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U.S. Department of Agriculture Science and Education Administration
December 1980

# Agricultural Research

# Research Agenda for the 1980's

*The following is based on remarks by Anson Bertrand, director of science and education, at the Agricultural Outlook Conference, November 19, 1980, Washington, D.C.:*

**Global 2000:** The Global 2000 Report to the President listed a number of severe problems facing us in the coming years: soil erosion, soil nutrient depletion, crop damage from pollution, water shortages, an exploding world population, and many more.

Perhaps more important than any specific was the underlying theme that American agriculture is part of a worldwide system. We must therefore work with and encourage less-developed countries to formulate their own long-term national food strategies, and call upon developed nations to join us in common research and development goals.

**U.S. Population:** We must also recognize and plan for the changing population in this country—not only in increased numbers but in population mix. Our population grows older; migration patterns are reversing with the flow now from North to South and from urban to rural areas.

How will these changes influence agriculture? What will be the demands on our farm industry? To answer such questions, we need not only those skilled in agricultural sciences, but also demographers, sociologists, economists and others.

**Agricultural Capacity:** A major challenge in the years ahead will be improving our agricultural capacity. On our research agenda are such things as developing crops to better withstand environmental stresses associated with temperature, moisture, air pollution, soil salinity, and acidity; and crops that can be grown economically on low-producing land. New varieties of barley, wheat, corn and soybeans capable of intercepting more sunlight already are with us.

Using our knowledge of recombinant DNA, we will genetically modify cereal grain plants so they can fix their own nitrogen and sharply reduce total energy requirements and production costs.

Along with crop productivity we must increase animal productivity, and there are many areas promising for the 1980's. For example, we are learning how to obtain and transfer embryos in cattle, and to control the sex ratio and number of offspring. Work is now underway to develop a safe, effective, and inexpensive vaccine for foot-and-mouth disease using recombinant DNA techniques.

Agriculture is faced with increasing constraints on use of pesticides. Science's response to this situation must include the development of effective integrated pest management systems. Some parts of these systems already exist—plant, insect, and nematode pathogens, pest-resistant plants, insect attractants, to name a few.

We also have a job to do in improving the quality and safety of food products and in developing better methods of handling, processing, and distributing. We need to achieve better utilization of all agricultural commodities, whether as industrial raw materials or as consumer end-products.

**Natural Resources:** A fourth major concern for the 1980's has to do with our natural resources. To reduce soil erosion significantly, we must at least double the acreage on which conservation tillage is practiced. Conventional conservation practices are not cost effective; whole new systems must be developed through research.

The dwindling supply of fresh water is already a critical problem. Science and technology must develop management practices for utilizing water more efficiently. We are talking here about new distribution systems, irrigation scheduling, recycling of waste water, all kinds of farming practices that conserve water, including plant varieties that require less water.

The whole process of the movement of chemicals through soil is an area about which we need more information. A pressing need in this area is to improve our knowledge of nutrient cycling, especially nitrogen—and this whole area is important for water quality as well.

We also expect the acidity of precipitation to increase because of a greater dependence on coal. This increase will place yet another stress on our crops and forests and water resources. We must have a better understanding than we do now of the extent and nature of acid rain and its effect on biological systems.

**Energy:** Agriculture's productivity in the past has been based very much on oil—oil not only to propel the tractors but as a base for fertilizer and pesticides. Now, our oil supplies either are being closed off to us or are becoming expensive beyond our ability to pay for them.

USDA has set the goal of making American agriculture net energy self-sufficient by the end of this decade. The plan has four parts:

First is energy conservation.

Next is development of new renewable crop sources of plant-derived hydrocarbons and the conversion of biomass from field and forest to methane, ethanol, or other usable fuels and chemical feedstocks.

(continued on page 16.)

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*Agricultural Research*
Vol. 29 No. 6
December 1980

Editor: Patricia Loudon
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*Agricultural Research* is published monthly by the Science and Education Administration (SEA), U.S. Department of Agriculture, Washington, D.C. 20250. The Secretary of Agriculture has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through June 15, 1982. Yearly subscription rate is $13 in the United States and its territories, $16.25 elsewhere. Single copies are $1.25 domestic, $1.60 foreign. Send subscription orders to Superintendent of Documents, Government Printing Office, Washington, D.C. 20402. Information in this magazine is public property and may be reprinted without permission. Prints of photos are available to mass media; please order by photo number.

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COVER: Although it's still done by the sun, drying grapes into raisins requires less time with new methods developed at the SEA Western Regional Research Center in Berkeley, Cal. Article begins on page 12. (0980X1168-28).

