the Sioux nation, was formed by deposits of sand, gravel, and silt eroded from the Rockies during the Tertiary period 5 to 24 million years ago. In effect there is no recharge of the aquifer because the 2 inches or so a year of water that penetrates downward makes no dent in the withdrawal rate, which amounts to as much

Growing grain sorghum

as 5 or 6 feet a year in some places.

In the west central area of Kansas, the aquifer is fairly thin but close to the surface, and irrigation began late in the 19th century. Original saturated thickness may have been 80 feet or so rather than the 200 feet or more which is not uncommon elsewhere.

In most of western Kansas, pumping from the aquifer began in earnest after World War II with the coming of high capacity pumps and cheap natural gas to provide power. Awareness of the decline of the water table did not spur organized action until the early 1970's. The mechanism chosen was formation of groundwater management districts (GWMD's) similar to those in California and other places dependent on groundwater. The five districts formed so far in Kansas let water users determine their own destiny so long as the measures they adopt do not conflict with laws on the books.

The restrictions prescribed in GWMD No. 1 in the dry, west central region provide for spacing of wells and a limit on use of 2 acre-feet of water per acre per year that can be pumped for irrigated land. Permits to irrigate forbid depletion of more than 40 percent of the groundwater over 25 years. Kansas wells are not metered so a kind of honor system prevails, which generally seems to work.

Predictions about the future of high plains agriculture are risky, if only because knowledge about water resources is still imperfect. Much more should be known after completion of a $6-million federally sponsored study on the Ogallala aquifer region in the six high plains states mentioned earlier.

A possibility being explored is bringing in water from outside the study region. One option for western Kansas would be the transport of Missouri River water, most probably from a point at St. Joseph, Missouri. The project and its costs would be monumental even by public works standards.

Another way to supplement the water of the area would be to tap the Dakota aquifer, a formation that underlies the Ogallala in many places. The Dakota dates from the Cretaceous period, 96 to 138 million years ago. A sandstone formation, it yields water less easily than the Ogallala's sand and gravel. Its water generally is more expensive to pump and has a higher salt content. An assessment of the Dakota aquifer is being made by the U.S. Geological Survey as part of a national water resources survey.

A significant break was given owners of aquifer water rights in a 27 September decision in federal district court in Wichita allowing irrigators to claim a depletion allowance similar to those which go to owners of oil wells. The decision applies only to the Ogallala at this point. In Kansas, where 2 to 3 million acres are irrigated by water from the aquifer, benefits of $1 billion are being estimated. It is thought that the tax break will prop up land values and help ease the transition from irrigation farming.

That transition will hardly be painless, but for western Kansas, the depletion of the aquifer hardly imposes a doomsday scenario. Use of the Ogallala was akin to rich strikes of gold, silver, or oil. Now the bonanza is being mined out. Western Kansas has adapted before, from ranching to wheat farming to corn raising. Change and retrenchment will be necessary. How it happens will test scientific agriculture and enlightened self-interest.—JOHN WALSH

Too Many Doctors in the House

Medical schools should produce fewer doctors, says a new report, but some foresee a lack of physician-researchers

The federal government has said it before and is saying it once again: there will be too many physicians in practice by 1990. Not only that, they will apparently be practicing in the wrong medical field. Clinical researchers say their group will be shortchanged in the midst of the so-called physician oversupply.

There will be an overabundance of 70,000 physicians in most specialties by the end of this decade, an advisory committee recently reported to the Department of Health and Human Services (HHS). The government contends that an oversupply of practitioners results in unnecessary medical costs.

Medical schools are worried about how they will survive if Congress acts to stem the surplus and adopts some of the committee's proposals that would limit their funds. The Graduate Medical Education Advisory committee recommended a 17 percent cut in freshman-year enrollment at medical schools and the termination of federal capitation funds. Capitation has been used as a special enticement to medical schools to boost class size. August G. Swanson, director of academic affairs at the Association of American Medical Colleges, says that, if the recommendations are carried out, medical schools will have to lay off medical faculty and some schools might be shut down.

Medical schools have been threatened with the loss of capitation funds in recent years. Former Secretary of Health, Education and Welfare Joseph Califano tried to eliminate capitation in 1979 during his crusade to cut health care costs.

Capitation was initiated in the early 1970's to alleviate what was thought to be a physician shortage. The government paid schools a bonus of $2084 for each medical student or per capita. The amount has dropped off in recent years, and this year hit a low of $784. Even though the bonus amount has fallen off the funding is still important to some schools, says a lobbyist for universities.

Faced with a capitation cutoff, the schools say they may simultaneously suffer lost revenue from tuition if freshman enrollment is reduced by the suggested 17 percent.

Legislation that phases out capitation is already before Congress. A House and

0036-8075/80/1114-0756$00.50/0