Agroborealis

Volume 19, Number 1, July 1987

Agricultural and Forestry Experiment Station

School of Agriculture and Land Resources Management

University of Alaska-Fairbanks

A Presidential Proclamation

The idea of agricultural experiment stations in the U.S. dates back to 1845 when John P. Norton, an agricultural chemistry professor at Yale, proposed a national system of experiment stations. In 1887, more than 40 years later, Congress passed legislation to establish Federally supported state experiment stations in land-grant colleges. Thus, the Agricultural and Forestry Experiment Station, University of Alaska-Fairbanks, is part of a network of state agricultural research in the U.S.

On March 2, 1987, the centennial of this legislation, President Ronald Reagan issued a proclamation outlining the vital role of state agricultural experiment stations. The presidential proclamation is shown below.

James V. Drew
Dean, School of Agriculture and Land Resources Management
Director, Agricultural and Forestry Experiment Station

Hatch Act Centennial, 1987

By the President of the United States of America
A Proclamation

For a century, we Americans and people around the world have benefitted tremendously from the agricultural research and training provided by our national system of agricultural experiment stations at our State land-grant colleges. This system was initiated by the Hatch Act, which President Grover Cleveland signed into law on March 2, 1887. In celebrating the Centennial of this legislation, we pay much-deserved tribute to our agricultural researchers of the present and to the generations of dedicated scientists who preceded them in this essential work.

Americans promoted agricultural education from the start. Private societies achieved much progress, and farmers, stimulated by nearly limitless opportunity, eagerly took advantage of new scientific knowledge. Public support for agricultural research grew because the results were so obviously beneficial. In the early and mid-19th century, specialized schools of agriculture appeared. The United States Department of Agriculture was founded in 1862; one of its missions was to acquire and diffuse agricultural information. The Morrill Act, which President Abraham Lincoln signed into law in 1862, provided for the creation of land-grant agricultural colleges in most states.

Despite these welcome developments, a generation later much remained to be done. It was then that William Henry Hatch, a Congressman from Missouri, proposed agricultural experiment stations for research and training. Today we know that the adoption of the Hatch Act of 1887 was one of the most significant steps ever taken in American agriculture.

It is no exaggeration to say that the wealth of technical knowledge developed at these stations has enabled America's farmers to revolutionize the practice of agriculture and bettered life for millions of people the world over. The existence of these institutions and the abilities of the scientists trained there ensure that future generations will continue to enjoy the benefits of agricultural research.

In recognition of the vital role of State agricultural experiment stations in American agriculture, the Congress, by House Joint Resolution 3, has designated March 2, 1987, as the Centennial of the signing of the Hatch Act of 1887 and authorized and requested the President to issue a proclamation in observance of this event.

NOW, THEREFORE, I, RONALD REAGAN, President of the United States of America, do hereby proclaim March 2, 1987, as the Centennial of the signing of the Hatch Act of 1887, and I call upon the people of the United States to observe this day with appropriate ceremonies and activities.

IN WITNESS WHEREOF, I have hereunto set my hand this second day of March, in the year of our Lord nineteen hundred and eighty-seven, and of the Independence of the United States of America the two hundred and eleventh.

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Composition . . . . Tobi Campanella and Teri Lawson
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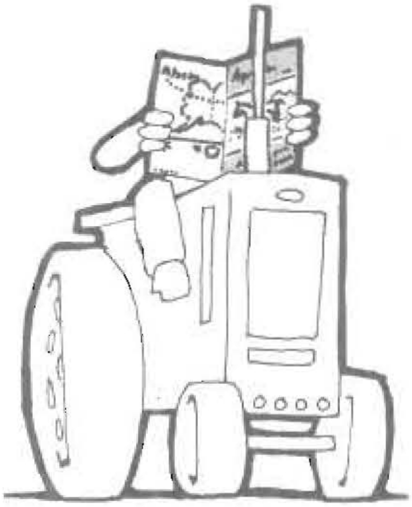
Table of Contents

ABOUT THE COVER . . . *Many types of annual flowers flourish at the Agricultural and Forestry Experiment Station's Demonstration Garden. Those cultivars shown here, plus hundreds more, are listed in the new AFES publication, Circular 59, Gardening with Annual Flowers in Interior Alaska. The 110-page book includes detailed information regarding the production of these plants, including listings by color, bloom period, plant height, and special purposes. The publication costs $3, including postage, and may be ordered by mail from the Agricultural and Forestry Experiment Station, University of Alaska-Fairbanks, Fairbanks, Alaska 99775-0080. (AFES staff photo)*



AFES Notes

Sigmund (Sig) H. Restad retired as assistant director of the Agricultural and Forestry Experiment Station on January 31, 1987, after about 22 years service with the University of Alaska-Fairbanks. After serving in the Korean War, Mr. Restad graduated from the University of Minnesota with a masters degree in dairy science and worked as an agent in the Minnesota Cooperative Extension Service from 1954 to 1958. He joined the Alaska Agricultural Experiment Station in 1958 as farm superintendent at the Fairbanks Experimental Farm. Governor Bill Egan appointed Mr. Restad director of the State Division of Agriculture in 1962, a post that he held until 1968. The experiment station reclaimed Mr. Restad in 1968 when then director Dr. Horace F. Drury convinced him to become experiment station executive officer, at which time he joined the staff of the Palmer Research Center. Current director Dr. James V. Drew promoted Mr. Restad to assistant director in 1978. He served as acting director for six months in 1985 during the temporary absence of Dr. Drew.

Sig Restad

Mr. Restad has been an active spokesman for agriculture and agricultural research, being particularly effective in enhancing the university's relationship with the legislators and agencies with whom he dealt. He was active in support of the Agricultural Development Council, Rural Development Council, and Resource Development Council as well as various community organizations.

Mr. Restad was granted emeritus status by President Donald O'Dowd at the 1987 university graduation ceremonies conducted on the Fairbanks campus. Appropriately, Mr. Restad retired to his home on Farm Loop Road north of Palmer.

Dr. William W. Mitchell, professor of Agronomy, has been appointed acting assistant director of AFES until a permanent replacement for Mr. Restad is selected.

Dr. Chien-Lu Ping, assistant professor of agronomy (soil scientist), has been invited to present a paper to the Ninth International Soil Classification Workshop to be held in Japan from 20 July to 1 August 1987. The purpose of the workshop is to provide a forum for members of the International Committee on the Classification of Andisols (ICOMAND) and the International Committee on the Classification of Wet Soils (ICOMAQ) as well as other soil scientists to develop the taxonomy of soils derived from volcanic ash and to revise the classification of hydromorphic soils. The title of Dr. Ping's presentation is the "Classification of cold andisols and association spodosols of Hokkaido, Japan, and southern Alaska, U.S.A." coauthored by Dr. Sadao Shoji and T. Ito of Tohoku University, Japan. The trip is partially supported by the U.S. Agency for International Development (USAID).

Fredric M. Husby, associate professor of animal science, was elected chairman of the Western Regional Hatch Pro-

. . . Continued on page 47

Notice of Release of 'Kenai' Polargrass

By

William W. Mitchell*

The Agricultural and Forestry Experiment Station, University of Alaska-Fairbanks, announces the release of 'Kenai', a cultivar of polargrass [*Arctagrostis latifolia* (R. Br.) Griseb.]. The new variety is recommended for forage and revegetation use under appropriate conditions from the central interior to southern portions of Alaska and, possibly, at other north-latitude stations. The cultivar 'Alyeska' polargrass, previously released by this experiment station (Mitchell 1980), is the only other known cultivar of the species.

Kenai is a medium to tall grass growing about 1.5 to 5.0 feet in height. Its relatively wide, lax leaves are produced along the erect, generally stout stems. In open stands, it spreads conservatively by means of short, stout rhizomes, forming dense clumps. Inflorescences are usually open and lax to erect and narrow. Kenai polargrass often is light green in color, tending to be lighter colored than Alyeska.

Polargrass is a strictly north-latitude species with a circumpolar distribution. It occurs throughout mainland Alaska in various plant communities. It is adapted to cold, boggy soils as well as to mesic upland soils. It is not well adapted to dry sites.

Kenai is based on bulk seed collections of polargrass made (a) near Mile 134 of the Sterling Highway and (b) at the townsite of Kenai, both on the Kenai Peninsula, Alaska, accessioned as IAS 63 and IAS 60, respectively. The two collections, IAS 63 and IAS 60, are being perpetuated in isolated breeding lines as IAS 633 and IAS 634, respectively. Seed lots of the two lines are composited in equal amounts of pure, live seed to constitute the breeder generation.

The components of Kenai have been tested separately and combined in synthetics in a number of forage trials, mainly in southcentral Alaska, and in some revegetation trials from central interior to southcentral Alaska. Their behavior also was observed for a number of years in spaced-plant nurseries at the Palmer Research Center. These trials and observations have shown that Kenai polargrass has application as a forage or revegetation grass from central interior to the southern coast of Alaska, particularly on strongly acidic soils in areas with relatively moist, cool growing seasons. Kenai has shown a greater tolerance of winter ponding and icing conditions than have timothy (*Phleum pratense* L.) and smooth bromegrass (*Bromus inermis* Leyss.), two commonly used forages in Alaska. It is expected that Kenai could be applied on boggy or peaty soils. It is adversely affected by droughty conditions and has shown stand depletion when harvested under these conditions. Also, taking two forage harvests within a season sometimes appears to have been detrimental. Polargrass has demonstrated immunity to snow molds (*Sclerotinia borealis* Buback and Vleugel and possibly others) that can affect such other grasses as timothy.

Polargrass generally does not surpass bromegrass for forage purposes where bromegrass is well adapted (Klebesadel 1969, Mitchell 1982). However, Kenai will provide another forage option in areas where bromegrass is marginally or poorly adapted because of strong soil acidity (Mitchell 1985). Kenai also can be used in revegetation mixes from lowlands to alpine situations, but it should not be used in the northernmost regions of Alaska. Alyeska polargrass is a better choice there, as it has demonstrated its adaptability to Arctic conditions.

Seed classes of Kenai are limited to *breeders, foundation*, and *certified*. Breeder seed is maintained under the supervision of the Alaska Agricultural and Forestry Experiment Station. Increase of breeder and foundation seed is administered through the Alaska Seed Growers, Inc. Seed yields of 150 to 250 pounds per acre may be obtained of Kenai polargrass.□

***Professor of Agronomy, Agricultural and Forestry Experiment Station, Palmer, Alaska.**

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Trip Report: A Visit to The Swedish Reindeer Industry, 1986

By

James Dau*, Robert A. Dieterich**, Wayne C. Thomas***, and Larry T. Davis****

Introduction

The State of Alaska indicated recently that it will become more strict in enforcing inspection requirements for reindeer meat that is mixed with meat from domestic animals (e.g., in sausage production). Therefore, we wanted to observe how reindeer are slaughtered to meet Swedish meat inspection requirements. Additionally, by following the processing and marketing of reindeer in Sweden, we hoped to discover alternative products that do not require blending reindeer with beef or pork. The Chernobyl tragedy further affected our decision to visit Sweden in two ways: it gave us the opportunity to review the impacts of widespread, intense radioactive contamination on reindeer and the reindeer industry; and it created a shortage of reindeer for human consumption in Sweden which in turn appeared to open a market for Alaska reindeer products.

Between 13 and 23 November 1986, we traveled to Sweden to meet suppliers and processors in the Swedish reindeer *(Rangifer tarandus tarandus)* industry. Wholesale and retail marketing of reindeer were reviewed in Stockholm; corralling, slaughter, and processing of reindeer were observed in Swedish Lapland. The specific objectives of this trip were as follows: 1) to observe reindeer slaughter facilities and techniques used in Sweden; 2) to trace the marketing of reindeer from Sami herders to retail outlets; 3) to assess radioactive contamination of reindeer and their ranges and observe how the problem is being handled; 4) to observe as many reindeer husbandry techniques as possible; and 5) to explore the possibility of establishing a market for Alaskan reindeer meat in Sweden.

***Research Associate, Agricultural and Forestry Experiment Station, Nome.**

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*****Professor of Economics, Agricultural and Forestry Experiment Station, University of Alaska-Fairbanks.**

******President, Reindeer Herders Association, Nome.**

The following is a summary of the results of our trip. It is organized along the market chain from Sami reindeer herders to retail outlets. All references to dollar values are expressed in U.S. currency at an exchange rate of 6.83 Swedish kroners to 1 U.S. dollar.

Reindeer Husbandry in Sweden

Ownership of reindeer in Sweden is restricted to Lapps, an ethnic minority of northern Sweden which has herded reindeer for centuries. Although only a small fraction of the Sami who live in Swedish Lapland are herders, reindeer still figure prominently in their cultural heritage.