A MARC I yearling heifer shows off her profile to SEA animal genetist Keith Gregory. Expected to excel in carcass characteristics, the MARC I population is a general-purpose composite based on a five-breed foundation: one-fourth each Charalais, Brown Swiss (predominantly European), and Limousin; and one-eighth each Hereford and Angus (1080W1202-16).

# Composites — Breeding Better Beef Cattle

Small beef cattle herds, for which complex mating systems are impractical, generally do not share crossbreeding advantages. But they will if a new breeding system is successful. The new system is under study at the Roman L. Hruska U.S. Meat Animal Research Center, Clay Center, Nebr., in cooperation with the University of Nebraska, Lincoln.

Under a conventional three-breed rotational system of crossbreeding, four cows can produce as much weight of calf at weaning as five straight-bred cows of the same breeds. This advantage can be maintained by continued, systematic crossbreeding. And crossbred cows have another advantage—longer productive lives.

Rotation crossing is difficult and frequently inefficient when there are fewer than 80 or 90 cows in the breeding herd, SEA geneticist Keith E. Gregory points out. And 80 percent of the beef herds in the United States contain 50 or fewer cows. Many of these small-herd owners are part-time farmers.

Gregory and associates are forming genetic "pools" by crossing breeds that provide a balance of traits closest to the performance characteristics most desired for specific production situations. Then composite "breeds" are formed by selective intermating within the resulting populations, while maintaining a low rate of inbreeding.

The geneticist visualizes general-purpose composites adapted to various climatic and feed-resource situations, as well as composites excelling in maternal or paternal characteristics.

A small-herd owner would select a general-purpose composite adapted to his production resources. He would manage it like straight-breds, using bulls from the same composite. Cattle producers with more resources might mate representatives of maternal and paternal composites to produce market animals.

The production advantage of crossbreds results from high levels of heterosis, or hybrid vigor, when genetically different animals are mated. Plant breeders similarly take advantage of heterosis in crop production.

Heterosis effects can increase calf weaning weight per cow by at least 20 percent, Gregory and SEA geneticist Larry V. Cundiff found. That increase is from three-breed rotational crossing, as compared with straightbreds. The increase, expressed as weight of calf weaned per cow exposed to breeding, includes cows not successfully bred and those that conceived but did not produce a calf.

The level of heterosis that can be maintained in composites will be determined in the current Germ Plasm Utilization Program.

Under rotational crossing, heterosis results primarily from the dominant effects of genes. Loss of first-generation heterosis under this breeding system is approximately proportional to loss of heterozygosity.

"Heterozygosity" is a genetic term that can best be defined by example. Genes are the units of inheritance and are present in pairs. One member of each pair comes from the sire and the

Top: A MARC II calf poses alongside her Simmental x Hereford cross dam. Not present for the family portrait is the sire—an Angus x Gelvieh cross (1080W1203-28).

Above: Agricultural research technician Rick Sholtz measures height of a MARC I yearling heifer (1080W1202-12).

This 6-month-old MARC III calf, left, is from a composite population that is one-fourth each Hereford, Red Poll, Angus, and Pinzgauer (1080W1202-5).

other from the dam. When genes of a pair differ (Aa) they are heterozygous—when they are alike (aa) they are homozygous. Heterozygosity is maximized when the sire and dam are from different breeds. Level of heterosis or hybrid vigor is highly associated with the degree of "heterozygosity."

In 1922, Sewell Wright, eminent USDA scientist known as the "father of modern animal breeding," showed that retention of heterozygosity beyond the first generation in crossbreds depends upon the number of inbred lines in the initial cross. Gregory has used Wright's formula to estimate heterozygosity retention, and he and colleagues are determining the extent to which loss of heterosis is proportional to loss of heterozygosity in composites.

When four breeds contribute equally to a composite, Gregory says about 75 percent of initial heterozygosity should be retained in the third generation. Retention should be about 78 percent in a five-breed composite in which three breeds each contribute one-fourth to the genetic base and two breeds contribute one-eighth each.

Heterosis retention in composites should be similar if losses of heterozygosity and heterosis are proportionate.

Gregory estimates a possible increase in calf weaning weight per cow of 17 to 18 percent over straightbreds in the four- and five-breed composites. This increase is intermediate between that in two- and three-breed rotation crossbreeding systems.

Gregory sees potential advantages of composites over crossbreeding systems beyond those directly related to heterosis. These include:

- Increased genetic variation in a population based on four or five breeds should result in greater opportunity for improvement by selection.
- Breeds crossed to form composites need not be comparable in birth weight, size, and milk production. This restriction is necessary in rotation crossing, where genetic composition based on breed differences fluctuates widely from generation to generation.
- Similar breeds need not be selected to avoid calving difficulty and associated higher death losses in calves.

