

Environmental Agriculture The Challenge of the Next Decade

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Abstract: Human populations are both expanding and using higher levels of technology for the production of goods and foods. The globe, in general, and California, in particular, are filling up. In the past, lower populations and less intense technologies allowed outputs from production systems to escape undetected into the environment. Presently our increasing populations are placing broad demands on our resources which means that the outputs from one sector may affect other sectors of society. Agriculture faces a major challenge in California as the state fills up. The next decade will be one of continuous and intensifying interaction between the urban and agricultural sectors. The major problem for agriculture will be how to remain productive while minimizing the negative impacts of production systems on the environment. Outputs from agricultural systems are problems of the fate of applied inputs: their efficiencies, mass balances on a regional scale and waste management. While agricultural research has emphasized the factors which control production, emphasis on environmental impacts will require a refocus on the management and field processes that control the fate of applied inputs. This focus requires that inputs and outputs be measured in field experiments; efficiencies calculated, and balances projected for regional planning on agricultural impacts for the long-term viability of California agricultural production. A component of the UCD Sustainable Agriculture Program is being established to address the factors controlling the fate of applied inputs. The University is committed to the development of a 300 acre site (Long Term Research on Agricultural Systems) and a Center for Integrated Agricultural Studies to examine the long-term affects of level of inputs and diversity of rotations on the efficiencies, mass balances and outputs from agricultural production systems.

Keywords: Environmental impact agricultural production, sustainable agriculture

INTRODUCTION

Agriculture first developed, flourished and faltered in the Mediterranean ecosystem. In Europe intensive production systems evolved in the context of land limitations. Only in North America have the fruits of the industrial revolution combined with extensive land resources to provide high-input, extensive agriculture. In California agriculture has come full circle. Here technology, high inputs and extensive land areas are coupled with the Mediterranean ecosystem. The California experiment is young and the future of irrigated agriculture in the State is facing major challenges.

In response to national and global requirements for food, the major emphasis of agricultural research in the last two decades has been to increase production. While production has been raised impressively, increasing attention is being focused on the effects of intensive agricultural production systems on the environment shared with other sectors of society. This concern is heightened by the lack of knowledge of the processes controlling the fate of applied inputs, the management alternatives required to influence the movement of these inputs and an inability to integrate the great store of knowledge about processes within the system to predict behavior of farming systems in the field.

In California, with the juxtaposition of large urban centers, an extensive high-input cropping system and 33 million acres of grazing lands, the conflicts are likely to appear sooner and be more intensive than elsewhere. California voters and their legislature are demonstrating increasing awareness of this interaction. The UC Davis Sustainable Agriculture Program is a mechanism to signal that the College is addressing these new issues and a mechanism to provide an organized, interactive and interdisciplinary approach to the development of knowledge by which to evaluate the sustainability of the State's major economy.

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UNIQUE ELEMENTS OF CALIFORNIA AGRICULTURE

California is a unique site for agricultural production. The combination of developed supplies of high quality water, fertile soils, and a Mediterranean climate provide ideal growing conditions. Water is furnished by winter rains and snowfalls, captured in reservoirs, and delivered by extensive irrigation systems during the hot dry growing season. Irrigation and mechanization allow the control of inputs of water and mineral nutrients such as nitrogen that are critical to plant production. Most crop soils of the state are young and having evolved under semiarid conditions are high in base metals and thus very fertile. While the dry climate during the summer season provides high levels of sunlight, it also restricts the growth of fungal pathogens that infect insects. In general, California has many more problems with insects than elsewhere in the US and uses large amounts of insecticides. The result is an agriculture characterized by both high production levels and great crop diversity.

ENVIRONMENTAL CONCERNS

Economic perspectives do not adequately encompass environmental costs. Part of the true cost of agriculture, as with other production enterprises, is the impact of production on the environment. In the future, the optimization of management is likely to include the constraint of the "cost" of inputs that escape production systems and contaminate other components of our ecosystems. Today in California agriculture there are no more pressing issues than the disposal of agricultural wastes: the management of irrigation drainage water, the contamination of ground water by fertilizers and pesticides, the disposal of dairy effluent, and the disposition of crop residues and pesticides entering the environment.

