Food supply

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ENHANCING NATURAL RESOURCE USE TO INCREASE WORLD FOOD PRODUCTION

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The natural resources we have available to grow our food--land, water, and energy--are finite in extent, and their use for agriculture is often in competition with other uses. Recent inventories suggest that 3.4 billion ha, or 25% of the world's land surface, in principle could be cultivated; at present the cultivated area is less than 11%. Thus the potential for expansion of cultivated area is substantial, but much of this land is not where the people are; furthermore, its development could readily lead to drastic and irreversible resource deterioration, both on-site and off. A similar situation prevails for water. The currently 170 million ha of irrigated land could be doubled, but not without tremendous investment and substantial risk. The obvious alternative for increasing food production is to increase production per unit of land. Both avenues must be pursued.

Two divergent, yet related, concepts are often advocated: to transfer the technology of U.S. commercial agriculture to other regions, and to greatly expand basic biochemical research--photosynthesis, nitrogen fixation, genetic engineering--in "pure" academic institutions. Both have their proper place in increasing food production, but they must be placed in perspective. I propose that higher priority be given to learning to use our natural resources effectively and conservatively, by adapting known principles imaginatively to existing ecological and socioinstitutional circum-

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stances, and by further developing these principles to aid in constructive development. This approach is less direct and more difficult than transferring large-scale mechanization, and less glamorous than biochemistry. It calls for inputs from more than the physical and biological sciences; from economics, if you wish, but not for myopic benefit-cost analysis.

Some examples may clarify the issue. In Nigeria, it is not uncommon to encounter 50 plant species that make up a farming system for a small community. Introducing monoculture techniques would be socially and agronomically disastrous, as well as expose the land to severe erosion. But the recent development of a hand-operated drill for precision planting in mulch or sod can greatly increase labor productivity. Combined with a back-carried herbicide sprayer that applies 10 ℓ/ha (as compared to the more usual 500 ℓ/ha), the energy required for planting is reduced more than tenfold, while production is increased by improving the existing multiple cropping system.

Pereira related an experience in Kenya, where some 20 years ago forest vegetation was transformed into a tea plantation, using the best conservation practices known. Peak runoff flows quadrupled during clearing and planting, and still were double those from forested watershed after a full canopy was established, even though consumptive use was equal. Brazil is committed to developing 3 million ha of Oxisol savannahs of their Cerrado by 1979, and 50 million by 2000; Peru plans to develop 2 million ha of its Amazon jungle by 1990. Do we know how to avoid adverse consequences, and if we do, can we implement the proper measures?

In Puerto Rico, intercropping a new planting of coffee with plantains the first 2 years, and taniers the third, increased net income more than $8000 per ha over the 3-year period. Furthermore, imaginative management practices resulted in subsequent annual coffee yields ten times the regional average.

Thus the potential has been demonstrated of significant impact on production by adapting imaginative concepts to existing farming systems. So have the dangers of large-scale changes without full realization of the consequences.

Within this framework, exciting possibilities exist for research to realize the full potential of the available resources, natural and human. The thrust of such research should be to help the independent, generally relatively small farmer improve his productivity with a minimal dependence on capital-intensive external inputs. This certainly does not obviate the need for sophisticated and basic research.

A key problem, especially in the tropics, is to provide adequate plant nutrition. In view of dwindling (and high priced) supplies of petrochemicals and phosphate rock, one valid approach involves accelerated research to manufacture ammonia more efficiently and from feedstocks other than natural gas, and to improve the inexcusably wasteful methods prevalent in the phosphate mining industry. An alternative, of at least equal merit, is to use the resources at hand to reduce the dependence on artificial fertilizer. The amount of major nutrients in organic wastes in 1971 was eight times that in the fertilizers sold. In the U.S., the N excreted by animals in confinement was about two-thirds that sold as fertilizer. Clearly, the potential for improved waste recycling techniques is large. Furthermore, research on the use of bacteria (rhizobia) to enhance nitrogen fixation and fungi (mycorrhizae) to increase phosphorus uptake by roots has tremendous potential for improving plant nutrition without dependence on expensive or even unavailable inputs; such research requires a high level of sophistication, but the results lead directly to simple field application.

Another opportunity concerns the adaptation of crop plants to environmental stresses. Historically, plant breeding has emphasized selection to fit an environment in which stresses--nutrient deficiencies, water, salinity--have been minimized. The selection of grains for aluminum tolerance and some preliminary results showing a wide range of salt tolerance among barley strains indicate the potential of fitting the plant to the environment, rather than the reverse.

Considering, now, irrigation, the need is for efficient use of water in the first instance. Current practices, in the U.S. and elsewhere, result in substantial waste of both water and energy and unnecessary degradation of land and water. The problems are partly technical, but as illustrated by Reidinger, institutional and economic issues frequently dominate.

Space does not permit further examples, but clearly there are tremendous opportunities as well as many problems in increasing productive use of limited natural resources within the framework of socially acceptable farming systems--problems that require technical innovation but, just as urgently, imaginative inputs from social scientists. Some of these are close at home, like the need to provide adequate incentives for academicians to address multidisciplinary real-world problems; others focus elsewhere, where textbook economic analyses have often aggravated rather than resolved unhappy situations.

REFERENCES

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FOOTNOTES

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