Opportunities for optimizing genetic composition for such traits as growth rate, mature size, and milk production should therefore be greater because of the ability to select between breeds in identifying contributors to composites.

In 1969, SEA geneticist Gordon E. Dickerson, Lincoln, Nebr., suggested the potential for using heterosis through the formation of composites, as an alternative to more complex crossbreeding systems. Information from the Germ Plasm Evaluation Program (GPE), begun at Clay Center the same year, as well as a 20-year crossbreeding study begun by Gregory in 1957, were the basis for initiating the current project.

GPE provided detailed information on production traits in breeds varying widely in biological type to help guide selection between breeds used in forming experimental composites. Twenty breeds—both old, established ones and recently introduced exotics—were evaluated throughout their life cycle. More than 5,000 crossbred calves were produced.

Three composites are being developed at Clay Center:

- *MARC I,* a general-purpose composite with a moderate degree of excellence in paternal performance traits, is based on a five-breed foundation: One-fourth each Charolais, Brown Swiss (predominantly European), and Limou sin, and one-eighth each Hereford and Angus.
- *MARC II,* a general-purpose composite suited to good environmental conditions, is one-fourth each Hereford, Angus, Simmental, and Gelbvieh.
- *MARC III,* adapted to a less-favorable feed environment and with a moderate degree of excellence in maternal characteristics, is one-fourth each Hereford, Angus, Pinzgauer, and Red Poll.

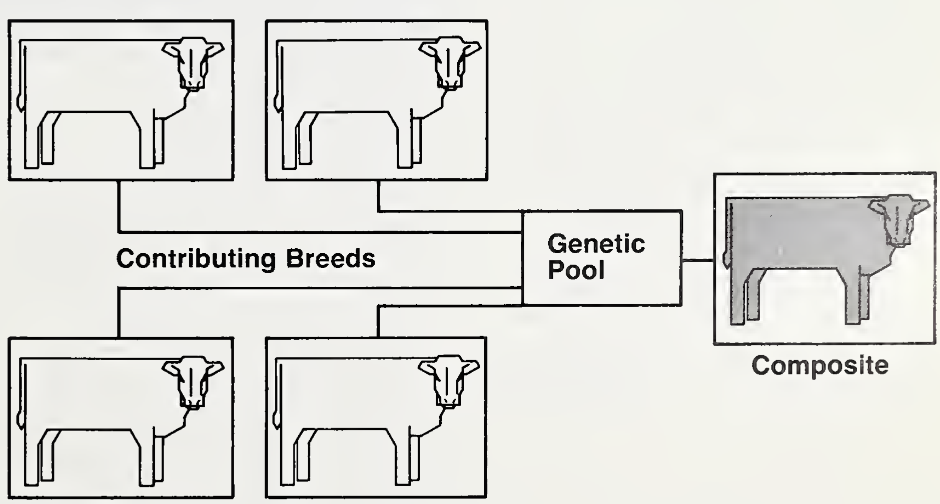
Gregory and associates will concentrate on improving selection methods, with emphasis on developing more effective selection procedures for reproduction traits, during the 6 more years needed to complete foundation matings. During the foundation period, researchers are also determining retention of heterosis by comparing performance of composite populations to that of contributing purebred populations.

Selection within the resulting composite populations and the contributing foundation purebreds will then extend perhaps two or three generations.

Will the composite concept prove practical? Preliminary scientific evidence indicates it should. But the final answer will not come quickly—cattle have a generation interval of 4 to 5 years.

Dr. Keith E. Gregory and Dr. Larry V. Cundiff are located at the Roman L. Hruska U.S. Meat Animal Research Center, P.O. Box 166, Clay Center, NE 68933.—(By Walter Martin, SEA, Peoria, Ill.)

The Roman L. Hruska U.S. Meat Animal Research Center located near Clay Center, Nebraska—This 35,000 acre facility is dedicated to a comprehensive beef cattle, sheep, and swine research program (1080W1208-11A).



# Spring and Summer Sheep Matings Successful

By exposing sheep to artificial lighting conditions that simulate the fall breeding season, researchers have successfully induced spring and summer matings.

This could change lamb production from a seasonal to a nearly year-round operation, says SEA physiologist Bruce D. Schanbacher.

Nature programmed sheep to be short-day breeders, Schanbacher explains. The gradually shortening day-length, or photoperiod, of fall triggers complex hormonal responses initiating their annual sexual cycle. However, rams can be led to believe it's the October breeding season in May, inducing them to approach their autumn readiness to mate successfully.