Officially, there are approximately 250,000 reindeer in Sweden; however, this estimate is thought to be conservative. Since local political influence and prestige of herd owners is considered proportional to the number of deer they own, and because of obvious monetary advantages, herders try to maximize the size of their herds. In opposition to unrestricted herd size, upper limits on maximum numbers of reindeer are established by government managers for individual ranges. To stay within legal limits, herd owners typically provide conservative estimates of reindeer abundance to government officials. These estimates are not verified by range managers. This has led to overpopulation by reindeer and resulted in deterioration of many, if not most, winter ranges. Reindeer lichens (e.g., *Cladonia* and *Cetraria* spp.) were scarce in the few feeding craters we examined, and arboreal lichens (e.g., *Alectoria* spp.) exhibited an obvious browse line. As a result, the deer we observed were small (about two-thirds the size of Alaskan reindeer) and in relatively poor condition. Very few of the carcasses we observed had more than a trace of back fat. Overpopulation is considered to be one of the most serious problems faced by the Swedish reindeer industry, perhaps second in severity only to radioactive contamination of reindeer ranges. Now fawns are commonly slaughtered since many starve during their first winter on the poor-quality ranges; previously, only adult reindeer were harvested.

Once nomadic, Lapps freely moved their reindeer herds through an annual cycle of range rotation via foot and skis. Now, reindeer ranges are fenced to control herd movements and grazing patterns. Travel between summer and winter ranges no longer involves long migratory treks. Instead, deer are gathered at corrallings, loaded into large semi- and tandem-trailer trucks, and transported over an extensive road system. Up to 200 deer can be hauled in one transport truck per trip. The average cost of approximately $6.00 per reindeer is paid through government subsidies and funds generated by local reindeer councils (described later). Motorcycles, snowmachines, and helicopters are used to gather and drive reindeer within seasonal ranges.

The Samis' use of mechanized transport for herding has made Lapp herders vulnerable to some of the problems that face Alaskan herders. Sami herders reportedly spend less time with their reindeer now than ever before and, as a result, their reindeer have become more wild. Even so, Swedish reindeer were considerably more docile than reindeer in Alaska. Also, trauma and stress-related problems are occurring more frequently now that mechanized herding and transport are widely used. We observed several carcasses with extensive bruises that probably occurred during transport via truck.

Another parallel between the Swedish and Alaskan reindeer industries is that change has not been uniform across all aspects of husbandry. For example, despite the rapid adoption of helicopters, snowmachines, and other means of transport, corralling techniques used by Lapps have remained essentially unchanged. We attended two reindeer handlings while in Lapland. The Samis drove their deer into a large circular corral where up to 200 herders roped individual reindeer. The deer were then dragged to small holding pockets that radiated off the main pocket like the areas between the spokes on a wheel. Reindeer from each herd were tallied by hand as they entered their respective holding pockets. It was the consensus of our group that the method of corralling used in Alaska is more efficient and less stressful on men and reindeer alike, especially when a squeeze chute is employed, than the method used in Sweden. Likewise, with the recent advent of computers as management tools, the record-keeping system used by some Alaskan reindeer herders is superior to the old hand-tally method still employed in Sweden.

Lapp villages may corral their reindeer 20 to 30 times a year to separate neighboring herds, mark fawns, estimate total numbers, and sell reindeer to slaughter facilities. In contrast, Alaskan herders corral their reindeer only twice a year: in June to harvest velvet antler and mark fawns, and between October and January to separate herds and administer inoculations. Velvet antler is not harvested in any Scandinavian country.

During the handlings, maverick reindeer were placed in a separate holding pocket. After all deer in the main corral had been identified and separated, herd owners entered the maverick pocket where these deer were "auctioned." A herder "bid" the minimum price when he roped a maverick in the maverick holding pen. This bid was honored by all other herders through a gentleman's agreement to not raise the initial bid. The minimum price per deer is set by the village council that administers local reindeer matters; the minimum price per deer is well below its market value, so herders are assured a quick profit. Most mavericks were immediately sold to the slaughter facility represented at the corralling.

The money paid by herders for maverick deer goes to the local village council that administers reindeer matters. This money is turned back into the local reindeer industry through the purchase of materials for corrals and fences, payment of helicopter charters, and transport expenses. Village councils are composed of prominent individuals in the surrounding region, many of whom are reindeer herders.

In Sweden, a minimum of 1000 reindeer is needed before a herder can be financially self-sufficient. Herders who own at least 1000 reindeer enjoy a comfortable standard of living that is roughly comparable to that of well-established farmers in rural America. We were impressed with the quality of herder's homes, corrals, and equipment. Most herds are inherited; "new" herders infrequently break into the business. Usually this can only occur if they have considerable experience working for another herder, if they can arrange to borrow reindeer or finance a loan to purchase them, and if they get approval for ownership from the local village council.

In Sweden, reindeer are essentially free from predators. Brown bears (*Ursus arctos*), wolves (*Canis lupus*), and lynx (*Lynx canadensis*) are extremely rare, and wolverines (*Gulo gulo*) are scarce. Ravens (*Corvus corax*) are considered to be the most serious predator of reindeer since they occasionally prey upon newborn fawns. Losses to traffic and trains equal or exceed losses to predators. The Swedish government reimburses herders for reindeer killed by predators or vehicles when herders show proof of such losses.

Slaughter Facilities and Meat Inspection

In 1985, approximately 75,000 reindeer were slaughtered for commercial use. This contributed less than 5 percent of the total meat produced in Sweden. The remaining 95 percent consisted largely of domestic and imported beef and pork, although other game, e.g., moose (*Alces alces*), roe deer (*Capreolus capreolus*), ptarmigan (*Lagopus* spp.), and Capercaillie (*Tetrao urogallus*), are also produced. Roughly 15,000 additional reindeer were killed for personal use by Lapps.

We were able to visit all three types of slaughter facilities used in Sweden: a permanent plant where reindeer were slaughtered and some finished products were processed;

a semipermanent field slaughter facility where reindeer are killed, and the head, legs, skin, and viscera removed; and a mobile slaughter operation that prepared carcasses as semipermanent field slaughter facilities but which traveled to corrals. In addition, some deer are slaughtered for local use by Lapps using methods that are similar to those used by Alaskan herders.

Mobile field slaughter

The mobile operation consisted of a 5- to 10-ton flat-bed truck fitted with an enclosed refrigeration unit and rail system, a small trailer, and several free-standing skinning cradles. The truck and trailer were backed into an opening at the edge of the main corral. Each reindeer was killed with a captive bolt gun, and immediately bled by slitting the throat, as its owner delivered it to the buyer. The carcass was then decapitated and placed belly up in a skinning cradle. The hide was opened from neck to anus and along each leg. Legs were removed below the knees (carpal and tarsal joints), and the hide was loosened almost to the back. The skinning cradle holding the carcass was then slid to a rail located on the back of the truck. A singletree was placed between the deer's hocks and then chained to the rail. When four deer were attached to the rail, they were raised to a hanging position by a hydraulic ram powered by the truck. The hides were pulled free, and all viscera removed. The inside of the carcasses were rinsed with clean, hot water, and the finished carcasses were hung from rails inside the refrigeration unit.

Semipermanent field slaughter facility

The plant that we visited consisted of a large quonset-shaped tent (about 20 × 40 × 15 feet) erected over a cement pad, an elevated killing deck at one end of the tent, a rail system from the killing deck through the inside of the tent, a skinning cradle, and a hide puller. Such facilities have a large (500-1000 gal.) water tank equipped with a heating element, or a mobile tank mounted on a trailer. Semipermanent facilities are established at corrals in areas far from permanent slaughter facilities and are rarely relocated. Although this facility was not processing reindeer the day we visited, we were told that it can slaughter about 150 reindeer per 8-hour day. Reindeer are slaughtered in the same manner that will be described for the permanent facility.

Permanent slaughter plant

We visited one of the two principal slaughter and processing facilities in Sweden (Sameprodukter AB). Located in Harads, it is near the center of Swedish Lapland. Five or six smaller processing plants are located throughout Sweden but none of them slaughter reindeer. Instead, they receive whole carcasses and merely cut and wrap finished products. The plant that we toured mainly handles reindeer, although moose, ptarmigan, and Capercailie are also processed. Since all of these species are available only during the fall and winter, the plant experiences a long period of inactivity during the spring and summer. This imposes a financial hardship that significantly contributed to its bankruptcy several years earlier (following the bankruptcy, Lapps purchased a controlling interest in the plant and reopened it to ensure a market for their reindeer and to provide local jobs). To minimize this problem, the other large slaughter and processing facility in Sweden handles fish and berries during the summer and fall.

Sameprodukter purchased reindeer from individual herders at the corrallings. During corrallings, one holding pen was reserved for deer sold to the slaughter facility. Deer were loaded from this pen onto a large, two-tiered transport truck owned by the slaughter plant. They were taken to the plant and released into large holding pens located behind the facility. Deer spent 1 to 3 days in these pens to cool and settle down. During this time, the deer were given brome hay and fresh snow, but little of the hay was actually eaten.

On the day of slaughter, three or four workers arrived at the plant 3 to 4 hours before the first reindeer were to be handled to clean and set up the equipment. Fifty to one-hundred deer at a time were moved to a small holding pocket that led into the plant. Four to six deer were brought into a knocking room within the plant and killed using a captive bolt gun. They were hung from a rail, bled through the thoracic inlet, and decapitated. Tongues were removed for packaging, and the antlers were taken for sale to Koreans; hard antlers sold for $2 to $4 per pound. Herders even collect shed antlers to sell to Koreans and local craftsmen.

The deer were then placed belly up in a skinning cradle. The hide was opened from neck to anus and along each leg, the ribs were loosened along one side of the sternum with a knife, and the esophagus was tied. The carcass was again hung from the rail system and moved to a hide puller where the front legs were clamped to a stationary bar. A chain was fastened to the front leg skins; as this wound onto a rotating spool, the hide was pulled from the front toward the back of the carcass. The hide puller was used only on bulls and steers; the hide on females and fawns was easily pulled by hand. Hides were banded into bundles, placed on pallets, and sold for $4 to $5 each.

The skinned carcass was moved along the rail system to the area where it was eviscerated. The abdominal wall was split along the midline allowing the viscera to fall into a stainless steel tub for inspection. The diaphragm was cut, and the heart, lungs and liver were removed; surprisingly, these were sold as dog food! The inside of the carcass was flushed with clean, hot water, moved to a section of rail that was attached to a scale, and weighed. A muscle sample (roughly 8 ounces.) was taken from the neck. Tissue samples were sent to Stockholm as soon as the day's slaughter was finished where they were analyzed for radioactive contamination. Sameprodukter corresponded with the laboratory where radioactive contamination was monitored via

Reindeer in a coniferous forest typical of many winter ranges.

Reindeer in a holding pocket during a handling in northern Sweden; the tethered deer were tame and used as decoys to lure the herd into the main corral.

A Sami herder in traditional garb oversees a typical reindeer handling in northern Sweden.

Reindeer mill about in a cloud of steam as Sami reindeer herders wield their ropes.

Lapp herders deliver a reindeer to its holding pocket during a handling in northern Sweden.

computer, so the results of tests were received the next day. The carcass was allowed to air dry, and an inspection seal was applied if the meat was clean and the level of radioactivity did not exceed maximum allowable limits (see below). Carcasses were then frozen whole and unwrapped until needed.

We were impressed with the efficiency and cleanliness of the slaughter operation at this facility. This plant can slaughter up to 46 deer per hour; during a 16-hour day, the plant had recently handled 650 reindeer. Even so, the meat inspector indicated that improvements could be made that would make this 20-year-old plant more efficient. The six-person skinning crew was paid roughly $9.00 per carcass; other employees at the plant (e.g., meat cutters) were paid by the hour. Most employees at the plant appeared to take pride in their work, and we were told that turnover in the work force is low.

In addition to slaughtering reindeer, the facility at Harads also cut and packaged reindeer products. In fact, it is more profitable for this facility to sell finished (cut and wrapped) products than whole or partial carcasses. When an order was received, carcasses were thawed for 1 to 3 days and cut into large sections (ribs, saddles, front legs, and hind quarters). The less desirable portions, e.g. the ribs and shoulders, were boned by hand; this meat was ground into a product resembling burger, or made into *skav* which, when prepared, resembles chipped beef. Bones were sold to a company in Finland that grinds them for dog food. Saddles were sold whole, especially fawn saddles, or cut into chops. Hind quarters were made into roasts and steaks. Some roasts were sent to another plant where they were smoked, but returned to the facility in Harads to be trimmed and wrapped. Products processed in the plant received a separate seal of inspection from the slaughter facility, although both seals were administered by the same inspector.

Meat inspection

In Sweden, inspection standards for reindeer and cattle are identical. Meat inspectors (specially trained veterinarians) conduct an antemortem inspection to ensure that deer to be slaughtered are in good health, and a postmortem inspection to assess general body condition and look for gross abnormalities in the viscera (e.g., extreme parasitism, abscesses, or tumors). The most frequent causes of condemned meat are radioactive contamination and emaciation.

Field-slaughtered reindeer can be distributed throughout Sweden only if a meat inspector is present during the slaughter operation. If a meat inspector is not present, meat can only be marketed locally. Reindeer slaughtered at the permanent facility can be marketed anywhere in the world since the meat inspector is always present. Each meat inspector is assigned to a specific permanent slaughter facility; he is responsible for inspection at all slaughter operations in the field and at the plant that employs his facility.