As the population of the state grows and its commerce expands, the interaction between agricultural and urban sectors will intensify. California is filling up. Because the western United States has been a region characterized by available natural resources and low population density, direct feedback on the use of resources from one sector of the society to another has been limited. This pattern is changing in California. Different sectors compete over resources, contaminate resources essential to each other, and exert political force to develop policy to protect themselves. For example, agriculture, the major user of water in the state, is the focus of much scrutiny about the quantity of the water it uses and the impact of its use on water quality. As the growing population of California spreads across the state, it uses and demands pure ground and surface water supplies. The more wells drilled, the more water pumped, the lower the detection limits that sensing equipment reach, the greater the likelihood of discovering contamination. An expanding and increasingly concerned urban public is placing greater constraints on agriculture's environmental impact. On the other hand, the transportation demands of the state, primarily an urban function and the user of 50 percent of the state's energy, is the major cause of air pollution that is already causing significant declines in agricultural yields of the Central Valley and these reductions are likely to increase.

While there are legitimate environmental concerns with regard to the impact of current agricultural farming systems on the environment, the discussion has not been constructive. The debate is difficult to resolve because of a lack of understanding about the fate of inputs into agricultural systems, the true risk of exposure to particular residues, and the absence of data on the costs of alternative production methods. This point is particularly evident in the perception of food safety. The characterization of risk by the use of short-term animal studies to evaluate pesticide ingestion is complex. Because of differences in life span, metabolic rate and body size between humans and animal models, risk studies require much interpretation to be appropriate for human estimates. The estimates of risk for chronic exposure to low levels of chemicals is particularly difficult to assess. Because of the lack of certainty inherent in these studies, the public has become uncertain, and unwilling to accept these projected levels of risk and has tended to demand zero tolerance. Major food chains have used this public sentiment to gain marketing advantage and have perhaps heightened the sense of risk. Consumers must also bear some responsibility for the influence they exert on production systems. The concomitant demand for cosmetically perfect produce, inexpensive prices and low pesticide inputs may not be possible. Management options in production systems have tradeoffs and the consumer should be educated to understand them and place reasonable constraints on the producer.

From the agriculturalist's perspective this lack of knowledge is equally troubling. The major changes in cropping systems since World War II have been intensification of nutrient inputs, increasing chemical control of pests, greater mechanization and improved germplasm to produce higher yields in this new environment. These developments reflected the major constraints on production in farming systems. Agricultural researchers focused on the factors controlling yield and were less concerned about the outputs from agricultural systems. With a relatively constant set of constraints on which to focus, researchers have been able to concentrate on elucidating the functioning of components within the system. This trend, combined with the tendency of federal agencies to fund more basic and less applied research, has caused agricultural scientists to distance themselves increasingly from the farming system. The environmental impact of agricultural systems is a new issue and its appearance represents the first major new constraint operating on farming systems since WWII. The answer to the environmental questions requires a precise but integrated systems perspective of a farming operation. Agricultural researchers must now integrate the components and understand the behavior of their systems to respond to the new environmental constraints. This integration is essential to provide the information required by the farmers to make production decisions that are in compliance with environmental concerns.

Knowledge is critical to frame any debate about risk and the role of agriculture in the future. In the absence of knowledge consumers will demand standards that may be unnecessarily stringent, forcing farmers into alternatives that may be perceived as solutions but whose environmental impacts are unknown, and thereby limit the flexibility of California agriculture to be competitive in world markets. Problems exist but they should be addressed by clear identification of the causal mechanism, careful identification of the risk, and thorough evaluation of alternative practices which modify the mechanism.