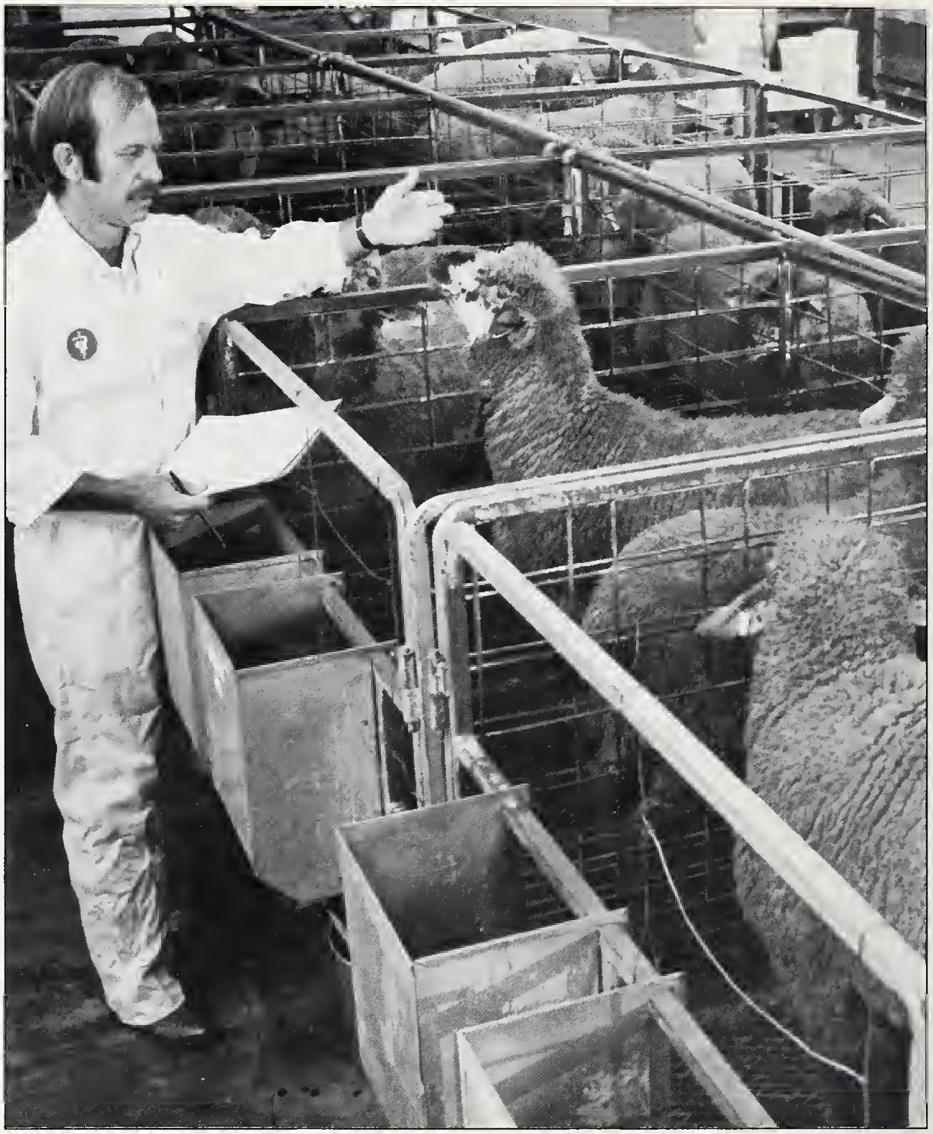
Schanbacher simulated the response usually produced by fall's short days by maintaining five Suffolk rams under a photoperiod of 8 hours light and 16 hours darkness from late February through a 3-week breeding season in May.

The Suffolk is one of the breeds most affected by photoperiod. Yet, the short-day rams sired 2½ times as many lambs as five Suffolk rams kept outside, where the spring days were getting longer.

The rams were exposed to 300 Finnish Landrace crossbred ewes in which out-of-season heat (behavioral estrus) was induced by treatment with reproductive hormones.

"Since sheep are short-day breeders and have an average gestation of 150 days, lambs normally arrive in April or May," Schanbacher says. "Exposing both rams and ewes to artificial photoperiods may be a useful management tool for distributing the lamb crop at predetermined times of the year."

Producing two lamb crops a year, under confinement or semiconfinement management, would make full use of the ewe's reproductive capacity, expand marketing periods, equalize lamb labor requirements, increase utilization



White facial markings may give him character, but they're not quite enough to identify this 24-week-old ram lamb. Bruce D. Schanbacher, SEA physiologist, identifies the rams by ear tag numbers so he can check growth rates. Geneticists will use this information, in addition to physiological data, to determine the rams' potential as breeding stock (1080W1210-28/29).

of lambing facilities, and consequently lower the producer's overhead costs per lamb.