Marketing Reindeer

Wholesale marketing

We met with the managing director and reindeer purchasing agent of AB O Annerstedt, a wholesale marketing enterprise based in Stockholm. Surprisingly, they indicated that, although reindeer are a common source of protein with a long history of use in northern Sweden, reindeer are not immensely popular in southern, urban portions of the country for several reasons. Reindeer compose less than 5 percent of the total meat produced in Sweden; therefore, its limited availability makes it a specialty item. This precludes broad public exposure and raises prices. This problem of is compounded by the seasonal availability of reindeer. Most importantly though, after the accident at Chernobyl, all game meat produced in Scandinavia is now viewed with suspicion by consumers. As in the New Zealand venison industry, Swedish reindeer distributors consider the United States to be a huge potential market for reindeer products because the low fat content of reindeer appeals to affluent, health-conscious consumers.

The marketing chain for reindeer is more fully developed in Sweden than in Alaska. In Alaska, no clear path exists among suppliers (Inupiat reindeer owners), processors (slaughter and meat processing facilities), wholesalers (distributors), and retailers (outlet establishments). Slaughter is conducted in the field. Processors purchase whole or partial carcasses and produce chops, roasts, stew meat, or sausage, and often retail their own products. With one exception, wholesale distribution of reindeer products has been by-passed in Alaska. Since no inventory of frozen carcasses has been maintained, reindeer have frequently been unavailable when demanded by buyers, and markets for reindeer (beyond local markets) have often been nonexistent during periods favorable for supply. Ultimately, this has frustrated both herd owners and entrepreneurs who have wanted to market reindeer.

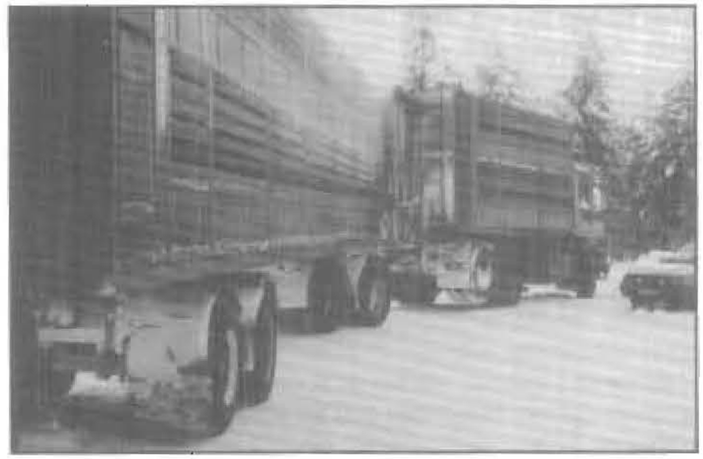
In Sweden, Annerstedt purchases reindeer from the Lapp-owned slaughter facility. Even though Annerstedt does not deal directly with Sami herders, their personnel clearly understand the fundamentals of reindeer husbandry and respect the problems faced by Lapp herders. The slaughter facility benefits herders by providing a constant outlet for reindeer; likewise, since this facility maintains a reserve of frozen carcasses, the supply of reindeer to Annerstedt is reliable and predictable.

Annerstedt conducts marketing research as it relates to their products and aggressively seeks new retail outlets and ways to market reindeer. They actively promote reindeer products in tasteful and effective advertising campaigns directed at retail markets and the public.

Retail marketing

Most of the reindeer products that we saw on the shelf in Stockholm were in specialty shops that were housed in

A Sami woman readies her lasso as reindeer race by in the working pocket of a large corral.



A transport truck used to haul reindeer between summer and winter ranges.

A mobile slaughter operation processing reindeer during a handling in northern Sweden.

The body cavity of a small reindeer is rinsed at a permanent slaughter facility.

A crew boning reindeer meat at Sameprodukter at Harads.

what looked to be a large, old hall. Since individual shops were not enclosed, the hall maintained an open atmosphere that combined characteristics of farmer's markets and cheese shops that are common in urban America. Independent establishments sold loaves of fresh-baked bread, fresh fish, fruits and vegetables, and game meat. At one end of the market, a delicatessen sold beverages and hot meals and provided tables where food purchased at the shops could be eaten. Reindeer steak sold for approximately $6 to $7 per pound. Several types of reindeer sausage and salami were also available at somewhat lower prices.

While in Lapland, we ate at a restaurant that featured reindeer dishes. The chops that we ordered were good, but tasted as if the deer had been excited when slaughtered. We also tried *renskav*, which was excellent! Skav is made from both reindeer and moose (*renskav* and *algskav*, respectively) at the facility in Harads. Since it is made with meat from the front quarters, it complements the production of steaks, chops, and roasts. *Renskav* is the most widely accepted and popular reindeer product produced in Sweden according to Annerstedt and Sameprodukter personnel; it does not require mixing reindeer with beef or pork.

It is noteworthy that we observed tanned reindeer hides (hair on) for sale in the Anchorage International Airport for $120 apiece! Currently, there is no commercial outlet for Alaskan reindeer hides; therefore, these skins probably came from Scandinavia or Canada.

Radioactive Contamination

The nuclear accident that occurred in Chernobyl, U.S.S.R., during April of 1986, imposed long-term, comprehensive effects on the entire Scandinavian reindeer industry. Reindeer and caribou are particularly vulnerable to radioactive contamination because they feed heavily on lichens during winter. Lichens absorb nutrients directly from the atmosphere so tend to concentrate airborne pollutants. Reindeer primarily acquire radioactive pollutants through lichens, not from direct exposure to radiation.

In Sweden, the maximum allowable level of contamination in fresh muscle tissue is 300 bq/kg for Cesium-137, and 400 bq/kg for Cesium-137 and -134 combined. In comparison, the maximum allowable level of Cesium-137 in Norway is 6000 bq/kg, while in Finland it is 1000 bq/kg. The extreme disparity in maximum allowable levels of radioactivity among nations suggests that biologically significant levels of contamination still need to be determined.

Although all reindeer ranges in Sweden received some radioactive fallout, primarily as Cesium-137 and -134, the distribution of contaminants was not uniform. Variations in slope and the moisture content of lichens, as well as the geographic pattern of precipitation soon after the Chernobyl accident, caused some areas to receive more contamination than others. In the least contaminated areas of Sweden, more than 60 percent of all reindeer exceed the maximum allowable level of radioactive contamination for human foods; in ranges highly contaminated, 85- to 100-percent of all reindeer exceed these limits. For example, of 24 reindeer purchased by Sameprodukter from an area north of Harads and slaughtered on 12 November 1986, only one was under the 300 bq/kg limit (290 bq/kg); the mean level of radiation was 685 bq/kg (SD 155), and the highest level was 1066 bq/kg. Of 175 reindeer purchased on 20 September 1986, none were under 300 bq/kg limit; the mean level of contamination was 7395 bq/kg (SD 2780), with a range of 2349 to 23673 bq/kg. In comparison, we found the mean level of radioactivity for 13 reindeer from the Seward Peninsula (Nome and Wales) tested during December 1986 to be 63 bq/kg (SD 23). A small sample of lichens ($n^{5}4$) collected near Nome had a mean value of 124 bq/kg (SD 44), while two moose had an average of 17 bq/kg (SD 8.5).

No direct mortality of adult reindeer or fawns was observed in Swedish reindeer herds during the nine months following Chernobyl. Such impacts are not anticipated, though no-one knows what the long-term effects of such widespread, intense contamination will be, especially when combined with range problems resulting from overpopulation by reindeer.

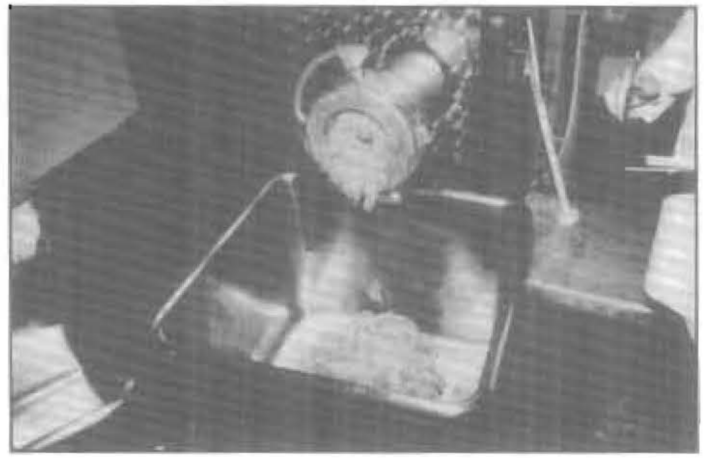
The principal impacts of radioactive contamination on the Swedish reindeer industry have been on marketing and on aspects of the Sami culture itself. Much of the marketing problem stems from the arbitrarily low maximum level of contamination Swedish officials have established for human foods. There is some speculation that, even before the Chernobyl disaster occurred, many Swedish reindeer exceeded the 300 bq/kg limit, as a result of fallout from tests of nuclear explosives during the 1960s. Until Chernobyl, however, reindeer meat was not monitored for radioactive contamination. Research is now being conducted to determine the relationship between the level of radioactive contamination in foods and the threat to human health. The Swedish reindeer industry is hoping that tolerable levels of contamination will be elevated to levels comparable to Norway or even Finland (see above).

Since Annerstedt has invested in the development and promotion of reindeer products in Sweden, they are concerned about the effects that radioactive contamination of reindeer will have on public acceptance of reindeer products. Annerstedt would like to purchase reindeer from Alaska and promote them as free from contamination to maintain existing markets. However, initial queries exploring the cost of shipping frozen reindeer carcasses from Nome to Stockholm do not look promising.

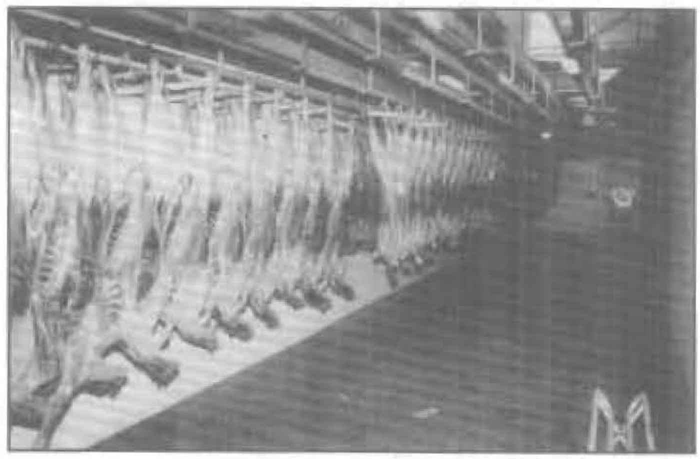
Sami herders are not suffering financially as a result of Chernobyl since the Swedish government is purchasing all contaminated carcasses and disposing of them at fur farms. In fact, the government actually raised the price paid for contaminated meat above that previously paid by slaughter facilities for uncontaminated meat! Subsequently, Sameprodukter voluntarily raised its price accordingly.

Reindeer carcasses drying before freezing; subcutaneous fat is apparent on only one carcass.

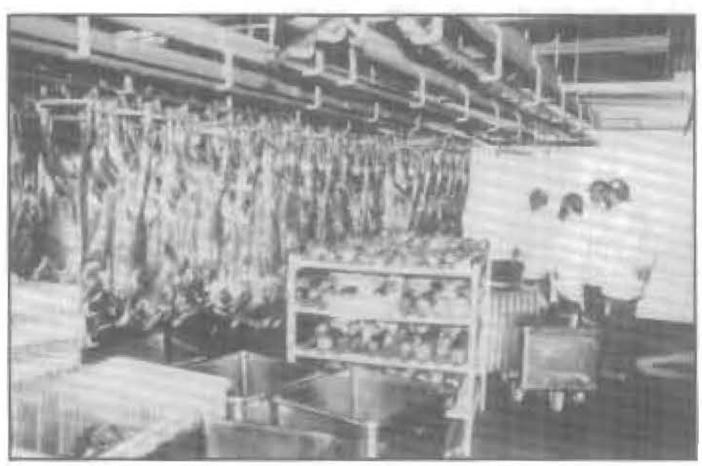
Hemorrhaging evident on the second carcass from the left probably occurred during transport via truck.



Meat trimmings and low-quality cuts are ground into burger.



Uncontaminated reindeer carcasses thaw before being processed at Sameprodukter at Harads.



Reindeer carcasses drying before being frozen with carts of finished products in the foreground at Sameprodukter.

Lapps are being affected by the contamination problem, as it specifically relates to reindeer, in two ways: they are afraid to eat their own reindeer, a source of protein that figures prominently in their traditional diet, so must buy alternative types of meat; also, they are dissatisfied knowing their reindeer are merely being disposed of as animal food. In the past, Lapps have taken pride in a product that they considered worthwhile. At least one young herder that we talked to indicated he was considering getting out of the reindeer business largely because it is not satisfying to produce "mink food."

Food supplements high in potassium are being tested to see whether they reduce levels of radioactivity in reindeer tissue. In addition, experiments are being conducted to see if levels of contamination in reindeer can be reduced by providing full rations of uncontaminated foods for a short period. The slaughter facility we visited also intends to slaughter some reindeer during late summer and early fall of 1987. During summer, reindeer eat proportionately more grasses and sedges than lichens; therefore, the slaughter facility hopes that reindeer will have proportionately lower levels of contamination at this time.

Conclusions

1. Mechanized transport, both on- and off-road, has brought major changes to Sami herding practices. While reducing the workload of herders, mechanization has also introduced new problems to an old industry. Government subsidies confound determining optimum levels of investment in such means of transport from a purely economic approach.