ALTERNATIVE AGRICULTURE

Agriculture has been identified by the U.S. Environmental Protection Agency as the largest nonpoint source of surface water pollution (NRC, 1989). In response to environmental concerns, new constraints are likely to be imposed on agricultural production that will require significant changes in the way California farmers produce food and fiber. In response to and anticipation of detrimental environmental impacts and to reduce input costs, many farmers are employing a wide range of new farming methods to reduce the effects of agriculture on the environment and improve profits. Although many of the components of alternative agriculture are derived from current agriculture, the report stresses that "alternative systems more deliberately integrate and take advantage of naturally occurring beneficial interactions". Though no formal study has been conducted to quantify changes in farming practices, this transition has been reflected in new research and application of agricultural technologies. The report also finds that farmers successfully adopting these systems generally derive sustained economic and environmental benefits. Of the eleven case studies in the report used to illustrate this point, four are California farms (Ferrari Farm, Linden; Steven Pavich & Sons, Kern County and Delano; Kitamura Farm, Colusa; Lundberg Family Farm, Richvale).

A health debate is being waged at all levels of the agricultural community over the appropriate level of chemical inputs to match profitable production with responsible land and environmental stewardship. The lack of research focus on system functions and the fate of applied inputs, coupled with the introduction of a myriad of new farming methods, makes the processes of sorting out appropriate approaches and constructing suitable systems a considerable project. A major target for agricultural research in the future will be to replace old and new dogma with carefully constructed knowledge about the impacts and efficiencies of agricultural practices.

UC-DAVIS RESPONSE

As the name suggests, the College of Agriculture and Environmental Sciences is uniquely qualified to address the problems related to environmental impacts of agricultural systems. In January 1989, former Dean Hess established the UC-Davis Sustainable Agriculture Program with the objective to develop and coordinate a program which integrates the research and teaching resources of the College to evaluate the short- and long-term impacts of current agricultural practices on the environment and

identify and develop solutions that will enhance the profitability and quality of agricultural production while sustaining and improving the environment of California

To achieve this objective two research components have been developed. First, the University has committed 300 acres and supplied a basic support budget for the development of a Long-Term Agricultural Research Site. The initial effort for long-term evaluation will study cropping systems which differ along gradients of levels of inputs and diversity of rotations. The performance of all production systems is ultimately evaluated in terms of inputs and outputs. These measures allow an objective comparison between systems both environmentally and economically because efficiencies characterize both the assimilation and escape of inputs from these systems. The central hypothesis to be investigated is that changes in farm resource base (i.e. primarily soil quality as defined by measured changes in physical, chemical, and biological properties) alters yield/input ratios. The focus is the degree to which the diversity of the rotation and input level interact to affect input/output relationships over time and the identification of the mechanisms and processes that govern these effects. Although the present high profile debate centers on whether chemicals should be used in agriculture, a more practical issue is how to accrue the benefits of this technology without generating negative impacts on the environment.

The second research component of the UC-Davis Sustainable Agriculture Program is a Center for Integrated Agricultural Studies (CIAS). The purpose of the CIAS is to provide a forum to enhance the understanding of systems level functioning of agricultural production systems and develop a forum to determine the decision making processes of farmers to better direct the mission oriented research of the College.

The shifting of constraints from the biological and physical limits on production to the environmental impact of production systems on the ecosystem is causing a major restructuring of farming systems. The requirement for knowledge to understand and adapt our production systems comes at a point when the University has been increasingly focused on disciplinary research. The CIAS will serve to both bring together systems level researchers on campus and to provide a forum within which our excellent disciplinary scientists can examine their research within the context of the production system (vertical integration).

Academics, even those located within production departments, know only a limited amount about the nuts and bolts of production agriculture. The trend toward basic science and specialization, and the increasing urbanization of the population is largely responsible for this situation. In this time of rapid change in the agricultural environment it is critical that the University establish new mechanisms to directly link the agriculturalist with the researcher. Yet the actual operation of farms, critical to defining the questions that a mission oriented program must address, is probably the least studied aspect of agriculture today in the University. When society is placing major new constraints on production, it becomes imperative that the real issues be brought directly to people responsible for their solution.

Production systems evolve as units within an environmental and economic context. The appropriate methods of research are to study the behavior of both the components of the system and the systems as a whole. Vertical integration organizes and focuses diverse research skills on a goal, while allowing a disciplinary focus at the component level. Because this approach uses disciplinary sciences as a basic element to address a specific goal, the UC-Davis Sustainable Agriculture Program will serve two major goals of the University: advancing fundamental science and synthesizing those advances to address society's problems.

BIBLIOGRAPHY

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