Schanbacher, at the Roman L. Hruska U.S. Meat Animal Research Center, Clay Center, Nebr., is investigating the photoperiod effects on ram reproductive performance as part of a team effort to determine whether out-of-season matings in sheep can be made a practical management practice (*Agricultural Research,* January 1977, pp. 7-9).

The effects of photoperiod on estrus activity in ewes and on sperm production and breeding performance in rams were documented 15 to 20 years ago. More recently, French researchers showed that photoperiod affects the levels of certain reproductive hormones in rams. Photoperiod also affects testis size, which is an indicator of mating success.

In Schanbacher's study, 10 mature Suffolk rams with previous breeding experience were divided into two groups for 10 weeks. Five rams were maintained outside, the other five were kept in a closed building with artificial lighting restricted to 8 hours daily.

During the 3-week breeding season in May, each ram was individually penned with 30 ewes for 16 hours daily. The short-day rams were returned to darkness between 2 and 10 p.m. daily to continue the photoperiod of 8 hours light and 16 hours darkness.

Increases in testis size in the experimental rams, beginning the third week under short-day photoperiod, indicated the rams were becoming prepared for mating. Semen quality in the first 9 weeks did not change for the short-day rams—but it continued the usual seasonal decline, as did testis size, in the rams kept outside. Semen volume was not significantly affected in the short-day rams.

Eighty-nine percent of the ewes were mated by rams under short-days, and 66 percent were mated by rams kept under the long-day photoperiod. Lambing rates were 67 percent for ewes exposed to the experimental rams and 32 percent for those exposed to the control rams.

Schanbacher says the 67-percent lambing rate in single-sire matings is comparable to that from previous out-of-season matings where multiple sires were used, the fertility of the ram breed was less affected by season, or the matings were scheduled nearer the normal breeding season.

Earlier research by Schanbacher and SEA physiologist J. Joe Ford suggests that testicular growth in rams exposed to decreasing photoperiods results from the actions of luteinizing hormone and follicle-stimulating hormone. Research to better understand how these and other reproductive hormones function in the ram may lead to ways of improving reproductive performance throughout the year.

Dr. Bruce D. Schanbacher is located at the Roman L. Hruska U.S. Meat Animal Research Center, P.O. Box 166, Clay Center, NE 68933.—(By Walter Martin, SEA, Peoria, Ill.)

# Vitamin $B_6$ Enhances Zinc Absorption

Vitamin $B_6$ greatly enhanced intestinal absorption of zinc in experiments with laboratory rats. This discovery by scientists at the SEA Grand Forks Human Nutrition Research Center, N. Dak., may lead to improved understanding of trace mineral absorption in humans.

"Thorough knowledge about relationships among dietary components is needed," says biochemist Gary W. Evans, who led the research. "Without it, attempts to supplement diets with trace minerals cometimes could be ineffective or even detrimental to health."

In his latest study, Evans fed weanling rats diets based on casein, a milk protein, that included about as much zinc as rats normally need and amounts of Vitamin $B_6$ ranging from 2 to 40 milligrams per kilogram of food. After a month, rats given the least amount of Vitamin $B_6$ were absorbing only 46 percent of the zinc in their diets. Rats fed the most Vitamin $B_6$ were absorbing 71 percent of the zinc.

The researchers also supplemented the diet with 200 milligrams of picolinic acid and 4 milligrams of Vitamin $B_6$ per kilogram in another part of the study. Zinc absorption from this diet was 72 percent.

In earlier studies, Evans identified picolinic acid as the main zinc-binding component in milk that may facilitate absorption of the trace mineral by the small intestines of humans and animals.

"There appears to be a connection between the two findings," says Evans.

Evans and his research team also found less than one-tenth as much picolinic acid in cow's milk as in human milk, shedding new light on its connection to a rare inherited disease —acrodermatitis enteropathica. Breast feeding had been long recognized as beneficial therapy for infants with this disease. (See *Agricultural Research,* September 1978, p. 11.)

He explains that animals and humans produce picolinic acid from the amino acid, tryptophan, through a series of biochemical reactions. Kyureninase, an enzyme that is involved in the biochemical pathway between tryptophan and picolinic acid, works with the help of Vitamin $B_6$.