2. Field slaughter is a practical and useful alternative to slaughter using permanent facilities if done in a proper manner.

3. Permanent slaughter facilities a) ensure a high standard of quality and cleanliness while slaughtering and processing reindeer, and b) maintain an inventory of frozen reindeer carcasses which provides a steady outlet for carcasses from herders and which serves as a dependable source of reindeer for distributors (i.e., they damp oscillations in supply and demand for reindeer).

4. Wholesale distributors promote reindeer products and actively explore new ways to market them.

5. A nuclear tragedy the magnitude of Chernobyl could have disastrous consequences for the Alaskan reindeer industry given the low probability of subsidization by state or federal governments. Initially, this would restrict marketability more than increase mortality or diminish productivity of reindeer.

6. AB O Annerstedt is interested in purchasing reindeer meat from Alaska. Inspection requirements and logistics for a sample shipment of meat are currently being investigated.□

Acknowledgments

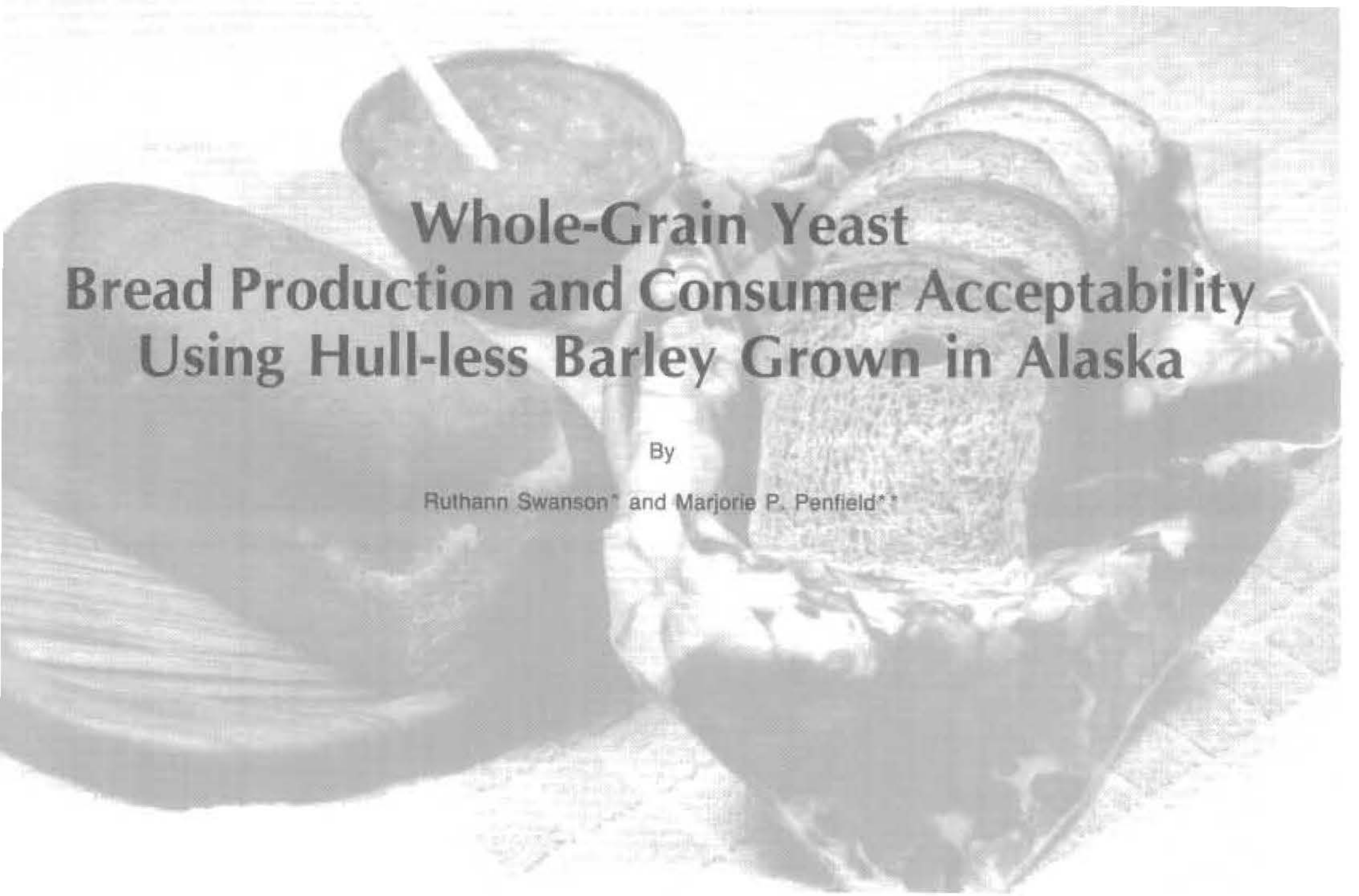
We would like to thank AB O Annerstedt for assistance in arranging this trip, especially Olle Asplund who proved to be an excellent host, reliable interpreter, and interesting conversationalist. We are also indebted to all of the Sameprodukter personnel who answered our many questions, showed us their facility, and introduced us to the Sami herders. The success of this trip stems largely from the generosity of these fine people. We would also like to thank Dr. D.F. Holleman for conducting the radioassays of tissue samples collected on the Seward Peninsula.

Reindeer carcasses contaminated with radioactive fallout from Chernobyl; contaminated carcasses have been sprayed with purple dye.

Crates of frozen reindeer meat contaminated with radioactive isotopes await distribution to Swedish fur farms.

Equipment used to produce renskav, *a reindeer product popular throughout Sweden.*

Reindeer products on display in a Stockholm meat market.



Whole-Grain Yeast Bread Production and Consumer Acceptability Using Hull-less Barley Grown in Alaska

By

Ruthann Swanson* and Marjorie P. Penfield**

Barley, one of the world's oldest grains, is produced commercially in Alaska and is available for use in food products. Unlike many other barley-producing areas, Alaska's farmers produce hull-less barley as well as covered barley. Although covered barley is preferred for making beer, hull-less barley is better suited for use in other human food products (Bhatty 1986). Its lower fiber content and improved performance as a food product ingredient makes the use of this hull-less grain a good way to capitalize on the "grown in Alaska" theme that is increasingly important to Alaskans and tourists.

Recent trends in bread sales indicate that American consumers are more and more frequently selecting variety breads in stores for home use (Raskin 1980, Milling and Baking News 1980) and in restaurants (Rich Products, Inc., 1980, Wheat Flour Institute 1980). Any bread other than white loaf bread is considered a variety bread. Whole-wheat bread is the most popular of these, although new variety breads continue to be developed to capitalize on their increasing sales appeal (Raskin 1980). Consumers report that nutrition, taste, and texture are important factors in their bread choices (Milling and Baking News 1980). Because barley has a positive nutritional and healthful image among consumers, products containing barley have an increased sales appeal (Moore 1980). A formula for the successful production of a 20 percent whole-grain Alaskan barley bread has been developed. Consumers like the appearance, texture, and flavor of this bread made with Alaskan grown barley.

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Formula and Production

A whole-grain barley bread formula (table 1) was developed for production using the straight-dough method that is common in smaller bakeshops (Ponte 1981). The steps in this procedure are outlined in Table 2. The straight-dough procedure is also the method commonly used in home production. All of the ingredients in this formula are commonly used in commercial bread production; the formula levels have been adjusted to enhance the barley bread's characteristics and flavor (Dubois 1978). Therefore, special note should be made of the ingredients and dough characteristics if bakers are going to produce this bread successfully.

The 'Thual' hull-less barley, which was used to test the formula, was produced in Delta during the 1983 growing

Table 1. Alaskan whole-grain barley bread formula.

Ingredient	Amount (Bakers percent[1])	Method
Bread flour	50.00	Add flours to mixer bowl; combine flours.
Whole-wheat flour	30.00	
Whole-grain barley flour	20.00	
Yeast (dry)	3.00	Soften yeast in warm water.
Water (108°F)	3.81	
Wheat gluten	2.50	Place remaining dry ingredients and shortening in mixer bowl with flours; add softened yeast.
Malt flour	0.25	
Sugar	7.00	
Sodium stearoyl lactylate	0.50	
Salt	2.00	
Shortening	3.00	
Non-fat dried milk solids	3.00	
Water (74-75°F)	60.97	Disperse yeast food + oxidants in a portion of the water; add water containing yeast food + oxidants and enough water to make a dough.[4]
Yeast food + oxidants[2]	66[3]	

Instructions:
1. Turn into a lightly greased bowl. Cover. Let rise at 93°F and 86 to 90 percent relative humidity until double in bulk.
2. Punch down and allow to undergo an intermediate proof at room temperature for 12 to 15 minutes.
3. Scale and mold tightly, pan and proof loaves at 93°F and a relative humidity of 86 to 90 percent until the dough height is slightly above the top of the pan.
4. Bake proofed loaves at 425°F until brown and bread sounds hollow when tapped.

[1]Bakers percent: all ingredients are measured as percent of total flour weight; flour weight = 100 percent.
[2]Yeast food + oxidant system used was Carbrea® -Tabs, manufactured by Cain Food Industries, Inc., Dallas, TX.
[3]Measured in parts per million.
[4]If yeast food + oxidants are omitted, just add enough water to make a dough.

Table 2. Straight-dough procedure.

Step	Definition
Mixing	Dry and liquid ingredients combined.
Dough development	Cohesive dough formed; kneading.
Fermentation	Yeast produced CO_2; dough doubled in bulk.
Punching	Dough reduced to original bulk; O_2 incorporated, excess CO_2 removed.
Rounding	Skin formed on dough surface; CO_2 prevented from escaping.
Intermediate proof	Dough rested at room temperature; cohesive proteins relaxed.
Scaling	Dough divided into units to be baked.
Molding	Dough units shaped into loaves or rolls.
Panning	Dough loaves or rolls placed on baking pans.
Proofing	Panned dough units allowed to double in bulk.
Baking	Dough units transformed to bread/rolls; bread was done when tapping produced a hollow sound.

Table 3. Particle size distribution of Thual barley flour.[1]

Screen analysis	Flour (%)[2]
On US #20 sieve	0.18
On US #40 sieve	9.44
On US #100 sieve	51.14
Through US #100 sieve	39.23

[1]Determined according to Code of Federal Regulations (FDA 1983) except that a mechanical shaker was used.
[2]Particle size meets industry specifications for regular barley flour (Nelson, K., 1985, personal communication. Minnesota Grain Pearling Co., Cannon Falls, Minn.)

Table 4. Proximate analysis for Thual hull-less barley flour on a 14 percent moisture basis.[1]

Flour component	%
Protein	10.50 ± 0.15[2]
Fat	2.28 ± 0.76[2]
Crude fiber	1.32 ± 0.12[2]
Ash	2.26 ± 0.40[2]
Carbohydrate	69.64[3]

[1]Determined using AOAC methods (AOAC 1980).
[2]Mean ± standard deviation, where n = 3.
[3]Determined by difference.

season. The grain was ground to produce a whole-grain barley flour. Because barley flour tends to absorb water more slowly than does whole-wheat flour (Cunningham et al. 1955), the barley flour was ground finer than is typical for whole-wheat flour. Use of a finer flour increased the rate at which water was absorbed and eliminated a prolonged dough development period. Particle size distribution of the whole-grain barley flour is reported in Table 3.

Values for protein, fat, crude fiber, ash, and carbohydrates, all important indicators of barley flour quality, are reported in Table 4. The fat, crude fiber, and ash values approximated the levels found in whole-wheat flour. Protein content of Thual barley produced in the Delta Junction area of interior Alaska ranges from approximately 11 to 14 percent (Husby 1987, Ulz, personal communication[1] 1987); protein content of the Thual barley that was grown during the 1983 growing season was 10.5 percent. An increase in protein is associated with a corresponding

[1]K. Ulz, Kobuk Feed and Fuel, Fairbanks, Alaska.

decrease in carbohydrates, mainly starch (Swanson 1986). Because barley protein is known to be of poorer quality than is wheat protein (Cunningham et al. 1955), several formula ingredients were included to enhance the bread characteristics that consumers find desirable. The bread flour that was used in this formula was a strong flour (12 percent protein). Strong bread flours are typically used to achieve good results when variety breads are made. Use of a strong wheat flour overcomes some of the detrimental effects of barley flour incorporation (Dubois 1978). Wheat gluten also was incorporated to increase the strength of the protein, resulting in improved gas retention and a desirable crumb texture (Dubois 1978). Sodium stearoyl lactylate (SSL) served a similar role. It complexes with the protein (Tsen et al. 1971) and starch (Ghiasi et al. 1982) thus increasing volume and producing a softer crumb.

Amylase enzymes, while important in all breads, are especially important in variety breads (Himmelstein 1985). Amylase enzymes are necessary to convert the flour starch to sugar. This flour sugar serves as food for the yeast throughout fermentation and proofing, thereby improving loaf volume. Barley flour tends to be low in amylase (Rubenthaler et al. 1965), therefore malt flour was included as an ingredient to provide the necessary enzymes.

The buttermilk solids used in testing this formula were an extremely important flavor component. Use of high-temperature dried milk solids eliminates the slight negative effect of milk on loaf volume (Swanson et al. 1966). A combination yeast food-oxidant system also was used in this bread. The oxidants serve to strengthen the protein complex in the bread throughout mixing, fermentation, proofing, and baking. The yeast food provides nutrients in a form that can be readily used by the yeast, enhancing gas production by the yeast and resulting in increased loaf volume (Dubois 1978). Although this yeast food-oxidant system improved the quality of the whole-grain bread, it may be omitted.

Dough development time was slightly increased when barley flour was an ingredient. This increase in development time was related to the decreased rate at which barley flour absorbed water. The appearance and feel of the developed barley flour dough differed from a whole-wheat dough. A properly developed barley dough lacked a glossy sheen and felt dry to the touch. The addition of water to "improve" these characteristics resulted in a wet, sticky dough that was difficult to handle during molding.

Holes in the bread crumb, a common characteristic of whole-grain variety breads, resulted from improper molding. To avoid large holes in the bread crumb, tight molding was necessary. As the size of the bread loaf increased, successful production required more careful attention to the molding procedure. The holes were not a problem when 1.75-ounce rolls or small bread loaves of 11.5 ounces that may be served at individual tables were made. Use of Thual barley flour with higher protein levels, approximately 13 to 14 percent, also helped to eliminate this problem (Swanson 1986).

Fermentation and proofing times tended to be slightly less for barley doughs than was typical for wheat doughs. The bread froze and reheated well. However, staling, which is always more rapid in variety breads than it is in white breads, occurred when the bread was held at room temperature for an extended period of time. The bread should be held covered in a warm and humid environment (Wheat Flour Institute 1980).

Consumer Acceptability

Overall acceptability of both the 20 percent Alaskan Thual barley bread and a whole-wheat bread (table 5) was evaluated by 48 consumers on a 6-point scale (Amerine et al. 1965). These consumers were regular eaters of bread. The overall acceptability rating for the barley bread was greater than mid-point on the scale for appearance, texture, and flavor. The consumers liked the barley bread and whole-wheat bread equally.

Table 5. Overall acceptability of whole-wheat and Thual whole-grain barley bread.[1]

	Bread type	
Overall acceptability	Thual barley	Whole-wheat
Appearance	4.8a[2]	5.1a
Texture	4.1a	4.2a
Flavor	4.2a	4.3a

[1] 1 = not acceptable and 6 = very acceptable.
[2] n = 48; means in a row followed by like letters did not differ according to Student's t-test ($\alpha = 0.05$).

Costs

An added benefit when using Thual whole-grain barley flour was a cost savings for ingredients. Since the cost of barley flour was 37 percent less than that of wheat flour, incorporation of 20 percent whole-grain Thual barley flour resulted in a significant savings. The price quotes were obtained in Fairbanks, Alaska, in the fall of 1986. An average price was used to calculate savings when more than one business sold the ingredient.

Conclusion

This formula for a whole-grain Alaskan barley bread overcame most of the problems asociated with incorporation of barley flour into a yeast bread. Consumers liked its appearance, texture, and flavor. Recent marketing surveys have revealed that restaurant patrons want a greater variety of breads. These patrons also prefer breads that are warm when served and are baked on the premises (Wheat Flour Institute 1980). Breads made with Alaska-produced Thual hull-less barley flour appear to have a good potential in this market. □

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Observations of Effects on Agricultural Soils Of the Artificial Enhancement of Snowmelt In Interior Alaska

By

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Abstract

A study of the effects of dusting the snowpack of small-scale agricultural plots in interior Alaska with albedo-reducing materials to accelerate snowmelt was undertaken during the spring breakup of 1982. The main objectives of this work were (1) to quantify the increased growing season afforded by the earlier loss of snow cover and (2) to determine the amount of moisture infiltrated into the soil of a prematurely thawed plot. Preliminary work over several seasons prior to 1982 by one of the authors (JGH) as well as the work of others (e.g., Austin and Nielson 1977; Cartee et al. 1986; Slaughter 1969) on the use of albedo-reducing materials in enhancing the rate of snow-melt suggested that the timing and duration of the breakup can be altered to produce results more favorable to growth of crops at high latitudes. This work formed the basis of the more comprehensive study described here. After completion of the field study and submission of this paper, a report by B.M. Bensin (1947) entitled "Coal dust for Alaskan gardens" was called to our attention. This copyrighted paper describes early work by the author similar to ours but the study lacked comprehensive soil temperature and moisture and other measurements.

Different types of albedo-reducing materials, delivery systems, application rates, and application timing were investigated. Urea coated with lampblack and applied at a rate of 200 pounds per acre with a gasoline-driven blower mounted on a back pack gave the best results. The most favorable time for dusting was found to be strongly influenced by fresh snow falling during the last few weeks preceding breakup. Later applications, 2 to 3 weeks before normal breakup, produced the earliest melt. These tests were conducted on flat and sloping land tilled by several methods. Snowfall, soil moisture, and snow and soil temperatures were monitored throughout the winter and breakup period by means of thermistor, neutron probe, and gravimetric sample measurements. Albedo and snow surface temperature measurements were made with radiometers before and after dusting and during breakup. Soil temperature and moisture measurements as well as thaw depth measurements were continued for several days after complete melt. Although these data provide a sufficient basis for a comprehensive modeling of the heat and moisture transport in the soil, this has not yet been undertaken. However, further analysis is not needed to conclude that tillage could be started at least five days earlier on the dusted plots than on adjacent control areas and that moisture was enhanced by as much as 15 percent in the first 8 inches (~ 20 cm) of soil over the control areas for the breakup of 1982.

Introduction

There are nearly 20 million acres (8.1×10^6 ha) of virgin lands in interior Alaska identified as having agricultural potential (Lewis and Wooding 1978). However, the severe winter and variable summer conditions of interior Alaska make agriculture an especially risky venture. The lands of interior Alaska are under a semiarid continental climate regime with average annual precipitation in the Fairbanks region about 12 inches (~ 30 cm). Perhaps as much as 50 percent of this is snow (Hartman and Johnson 1978). The growing season from last to first frost is intense, but brief: about 110 days, with long hours of sunlight and twilight. In some years, however, late or early frosts can shorten this nominal growing season for some crops.

Although climatic conditions are adverse, research has been and continues to be done to promote successful

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agriculture in Alaska and other high-latitude regions. Such improvements fall under two broad categories: biological and technological. Development of cold-adapted plant varieties belongs to the biological category, while artificially heating the soil under horticultural crops and trapping solar radiation under clear plastic are examples of technologies that have proved successful under Alaskan conditions. Although it is not well documented in an Alaskan agricultural context, another technique that falls under the latter category is accelerating snow melt at spring breakup with albedo-reducing materials (Austin and Nielson 1977, Slaughter 1969). Such a strategy may extend the growing season while enhancing moisture infiltration of the soil.

Causing the snowpack to disappear at an earlier time than normal by darkening its surface with albedo-reducing materials should permit an earlier dry down so that field operations may commence earlier. Preliminary work done by one of us (J.G.H.). suggested that the irregular surface of the snowpack largely immobilizes the meltwater, particularly at night. This allows greater infiltration of the moisture into the soil.

Management of the snowpack may lead to other innovations in cultivation techniques which now require the soil to be relatively dry for conventional spring tillage practices. Overwintering crops such as winter wheat can benefit directly from the additional growth period possible with early snowpack removal; and early snow removal may lessen damage from snow mold (Austin and Nielson 1977, Cartee et al. 1986, McBeath 1984). For spring-planted cereal crops, however, it would be ideal if field operations normally undertaken just after spring breakup could be replaced with premelt cultural innovations to take full advantage of the growing season.

In the interest of enhancing the chances for success of agriculture in Alaska and to put the technique of snowpack dusting on a firm scientific basis, our group undertook a detailed study of the physical parameters associated with accelerated melt compared with normal melt of snowpacks on small agricultural plots at the University of Alaska-Fairbanks, Agricultural and Forestry Experiment Station (UAF-AFES). Soil and snowpack temperature and moisture, solar radiation, and other parameters were monitored through the 1981-82 winter from initial snowfall through the melting and dry-down periods. Our primary objectives in making these measurements were to determine for treated plots (1) how much time could be gained in the duration of the growing season and (2) the increase in moisture that infiltrates the soil over that of untreated plots. Secondary objectives include investigations of application techniques, rates and types of materials to use, and modeling of the seasonal heat and moisture transport in the soil.

Experimental Background and Methods

There is a high degree of solar insolation during spring breakup in interior Alaska with the greatest number of cloud-free days occurring in April (Hartman and Johnson 1978). Reflection of the incident (or incoming) radiation delays breakup of the snowpack, but the increasing radiation, warmer air and even rainfall at this time cause considerable alteration of the snowpack surface leading to decreased albedo. Although albedo may decrease fairly rapidly, the cold ground temperatures and its thermal mass tend to retard the melt. Generally, if initial weather conditions are favorable, i.e., warm air temperature and high insolation, breakup proceeds rapidly, and much of the melt water is lost in runoff because the near-surface frozen soil is still relatively impervious.

Observations of the breakup of 1982 and those of earlier and subsequent years, show that use of a material that darkens the snowpack, causing absorption of solar radiation initially leads to a physical alteration of the surface of the snowpack, rapid melting of the snow in irregular jagged patches, and early exposure of the soil surface in patches that are covered with meltwater. Such premature (or early) meltwater usually refreezes at night as a result of lower temperatures and radiation cooling. For a normally melting snowpack, the melting process accelerates when the overnight low temperatures exceed the freezing temperature by several degrees.

Figure 1 is a photograph taken during the spring breakup of 1979 of small plots dusted with coal ash in a preliminary, unfunded study. The 1979 breakup was ideal from the standpoint of temperature and solar radiation and led to the dramatic difference in the time of soil exposure that may be inferred from the photograph.

The initial pooling of meltwater associated with artificially accelerated snow melt in areas free of snow or even underneath a thin snowpack allows the water to act as a heat reservoir that helps thaw the underlying soil, even though the water surface may refreeze at night. Thus, not only will the snowpack melt earlier when dusted with albedo-reducing material, but it should allow greater retention of snowpack moisture in the thawed soil.

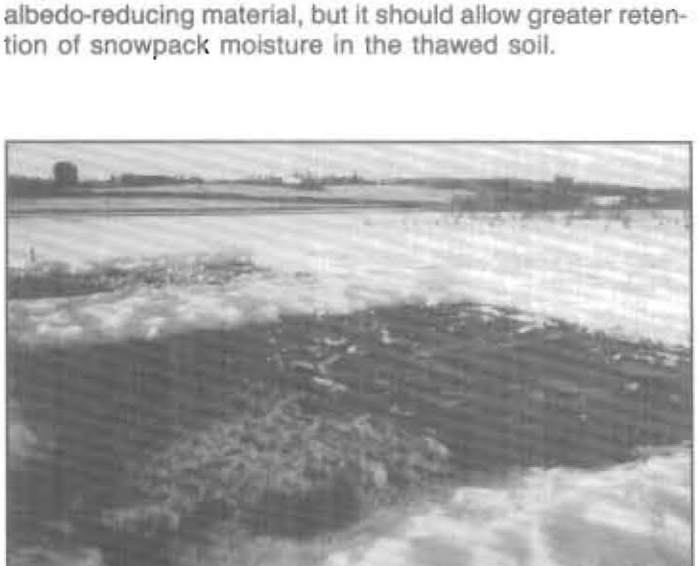

Figure 1. Examples of melt accelerated by coal ash 12 April 1979. When the soil was fully exposed, some 16 inches of snow remained in the surrounding area, requiring 12 additional days to melt.

To quantify the snow melt under disturbed and undisturbed conditions, an area of the University of Alaska-Fairbanks AFES farmland was selected for this study. This area was subdivided into five adjacent, circular plots 56 feet in diameter and instrumented for measurements of temperature, moisture and other parameters. Temperature measurements were made periodically using strings of thermistors extending about 8 inches up into the snowpack and down about 20 inches into the soil to provide profiles through the period of study from late fall 1981 to late spring 1982. Snowpack albedo and surface temperature were measured with radiometers. A combination of neutron probe and gravimetric measurements were made to produce moisture profiles for the soil periodically through the study period. Samples of snow and soil for the gravimetric measurements were taken by digging pits in the snow and soil and coring laterally or from the surface through the winter, through the melt period, and several days after breakup. Thawing was also investigated by probing with a rod to the depth that soil was bonded with ice. Additional details of these measurements are discussed below.

Dusting

Beginning in the last week of March 1982, the first of the five instrumented plots was dusted with a mixture of urea and lampblack using a portable, back-pack mounted blower. The other plots were subsequently dusted after intervals of several days until the final plot was treated in mid-April. Under natural melt conditions, the farmland area of the UAF-AFES is usually free of snow by the last week in April. Some light snow fell after the first two plots were treated. This snowfall permitted us to observe the effect of new snow over a disturbed plot and evaluate the effects of a subsequent disturbance on melt rate and soil moisture. Earlier work (Holty, unpublished) with dusted plots had shown that the earliest application is not necessarily the most efficient in terms of accelerated melt since a later application is much less vulnerable to a new snowfall.