For human adults and children more than 4 years of age, the U.S. recommended daily allowance (RDA) of Vitamin $B_6$ is 2 milligrams. Sources of the vitamin include whole grain cereals, meat, poultry, most fish and shellfish, dry beans, peanuts, bananas, raisins, prunes, potatoes, and most dark green leafy vegetables. Over-cooking can destroy some of the vitamin.

For adults and children more than 4 years of age, the RDA of zinc is 15 milligrams. Good sources of zinc include meat, shellfish, cheese, whole grain cereals, dry beans, and nuts. Pregnant women and nursing mothers may need greater amounts of both Vitamin $B_6$ and zinc than other adults, Evans says.

Dr. Gary W. Evans is located at the Grand Forks Human Nutrition Research Center, P.O. Box 7166, University Station, Grand Forks, ND 58201.—(By Ben Hardin, SEA, Peoria, Ill.)

# Moving Lettuce to Market

Above and Opposite page: By the time iceberg lettuce heads reach supermarket shelves, their price tags often reflect the considerable cost of damage and loss incurred while being packaged in the field (1180L390-17A).

By improving packing and shipping methods, the number of iceberg lettuce heads reaching grocery counters in saleable condition could be increased by 15 percent, say Tom Hinsch and Roger Rij, SEA marketing specialists, Fresno, Calif.

Lettuce production in the United States amounts to about 6 billion pounds per year with a value of nearly $648 million at the point of shipment.

Improved packing and shipping methods could result in consumers paying somewhat less for lettuce; and growers, shippers, and wholesalers adding to their profits.

Hinsch and Rij examined physical injury to California and Arizona lettuce destined for eastern markets. They found that nearly 15 percent of the field-packed lettuce reached those markets in less than saleable condition.

One hundred million cartons of iceberg (crisp-head) lettuce are shipped east from California and Arizona fields each year. Nearly 70 percent of this total is field-packed directly into corrugated fiberboard boxes with minimum trimming and with no additional packaging materials.

Called "naked" lettuce by industry, the heads are not sized before they are hand-picked and hand-packed—24 heads to a box. Because this amount must be layered and compressed to fit into most cartons, damage results.

"That's where the problem starts," Hinsch says. Some of the boxes are packed on the ground and others are packed on a wheelbarrow-like device called a "hump." Ordinarily the hump has a full bottom, but some packing crews remove the bottom to make the hump lighter and more mobile.

Ground-packed cartons and those packed on the hump with a bottom have about the same number of damaged heads. The bottomless hump creates more damage because it allows the carton to bend when the heads are forced into it.

"But," Hinsch says, "the greatest damage is created when the flaps of the carton are closed."

After the carton is packed, a worker using a metal frame closes the flaps and staples them together. Usually, the flaps must be forced down on the heads in the overpacked carton.

Previous studies showed that crushing and bruising were the principal types of damage incurred by lettuce prior to the time it arrives at the terminal. The present study shows that most of this kind of injury occurs during the packing process in the field and results in lettuce that is unacceptable to consumers.

Such lettuce may be salvageable for shredding or sold as damaged merchandise. Loss is reflected in the price of the remaining merchandise.

Lettuce heads defined as moderately injured have bruised leaves that must be trimmed before retail display, and that has an effect on consumer purchase.

Slight injury involves torn or broken leaves that do not have to be trimmed and are barely noticeable to consumers.

Additional injury to lettuce results when the overstuffed cartons are loaded onto pallets on trucks in the field, loaded by machine into vacuum coolers, unloaded by hand onto conveyor belts, hand-loaded into trailer trucks for transport to market, and offloaded by hand into retail stores.

Hinsch and Rij point out the need for research to develop methods of packing and closing lettuce boxes that would minimize physical injury to this important crop, and to develop packages that would accommodate heads of different sizes.

Scientists are studying ways to standardize the size and patterns of packing containers. Details of Tom Hinsch's study are contained in a new publication. "Shipping Containers of Standard Size for Lettuce, Nectarines, Peaches, and Strawberries," can be obtained by writing to Hinsch at the U.S. Horticultural Field Station, Market Quality and Transportation Unit, 2021 S. Peach Ave., P.O. Box 8143, Fresno, CA 93747.—(By Paul Dean, SEA, Oakland, Calif.)

# Accelerated Drying—A New Raincoat for Raisins

Awaiting harvest, these grapes—raisins-to-be—ripen in the California sun (0980X1168-34).

Raisins, the largest dried fruit crop produced in the United States, will suffer less rain damage if growers adopt accelerated drying methods recently developed by scientists at the Western Regional Research Center, Berkeley, Calif.

Grapes are not usually ready for harvest until September, when early rain often damages them while they lie on paper trays for sun drying. Exposed grapes then mold and spoil. This results in reduced supplies and, therefore, higher prices for consumers and economic losses for growers.