Materials used in darkening trials were sea soil, coal ash, lampblack, and a mixture of lampblack and prilled fertilizer. Sea soil, a brown, dry, rough-shredded, organic by-product of kelp refining, disperses well by blower, is light-weight and requires only a fraction of an ounce per square foot to achieve a significant albedo change. Coal fly ash, a waste product of the UAF heating plant is very dark in color and granular in nature. It requires screening to achieve a uniform particle size and does not flow smoothly from a feed hopper. Coal ash on snow makes a dramatic change in albedo, but required more ash per square foot than did the sea soil for a significant albedo change. Crushing to a fine powder would be expected to reduce the amount required. Lampblack (carbon), on the other hand, can be dispersed as an extremely fine particle dust and theoretically would be the optimum dark, yet lightweight, absorptive material. Indeed, about a quarter of an ounce of this material theoretically has a surface area equivalent to an acre. However, lampblack is cohesive and does not disperse well when used alone; further, it is subject to drifting in the slightest breeze. We found that mixing the lampblack with prilled urea fertilizer solved this problem and also had the added benefit of producing droplets of melted snow on the surface of which the fine carbon particles become dispersed, thus providing for maximum solar absorption. The mixing ratio per acre used in these trials was between 1 and 2 pounds of lampblack to 200 pounds of urea per acre.

Figure 2 shows samples of the urea prill/lampblack mixture placed on a piece of paper. Note that there is little if any smudging or roll marks on the paper from the lampblack indicating the urea and the lampblack strongly adhere to one another. Comparison of Figure 3 with Figure 4 indicates how rapidly the urea/lampblack mixture can alter the surface of snow when there is sufficient solar radiation. These photographs were taken between 10 and 11 AM AST 29 March 1982 some 25 minutes apart, with Figure 3 taken 12.5 minutes after application of the mixture. Note that some of the prills have penetrated the snow cover, causing a physical alteration of the surface. This physical change in the snow surface, together with the absorption of solar radiation by the lampblack-covered prill, subsequent melting of snow in contact with each prill, dissolution of the urea in the water thus formed, and dispersal of the lampblack, causes a rapid decrease in albedo as may be inferred from Figures 3 and 4. Direct albedo measurements made with a hand-held radiometer confirmed the more subjective evidence of darkening as shown by the photographs.

Observations of Accelerated Melt

Small applications of lampblack made a change in albedo of 5 to 12 percent. On the other hand, the albedos for plots on which fertilizer/lampblack mixtures were applied in-

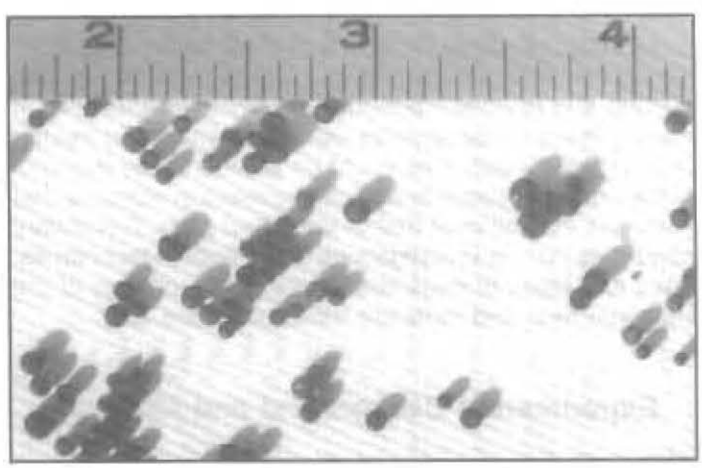

Figure 2. These samples of prills covered with lampblack show no smearing or roll marks from the coating on the white paper.

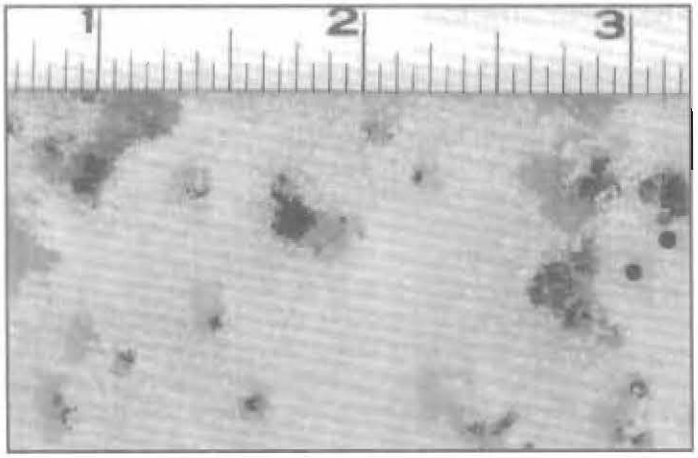

Figure 3. Snow darkened with lampblack/urea mixture 12.5 minutes after application.

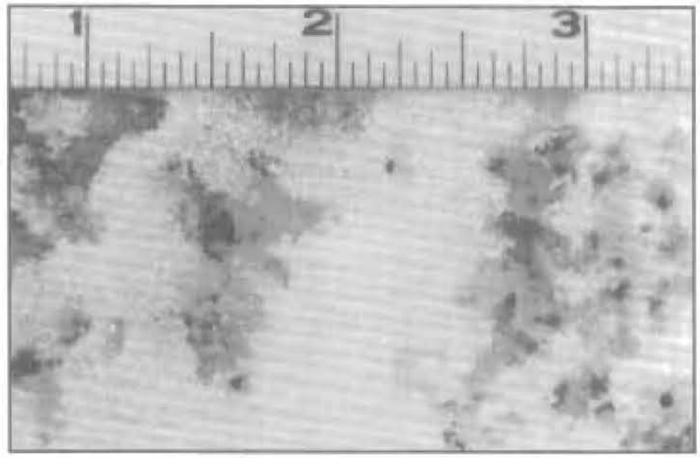

Figure 4. Same as Figure 3, 25 minutes later (total lapsed time from initial dusting: 37 minutes).

creased considerably and ranged from 20 to 30 percent. A few days after application the difference in albedo between the untreated and treated snow reached 35 percent, but appeared to drop from this as the untreated snow rapidly changed in structure. The coal ash was applied at more than one application rate, the heaviest amount made a difference in albedo of 40 percent, but this lessened with time as well until exposure of soil occurred. When the soil became exposed, the difference in albedo rose further and reached 48 to 58 percent. This range of albedo corresponds to an eight- to tenfold increase in the absorption of radiation by the soil over that by the undisturbed snow.

Figures 5 and 6 show one of the plots dusted with the lampblack/fertilizer mixture near the beginning and end of the melt period of 1982. Although the difference between the treated plot and adjacent untreated areas is not as dramatic as in the 1979 test (fig. 1), it is apparent that the melt rate was substantially greater on the treated plot.

The earliest date of complete melt for each application was observed. Reduction in snow depth with time prior to the exposure of soil was recorded. As soon as the soil was first exposed, depth measurements to the thaw/freeze interface were made by probing to the frozen layer with a bronze rod. The thaw penetrated rapidly, and the surface soil moisture dropped below saturation due to deepening of the thaw zone as well as to evaporative losses; the earliest date at which the soil at each trial plot could support traffic and tillage was recorded. All four plots that had been dusted were free of snow by 28 April 1982, while about 5.5 inches of snow remained on the untreated plots.

Soil Moisture

Soil moisture was observed at the sites soon after standing water had disappeared indicating that the surface soil

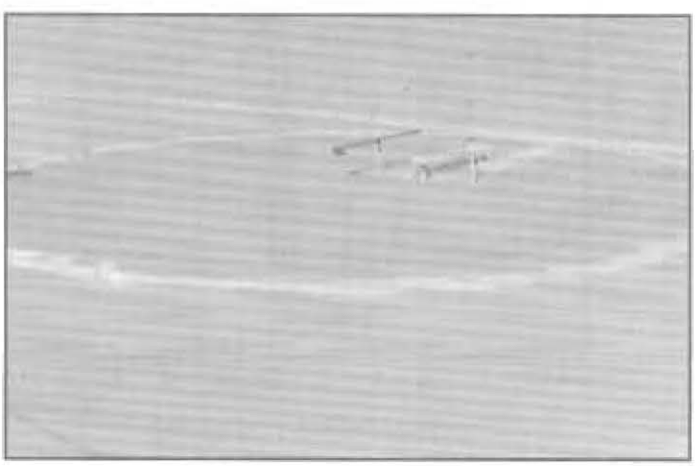

Figure 5. Example of fertilizer/lampblack-darkened plot, late March 1982.

Figure 6. Same plot as Figure 5 shortly before complete melt, late April 1982.

had absorbed all the moisture available from the snow melt. This was done when the soil surface changed from a glossy to a flat appearance. Moisture was measured both by neutron probe and gravimetric sampling throughout this period. Gravimetric sampling included use of a small hand vacuum pump and coring tube to extract the saturated soil from the surface as well as digging pits and taking samples horizontally in the pit wall. Figure 7 shows examples of two moisture profiles on one of the treated plots down to a depth of about 110 inches just before (21 April 1982), at (28 April 1982), and just after melt (2 May 1982) when the soil surface had dried sufficiently to be walked on. The upper 50 inches of values include both gravimetric and neutron probe data. There is a clear indication that moisture had infiltrated the soil with an increase of as much as 15 percent in volume within the first 8 inches.

It should be noted (fig. 7) that the relatively high values of moisture found at about 39 inches were not observed in moisture profiles made in fall 1981 indicating moisture accumulated in this zone through the winter.

The earliest date on which tillage could be done can be determined without sophisticated instrumentation or procedure. The soil moisture conditions changed so quickly during this initial thaw period that there was a very clear demarcation from one day to the next in the physical conditions of the soil which were readily observed by eye and by probing to the thaw/freeze interface. Minimal compaction occurred within a day of the time when earliest tillage could be performed. This was especially evident for plots on which the snow cover was melted artificially. In comparison, the soil of adjacent, untreated plots was still extremely wet. A clear indicator of the time at which traffic can be borne is when a footprint no longer indents the soil surface. A soil smear or sticking test reflects, to a degree, problems to be encountered in tillage or if wet clods would be formed. The silt-loam of the Fairbanks area crumbles easily when past the sticking phase. Under normal weather conditions, there may be only one day between, for example, the time when the soil sticks to a disc blade and the time when tillage can be done effectively.

Soil Temperature

Soil temperature profiles during spring melt respond directly to loss of depth of snow cover. Figure 8 shows a set of temperature profiles on the same plot as Figure 7 taken from six weeks before to a few days after complete melt. The slope of the temperature profile to a depth of about 20 inches changed steadily from a negative to a positive one, so that, when the snow was still covering the soil (2 to 4 inches), the surface soil temperature was at or very near the freezing point. In the soil the temperature decreased with soil depth to at least 20 inches. As soon as the snow melted and the soil was fully exposed, the surface soil temperature rose quickly, but the time it took for the soil temperature to rise above freezing increased with increasing depth.

Thaw Penetration

On each of the five instrumented sites, the depth of thaw was observed regularly after complete melt by probing with a metal rod to the layer which was still frozen. This was continued until the thaw depth was over 20 inches, where it became more difficult to determine a precise depth to the frozen layer. These observations, graphed with time (fig. 9) give an indication of the nature of the thaw penetration. Over a short duration after soil exposure, the thaw vs. time appears very linear. If anything, the deviation from this is the opposite of what might be predicted (given a uniform moisture content and constant thermal properties), as the rate of thaw per day appears to increase with time after

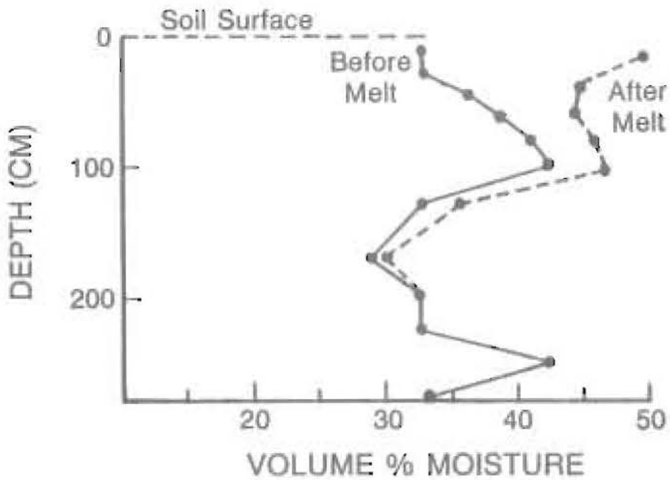

Figure 7. Soil moisture vs. depth just prior to breakup and shortly after breakup.

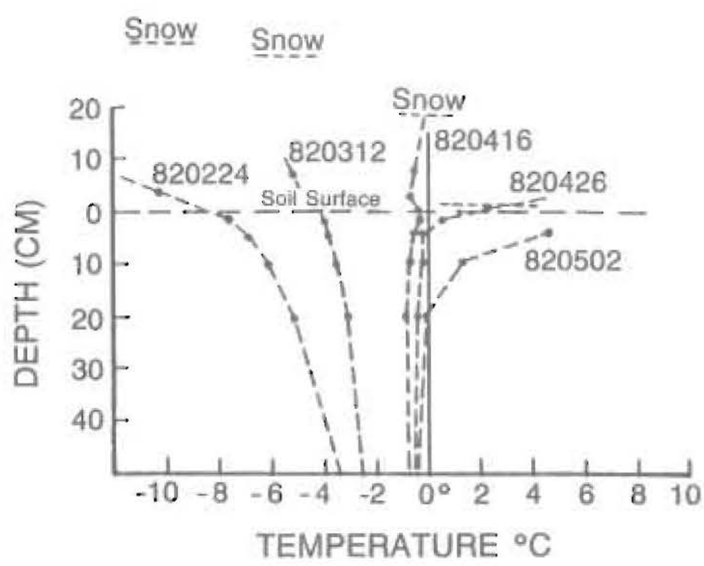

Figure 8. Temperature vs. depth chronologically through accelerated snowmelt. Temperatures tend to be isothermal with depth prior to exposure of soil to direct insolation.

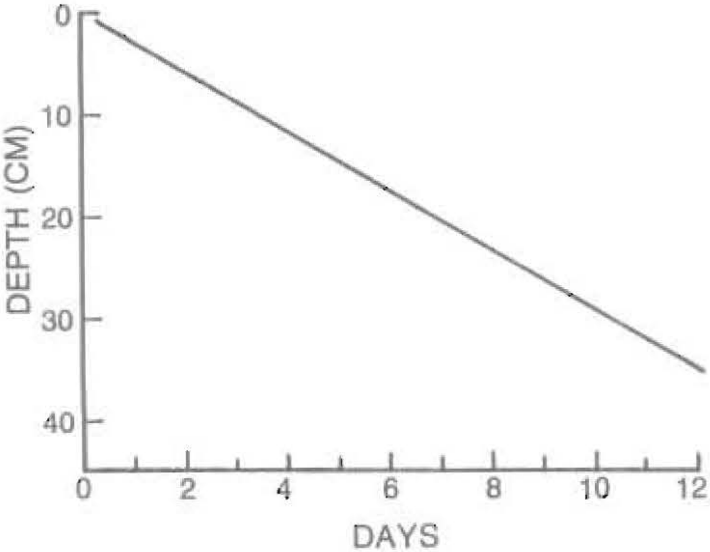

Figure 9. Thaw penetration vs. days after first exposure of soil showing a roughly linear progression of the thaw front beginning with the first exposure of the soil surface.

10-14 days. This behavior is likely to have been a result of meteorological conditions, the driving force for the thaw. Small short-term variations in the curve seem to lag behind the variations resulting from short warming or cooling trends in the weather. Finally, it should be noted that even though each site was snow-free on a different day, the penetration of the thaw front proceeded at nearly the same rate thereafter.

Summary, Conclusions and Future Plans

Working under the hypotheses that 1) earlier tillage might be possible if the snowpack melt were artifically accelerated and 2) greater meltwater infiltration in the soil would result from an earlier melt, the minimum observations deemed necessary for the study were 1) soil temperature and 2) soil moisture through the melt period and a few days beyond. However, to gain a more comprehensive understanding of the melt process, baseline values of soil temperature and moisture, total snowpack moisture and temperature, and snowpack and soil albedo, as well as their evolution during the course of the winter, were monitored. Our conclusion is that dusting the snowpack is beneficial from the standpoint of earlier tillage and greater entrainment of meltwater. These conclusions, however, must be held as tentative because we have observed the complete process through only one melt season.

Because of the small scale of the project and the single study season, economic viability of the technique of dusting, application rates, and other criteria that would make the technique routine could not be fully examined. Our observations suggest, however, that five to ten days may be gained in the early part of the growing season and that moisture enhancement in the upper 8 inches may amount to as much as 15 percent, by volume. These results are preliminary, and detailed analyses of the temperature, moisture, and albedo changes of the snowpack and underlying flat agricultural land, from onset of first snow to a month or more after complete melt, will be published in separate reports.

We intend to make a comprehensive study of the overall results from the data of the 1982 season as well as data from subsequent, although less well-documented, melt seasons. The data on albedo, surface temperature measurements of the snow pack, and temperature in the snow will be evaluated in a separate report. Temperature and moisture in the soil during the breakup process will be modelled using a program available to us.

An aspect of this research warranting further investigation with the present data as the basic data set is the observation of moisture migration to the freeze front at about 31-59 inches from a zone of saturated soil detected at a depth of 177 to 217 inches. This zone of enhanced moisture associated with the freeze front may provide additional moisture for plant growth.

Another aspect of management of snowpack by dusting is the possibility that snow molds that cause destruction of overwintering grain crops (Austin and Nielson 1977, Cartee et al. 1986, McBeath 1984) can be controlled by early removal of the snowpack when conditions are favorable. We have some data on this aspect of snowpack management taken in coordination with J. McBeath of AFES; this study will be reported later.

Finally, it may be noted that should management of the snowpack by means of dusting as described prove feasible in the long term, other innovative technologies may be possible. For example, with the extension of the growing season and enhanced soil moisture infiltration, new crops might be grown. Another is that it may be possible to eliminate altogether conventional, time-consuming tillage and other soil preparation practices that are done soon after melt. For example, since meltwater can be largely confined in place (provided the land is not too steeply sloped), soluble fertilizer may be incorporated into the dusting process. Other soil-conditioning amendments may also be incorporated in this way and evaluated in counteracting adverse soil compaction and crusting around overwintering seedling and annual plants. □

Acknowledgments

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Performance, Costs, and Value Of Holstein Steers Fed a Corn Diet Or an Alaskan Barley Diet

By

Leroy Ben Bruce*, Ed Arobio**, Mary Lou Herlugson***, and Wilder Simpson****

Introduction

Alaska's livestock producers have several concerns with raising and finishing feedlot-type cattle. First, about half of all calves born to dairy cows are bull calves and are of little use unless they can be fed out successfully for beef. Second, the feeding value of Alaskan-grown barley is often questioned compared to traditional livestock finishing feeds. Finally, costs associated with feeding out small numbers of feedlot-type cattle under Alaskan conditions are not well documented. With the opening of the slaughter plant in Palmer and the establishment of a ready market, feeding out available dairy steers is becoming more attractive. This study was undertaken to address some of these concerns.

Experimental Procedures

Existing facilities at the Matanuska Research Farm were used. They consisted of a three-sided metal shed on one edge of a one-half-acre paddock. The shed provided a wind and rain break, but was not insulated, and was not built to provide artificial heat. A four-strand barbed wire fence down the middle of the shed and through the middle of the paddock created two pens equal in size and shape. Steel posts were used for the perimeter and dividing fences. Water was provided separately to each pen by a tank with an electric water heater. Tanks were filled daily by hose. Each pen was equipped with a feed trough providing 28 inches of bunk space to each animal so that all animals could feed simultaneously. No special bedding or other facilities were provided.

Twenty Holstein steers born to dairy cows at the Matanuska Experiment farm were used for this study. The calves were raised in outside calf hutches prior to this study. They were fed waste milk from the dairy for 56 days and then grain and hay or grain and silage. When designated for this experiment, calves ranged in weight from 400 to 750 pounds. Table 1 shows the amounts and costs of feed used in raising the calves prior to the feedlot study.

At the beginning of this feedlot study, steers were divided into two weight groups: heavy and light. Then they were assigned randomly to one of the two feeding groups by alternating between weight groups until there were ten animals per pen. The variation in starting weight was due to age differences. Rations were designed following NRC guidelines (1984) for feedlot animals with either corn or Alaska barley for the main ingredient (table 2). The corn and barley were not processed but fed as whole grains. Alaskan brome hay was fed to both groups to provide roughage; limestone was added to provide calcium. Trace mineral salt was provided free choice in each pen. Care was taken to see that access to ice-free, clean water was never disrupted. Diets were fed once a day; however, bunks were never unfilled for more than a few hours. Intake by each group was measured daily. Weights were taken every

Table 1. Feed costs for one Holstein steer prior to being fed a finishing diet.

Item	Amount	Cost/unit	Total cost
Waste milk	280 (lb)	$ 19/cwt	$ 53
Grain, diary mix	0.47 (t)	300/ton	141
Brome hay	1 (t)	100/ton	100
Silage	1.9 (t)	50/ton	95
			389

Cost per pound for a 600-lb steer = $389/600 = $0.65

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Table 2. Daily dietary composition and nutrient content for a Holstein steer fed either corn or barley diets.

	Barley diet		Corn diet	
	as fed	dry basis	as fed	dry basis
Ingredient(lb)				
Brome hay	8.1	6.8	8.1	6.8
Barley	17.0	14.3	0.0	0.0
Corn	0.0	0.0	16.5	14.3
Limestone	0.2	0.2	0.3	0.3
Nutrient content				
TDN (lb		15.2		16.6
Crude protein (lb)		2.3		2.3
Calcium (gm)		42		42
Phosphorus (gm)		38		33

two weeks. Steers were switched from pen to pen every two weeks to avoid any advantage one pen might have over the other. Costs and the amount of time spent on each aspect of taking care of the livestock were recorded. Steers were fed to approximately 1150 pounds, then slaughtered, and appropriate carcass data were taken and analyzed.

Results and Analysis

Feedlot Performance

These steers were fed through the winter, and, although Holstein steers are not particularly adapted to winter stress, the wind and rain/snow break provided adequate protection and all steers performed satisfactorily. Special care was taken with bunk management because it is critical for animals on a high-energy diet. Animals were managed so that no old feed accumulated, yet feed was present 24 hours a day.

The corn ration showed definite advantages in steers' feedlot performance (table 3). Animals gained slightly over 3.0 pounds per head per day on a feed consumption of 7.38 pounds of feed per pound of gain. The barley group gained 2.5 pounds per day on 10 pounds of feed per pound of gain. The corn group consumed 2 tons of feed (dry basis) each to reach the desired end weight. The barley group had to consume 2.75 tons to reach an identical end weight and took slightly over a month longer to finish. This is a typical performance profile based on the large difference in energy between corn and barley as measured by TDN (total digestible nutrients). Producers should have a feed analysis done on each batch of feed as both barley and corn, but barley, especially, can vary between lots in energy and nutrient content. Obviously, part of the decision to use corn or barley will be based on the price differential. A price analysis on the basis of feed price and animal performance was conducted (table 4). Based on feeding performance alone, when corn costs $10.60 per hundred weight (cwt), barley would have to sell at $6.63/cwt to make feed costs equal for the period. A more general conclusion is that barley would have to be about two-thirds the price of corn to be competitive. This includes the extra feed to get the barley group to 1150 pounds, but does not include the increased overhead cost of maintaining the barley group for a month longer.

Both groups had similar carcass data (table 5), with the corn group having a slight advantage in quality grade and the barley group in yield grade. The slight advantage in quality grade is typical of animals on a faster-gain track. Both groups produced acceptable meat, but carcasses were slightly below the industry standards of yield grade 2 and quality grade high *good* to low *choice*. Industry standards could easily be met by feeding to an end weight of 1200-1250 pounds, instead of 1150 pounds.

Table 3. Feedlot performance by individual Holstein steers fed either corn or barley.

Date	Total feed consumed (lb)	Cumulative feed per lb of gain (lb)	Cumulative average daily gain (lb)	Total days on feed
	Barley diet			
18 Dec 85	286	4.05	5.04	14
12 Feb 86	1587	9.08	2.50	70
9 Apr 86	3104	10.97	2.25	126
4 Jun 86	4287	9.78	2.59	182
30 Jul 86	5148	9.75	2.64	238
3 Sep 86	5491	10.17	2.54	273
	Corn diet			
18 Dec 85	253	2.78	6.49	14
12 Feb 86	1398	6.80	2.94	70
9 Apr 86	2769	7.99	2.75	126
4 Jun 86	3575	7.24	3.15	182
30 Jul 86	3964	7.38	3.15	238

Table 4. University diet costs for entire feeding period and associated price breakdowns for one steer fed either a corn or barley diet.

Item	Cost/unit	Cost/lb	Barley diet		Corn diet	
			Amount(lb)	Cost	Amount(lb)	Cost
Brome hay	$150.00/ton	$0.075	1753	$131.48	1260	$ 94.50
Barley	10.50/cwt	0.105	3686	387.03	0	0.00
Corn	10.60/cwt	0.106	0	0.00	2649	280.79
Limestone	17.60/cwt	0.176	52	9.15	55	9.68
Totals				$527.66		$384.97

Table 5. Carcass characteristics of Holstein steers fed either corn or barley diets.

Carcass measurement	Dietary group	
	Barley	Corn
Live weight (lb)	1141.6	1144.2
Hot carcass weight (lb)	595.9	624.1
Dressing (%)	52.2	54.6
Fat thickness (in)	0.06	0.10
Kidney, heart, and pelvic fat (%)	3.2	3.4
Ribeye area(in²)	11.7	11.1
Marbling score	slight –	slight
Quality grade	low good	good
Yield grade	1.8	2.2
Retail cuts (%)	52.7	51.6

Economic Analysis

The information developed in this study can be used to estimate production costs for farmers interested in the possibilities of finishing dairy steers in a backyard feeding situation in the area of Palmer, Alaska. This has been done and is summarized in Table 6.

The costs of producing any commodity—in this case a market steer—can be divided into two components: variable and fixed costs. Variable costs are costs that only exist when an activity is taking place. Variable costs associated with cattle feeding include feed costs, veterinary and medical expenses, calf raising, repair and maintenance on facilities, electricity, and operating interest. We are not including labor as a variable cost, since an assumption of these budgets is that all labor is provided by the owner or family members. Any return to owner labor and management is to be paid through any net return from the sale of market steers. Records kept during the study indicated that each steer required 14.5 hours of labor input to reach market weight.