In 1978, rain reduced raisin production from more than 270,000 tons to approximately 100,000 tons. Subsequently, wholesale prices rose from 69¢ to about $1.45 per pound.

To reduce the risk of rain damage, SEA scientists, in cooperation with Vincent Petrucci, of California State University at Fresno, have developed a water emulsion spray of a vegetable oil derivative that accelerates drying. The spray interacts with the waxy outer layer of the grapes. Normally, the outer layer acts like wax paper keeping moisture in. The spray allows internal moisture to escape faster, thus producing raisins faster.

The spray process cuts sun-drying (and potential rain-exposure time) from more than 2 to 3 weeks to 8 to 12 days. The new method could also benefit grapes currently dried by dehydrators (about 10 percent of the U.S. crop), thus reducing energy costs significantly.

"Recent findings indicate that two applications of the drying aid are more effective than one in certain cases," says Allan E. Stafford, SEA chemist at the center. "There is a loss of the drying aid as grapes dry. After about 80 percent of the first application has been lost, the drying rate slows rapidly. But it can be increased by a second application."

Last year about 850 acres of grapes were dried using the new process. One company is now test-marketing these raisins. This year approximately 10,000 tons of raisins were produced.

"These raisins are lighter and more varied in color than regular sun-dried raisins," says Glenn Fuller, SEA chemist at the center. This is because the fast drying action of the spray reduces darkening of the grapes during drying to raisins. One company will export some of these raisins to Europe where light brown raisins are preferred.

An inexpensive polyethylene solar-collector that absorbs the sun's heat is also being studied at the center. The collector reduces drying time by 40 percent. In addition, it covers the grapes during drying to minimize rain damage.

To avoid rain damage, some growers harvest grapes before they achieve maximum sugar levels and quality. But early harvest would not be necessary with the solar collector.

Two different drying systems use this method. In one, grapes are exposed directly to solar radiation within the collector. A 100-feet long by 5-feet wide sheet of black plastic is placed between two rows of grapevines. Harvested grapes are spread on one half of the plastic sheet. The other half is used to preheat air.

The grapes are sprayed with the same drying aid discussed earlier and a 6-feet wide clear sheet of polyethylene is then unrolled over the grapes and the bottom sheet of plastic. The two sheets are stapled to light-weight boards that run the length of the row,

Above: Food technologist Rogernald Jackson holds while Huxsoll trims plastic tubing for a snug fit onto an electric blower used to circulate air between the polyethylene sheets of his field-constructed solar tunnel (0980X1168-4).

Left: Huxsoll secures one end of solar tunnel to a portable grape-drying cabinet. Air moving through the tunnel is heated by the sun, making the grapes in the cabinet dry more quickly (0980X1167-19A).

Top: Electric blower begins drying the grapes inside the inflated solar tunnel (0980X1168-9A).

Above: Checking the fruits of their labor, Huxsoll (right), and colleagues Bolin (center) and Petrucci (left), note the color, texture, and firmness of sun-dried raisins (PN-6814).

thereby forming a long, flat tube.

An electric blower attached to the front of the tube inflates it to form a tunnel greenhouse and circulates air over the grapes.

In the second system, grapes are not exposed to direct solar radiation. Instead, the entire length of the same greenhouse tube is used to heat air. The end of the tube is connected to a portable drying cabinet where grapes are arranged in a single layer. One row of grapes, 100 feet long, produces about 500 pounds of grapes, which can be dried in a cabinet 3-feet wide by 6-feet long by 4-feet high.

"Both systems seemed to dry grapes at a similar rate," says Harold R. Bolin, SEA chemist at the center.

"In 2 days, moisture content dropped from an average 77 percent to 54 percent. By the 6th day, it was down to less than 10 percent," says Bolin. "About 5 days would be adequate to get the 14 percent moisture content preferred by packers."

The solar driers do not require a large area of land taken out of production. They fit between rows, and this area is not needed for production activity during September.

"So far the solar-drying system seems technically feasible," says Charles C. Huxsoll, SEA agricultural engineer at the center. "Because electricity is required for the blower, a portable power source, such as a diesel-driven generator could be used, or electrical lines could be permanently installed in the field," he suggests. "An alternative would be to use a certain vineyard area where power is already in place. Grapes would be transported from other areas for drying in this vineyard."

The address of the Western Regional Research Center is 800 Buchanan Street, Berkeley, CA 94710.—(By Dennis Senft, SEA, Oakland, Calif.)

# Radio Reveals Feeder Pig Stress

The stress that often accompanies the routine handling and transportation of feeder pigs may directly affect their ability to gain and retain weight. By using radio telemetry and strip chart recorders, SEA agricultural engineer Herman F. Mayes is able to document the relationships between stress and heart rates of pigs during marketing.

Miniature radio transmitters taped to the backs of the pigs pick up the heart beats under closely monitored conditions. This provides information about the stress that feeder pigs undergo during each step of the marketing process.

"We're trying to gain insights on changes in market facility design and handling procedures that could minimize such stress," says Mayes.

Mayes' work is part of a larger research project at the University of Missouri's Animal Husbandry Department. The project includes a follow-up study on effects of diet and medication on pigs under stress.

"We're studying weight losses associated with handling and transport and subsequent weight gaining performance of the pigs," Mayes says.

Mayes obtained heart rate data on pigs in about a dozen activities. The heart rate of sleeping pigs usually ranges between 100 and 160 beats per minute, Mayes says. But when the porkers are forced to climb a loading chute to begin their trip to a feeder pig auction, he found that heart rates may range from 250 to 260.

Pigs experience reduced blood flow when their hearts beat more than 210 times per minute. "This results in something similar to a heart attack in humans," says Mayes, "slowing blood flow to extremites and raising body temperature."

Pigs that are pressured into prolonged physical exertion could collapse. But the 35- to 85-pound pigs that Mayes studied instinctively adjusted their activities to reduce their heart rates.

When pigs stopped after running, they would stand still or lie down until their heart rates dropped to about 200 beats per minute. While lying down, some pigs ignored any stimulus to make them move.

Herman F. Mayes, SEA agricultural engineer, inspects electrodes taped on pig's back to monitor heartbeat and other stress indicators (1080W1198-25A).

Mayes observed no statistically significant differences in average heart rates when pigs stood, ate, drank, or walked. However, pigs that were running, lying down and alert, and lying down asleep had significantly different heart rates.

Marketing practices put pigs in many stressful situations, which Mayes will observe as the study continues. For example, after being transported to a marketing facility, feeder pigs are normally sorted, graded, weighed, and penned. At some markets, feed and water are not provided. After the sale, pigs may remain at the marketing facility up to 15 hours awaiting transportation, which can take an additional 20 hours.

Herman F. Mayes is located in Room 202, Agricultural Engineering Building, T-12, University of Missouri, Columbia, MO 65211.—(By Ben Hardin, SEA, Peoria, Ill.)

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AGR-101

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# Research Agenda for the 1980's

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Third is the utilization of alternate sources such as solar and wind energy.

Finally, the plan would provide economic assessments of energy alternatives in agriculture and make it a special responsibility of research and education to consider incentives to foster adoption of such alternatives.

**Clientele Concerns:** Various clientele concerns will continue to figure strongly in the 1980's. Research backup for action and regulatory agencies can help make them work better. We can profitably aim more research efforts at helping improve regulatory actions in the 1980's, or at making them unnecessary by eliminating the problems they are designed to control.

Interest in the relationship between diet and long-term well-being will continue. Major research thrusts will be toward critical areas of human health and well-being at the differing stages of life—the nutritional needs of pregnant and lactating women, of infants and young children, and of the elderly.

We are only beginning to understand the effects of nutrition on mental and physical development and the impact of intervention programs upon nutrition status.

**Information Technology:** Agriculture, like the other areas of our society, is caught up in the new information technology explosion of computers and telecommunications. The new information technology—new ways of generating information, handling it, storing it, retrieving it, communicating it and using it—has transformed the way we do science and will become even more critical in the future. In agriculture we have barely scratched the surface in the use of these powerful information tools. We must master them and do it soon.

**Basic Research:** Of all the items on our agenda for the 1980's, the most significant is basic research. Before we can make the really dramatic improvements in agricultural productivity, we must have more fundamental knowledge. We are lagging in replenishing our store of basic information, in effort expended on basic research, and in the transfer to the applied stage.

The pool of basic knowledge sets the foundation and limits of applied and developmental research, which, in turn, can be translated into technologies for application and use. Without planned and accelerated basic research efforts and some major breakthroughs, the rate of growth of our food crop and animal production will not keep pace with needs.

Areas where we must undertake more basic research include the entire genetic frontier in both plant and animal agriculture; photosynthesis; the relation of physiological and biochemical factors to diet; and the effects of nutrient availability on regulation of cell differentiation, growth, and function.

The base of fundamental knowledge from which most of agriculture is working today is not very great. It is, in fact, a very thin foundation. I don't believe the general public has the slightest idea of how precarious our position is, or what it takes to make significant progress.