Fixed costs are those costs that exist even if no production is taking place. In this analysis fixed costs are annual depreciation and interest for the livestock corral, shed, and watering system. Only rudimentary facilities are required, and, on many of the new farms currently being developed in Alaska, materials available on the farm, i.e., log poles, etc., could be used to construct pens and shed.

Estimated costs for cattle finished on the corn diet total $683.58 per head, while the per-head costs for animals fed barley total $830.82. The differences in cost were attributable to lower corn prices and the greater quantities of barley required to reach market weight.

Feed costs used in the cost analysis (table 6) are the same as those in Table 4, except for the cost of grain. In Table 4, our actual costs are used; however, cheaper grain can be purchased, and these costs are used in Table 6 because they are more representative of what farmers can achieve in order to maximize successful production. Because of the low profit margins traditionally associated with cattle feeding, success is based on keeping costs as low as possible. In February 1987, the cheapest corn available to the livestock producer in Palmer was through purchase of railroad car lots from the northwest United States. In two-car lots, approximately 190 tons, corn can be landed in Palmer for $133 per ton. This is more than a two-year supply for finishing 40 steers per year, slightly more than the capacity of the feeding situation described in this study. However, the livestock feeder needs to obtain corn at this cost level to be successful. One way to purchase railroad car loads of corn economically is for several farmers to share the cost. Barley in this study has been priced at $155 per ton. This is the cost of purchasing barley in Delta Junction and shipping it to Palmer. There does not appear to be an advantage to purchases of railroad car lots of barley from outside of Alaska. Higher per-car freight rates for barley, due to its lighter weight per volume compared with corn, results in a cost of barley landed in Palmer of $156 per ton.

Table 6. Current costs of finishing a dairy steer on corn or barley diets, Palmer, Alaska (not University costs, table 4).

	Corn diet	Barley diet
Variable costs		
Feed		
Hay	$ 94.50	$131.48
Corn	175.00	0
Barley	0	285.20
Limestone	9.68	9.15
Veterinary & medicine	4.46	4.46
Electricity	3.00	3.00
Repairs	.25	.25
Interest	1.14	1.73
Calf raising	389.00	389.00
Fixed costs		
Corral, shed, waterers		
Depreciation	4.37	4.37
Interest	2.18	2.18
Total cost	$683.58	$830.82

In order to break even, and just cover the costs listed in Table 6, a market price of $ .59 per pound would be required for steers on the corn diet assuming an average weight of 1150 pounds. For steers on the barley diet, an average market price of $ .72 per pound would be needed. According to the 25 February 1987 *Alaska Agriculture Market Report*, Holstein steers on the St. Paul market were selling in the range of $ .50 to $ .56 per pound for good to choice dairy steers. Under this price-cost relationship, market prices are not covering production costs, even for a animals fed the corn diet. If the option of purchasing corn in railroad car lots is unavailable, corn can currently be purchased in bulk in Palmer for $175 per ton. This increases total cost per steer for animals on the corn diet to $746.94. A market price of $ .65 per pound is then required to cover costs.

The major importance of this study is that, first, it provides input requirements to finish dairy steers successfully without elaborate feeding facilities or sophisticated feed rations. Second, it provides information on the costs of producing market steers. While it was not possible to show a profit with the costs estimated in this study, this may not always be the case, since opportunities for changes in costs and prices exist.

We only included the feed costs associated with raising calves in this study since other cost data were not available. Nevertheless, there may not be major additional calf-raising costs because feed is the largest cost, and no effort was made to limit feed costs; certainly reductions could be made in feed costs. Another significant cost was hay. It may be possible to lower this cost through alternate roughage sources such as silage, haylage, treated straw, etc. Production of one's own feed versus purchase of feed may lower cost. The relationship between costs and prices can also change as cattle prices move up and down.

While corn showed a large cost advantage over barley in this study, for the Palmer area, a shift in advantage to barley may occur in other areas of the state. For example, barley is currently available in the Delta Junction area at $125 per ton or less. Farmers feeding steers in the Delta Junction area would use barley because of its greater availability and lower cost.

Conclusions

This experiment shows that dairy steers can be successfully finished under Alaskan winter conditions. The trial also shows that Alaskan barley can be used as successfully as traditional feeds, but will have to cost one-quarter to one-third less than imported corn. □

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Effect of Basic-H On Vegetable and Agronomic Crops And Soil Fertility at Pt. MacKenzie

By

Winston M. Laughlin*, Glenn R. Smith**, and Mary Ann Peters***

In the spring of 1983, Basic-H was suggested as a means of increasing crop yields and of rendering less acid the soils in the new farming area at Pt. MacKenzie. Basic-H is a surfactant also advertised as a detergent for use by surgeons and a biodegradable cleansing agent suitable for outdoor use. Although its exact chemical composition is a trade secret, the label states it contains "28% linear alcohol alkoxylates." Basic-H was reported in company advertising to have increased yields of corn and other crops in Minnesota, Kansas, and Ohio, but no tangible reference was given. It was advertised to: 1) release soil nutrients by a wetting action, thus building soil health; 2) be an organic, biodegradable, phosphate-free, nontoxic, nonirritating, nonmagnetic, nonvolatile, and safe material; 3) be a nutrient release, a wetting agent, and a surfactant; and 4) cause soil to absorb rain faster and to hold moisture longer in dry weather.

Experimental Procedure

An experiment of twelve plots was laid out 25 May 1984 on land allotted us at Pt. MacKenzie. We replicated two treatments (no Basic-H and Basic-H) six times. All plots received 1250 pounds 8-32-16 commercial fertilizer per acre which applied 100 pounds nitrogen (N), 400 pounds P_2O_5 [176 pounds phosphorus (P)], and 200 pounds K_2O [166 pounds potassium (K)] per acre. The area was rototilled, fertilized, and planted May 25. One 15-foot row each of 'Formanova' table beets, 'Ithaca' head lettuce, 'Klondike Nantes' carrot, 'Weal' barley, 'Toral' oats, and 'Candle' rape were planted with a Planet Jr. seeder in each plot. After planting, Basic-H (2 quarts per acre) was applied to each of the six plots receiving this material using a sprinkling can filled with water. Each of the remaining six plots received the same quantity of water using a sprinkling can which had never been used with the Basic-H. Each of the twelve plots were given 1 gallon of water on the following Monday, Wednesday, and Friday which moistened the soil surface.

Lettuce, beets, and carrots were harvested 30 August 1984. The number and weight of lettuce plants (no mature heads had formed) and the weight of foliage and roots of the beets and carrots were recorded. On the following day the barley, oats, and rape were cut at the ground surface. The entire growth of each crop on each plot was placed in a cloth bag and dried in the greenhouse. These three crops were threshed September 15, and weights of both straw and grain were obtained. At this time a sample of both straw and grain was taken from each plot of oats, barley, and rape for chemical analyses. On August 30 a soil sample was taken from each plot. Chemical determinations were as follows:

1) The soil pH was determined with both water and 0.01M $CaCl_2$ using one part soil with two parts of water or chloride solution. The ammonium and nitrate N were extracted from the soil with 2N NaCl and determined with a Technicon autoanalyzer at 630 and 520 mμ, respectively (TIS 1973). Bray No. 1 extractant was used to extract the P which was measured by a spectrophotometer at 660 mμ (Gaines and Mitchell 1979). Potassium was extracted with 1 N ammonium acetate at pH 7.0 and determined with an atomic absorption spectrophotometer at 766.5 mμ

2) The plant tissue was analyzed for nitrate N with a nitrate electrode (Smith 1975); total N and P were determined colorimetrically with a Technicon autoanalyzer (TIS 1976), magnesium (Mg) with an atomic absorption spectrophotometer following a sulfuric-selenous acid digestion and using 1000 ppm lanthanum to control interferences (Perkin-Elmer 1973), and total sulfur (S) using an automatic S analyzer (Smith 1980).

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Analysis of variance was used to determine if significant effects due to application of Basic-H occurred. The coefficient of variation (C.V.) expressed as a percent indicates the dispersion of the individual values around the mean. The larger the value, the greater the variation within the experiment.

Results and Discussion

Frequent observations during growth revealed no visible differences between the two treatments related to emergence or growth.

Head lettuce, table beets, and carrots

Basic-H had no significant effect on head lettuce number or yield or on the yield or foliage to root ratios of table beets or carrots. No mature marketable lettuce heads were obtained. This probably resulted because of the lateness of planting and because no lime had been applied (table 1).

Rapeseed

Basic-H had no significant effect on rape yield, NO_3-N, N, P, K, S, Ca, or Mg concentrations in straw or seed, or on N, P, K, or S uptake (table 2). Comparing the above nutrient uptake values with those applied show the entire rape crop recovered 145, 27, 175, and 63 percent of the applied N, P, K, and S respectively.

Weal barley

Basic-H had no significant effect on the barley yield, NO_3-N, P, K, S, Ca, and Mg concentrations in the straw and grain or on N, P, K, and S uptake (table 3). The total barley crop took up 125, 15, 95, and 19 percent of the N, P, K, and S applied, respectively.

Toral oat

Basic-H had no significant effect on the oat yield, NO_3-N, N, P, K, S, Ca, and Mg concentrations in the straw and grain or on N, P, K, and S uptake (table 4). The total oat crop received 128, 19, 130, and 21 percent of the N, P, K, and S applied, respectively.

Soil test measurements

Basic-H had no significant effect on the soil pH or the available N, P, or K 31 August (table 5).

Conclusions

Application of Basic-H at 2 quarts per acre had no significant effect on the yield of head lettuce, table beets, and carrots; nor did it affect significantly the yield and chemical composition of barley, oats, and rape, or the soil pH and

Table 1. Effect of Basic-H on head lettuce, table beets, and carrots 30 August 1984 (means of 6 measurements).

	No Basic-H	Basic-H	C.V.(%)
Head Lettuce			
Number (per 15-ft row)	11.7a[1]	11.5a	16.1
Yield (T/A)	0.75a	0.66a	63.4
Table beets			
Foliage (T/A)	10.15a	8.45a	23.6
Roots (T/A)	3.24a	3.02a	43.9
Total	13.39a	11.47a	27.1
Foliage: root ratio	3.58a	2.87a	28.0
Carrots			
Foliage (T/A)	0.94a	0.82a	15.8
Roots (T/A)	2.69a	2.33a	16.1
Total	3.63a	3.15a	16.0
Foliage: root ratio	0.35a	0.35a	2.3

[1]Any two values within a row not followed by the same letter are not significantly different at the 5 percent level of probability.

Table 2. Effect of Basic-H on Candle rape yield, NO_3-N, N, P, K, S, Ca, and Mg concentrations and N, P, K, and S uptake 31 August 1984 (means of 6 measurements).

	No Basic-H	Basic-H	C.V.(%)
Yield (T/A)			
Straw	8.33a[1]	8.11a	11.1
Seed	0.50a	0.55a	31.8
Concentration (%)			
NO_3-N			
Straw	.018a	.018a	14.5
Seed	.090a	.094a	10.5
N			
Straw	.63a	.65a	25.2
Seed	3.74a	3.69a	4.1
P			
Straw	.20a	.24a	33.2
Seed	1.03a	1.05a	4.5
K			
Straw	1.69a	1.73a	4.9
Seed	.96a	.97a	5.6
S			
Straw	.237a	.241a	13.7
Seed	.358a	.380a	7.6
Ca			
Straw	.81a	.77a	13.2
Seed	.52a	.55a	6.8
Mg			
Straw	.200a	.195a	11.1
Seed	.372a	.377a	4.3
Uptake (lb/A)			
N	142a	146a	21.2
P	43.9a	49.8a	26.7
K	291a	292a	11.0
S	43a	43a	11.0

[1]Any two values within a row not followed by the same letter are not significantly different at the 5 percent level of probability.

Table 3. Effect of Basic-H on Weal barley yield, NO3-N, N, P, K, S, Ca, and Mg concentrations and N, P, K, and S uptake 31 August 1984 (means of 6 measurements).

	No Basic-H	Basic-H	C.V.(%)
Yield (T/A)			
Straw	2.83a[1]	2.96a	16.6
Seed	2.01a	1.92a	9.5
Concentration (%)			
NO_3-N			
Straw	.043a	.052a	27.9
Seed	.002a	.002a	0.0
N			
Straw	.74a	.61a	28.8
Seed	2.18a	2.14a	5.6
P			
Straw	.14a	.16a	65.3
Seed	.44a	.45a	7.9
K			
Straw	2.22a	2.48a	12.7
Seed	.62a	.61a	5.6
S			
Straw	.104a	.102a	21.9
Seed	.104a	.104a	6.9
Ca			
Straw	.30a	.33a	13.1
Seed	.072a	.082a	20.1
Mg			
Straw	.12a	.10a	16.2
Seed	.14a	.13a	4.3
Uptake (lb/A)			
N	129a	118a	15.9
P	26a	27a	26.5
K	150a	169a	13.7
S	13a	13a	17.3

[1]Any two values within a row not followed by the same letter are not significantly different at the 5 percent level of probability.

extractable N, P, and K at Pt. MacKenzie. These results were similar to those reported by Wolkowski et al. (1985) who found no soybean yield differences or any difference in nutrient availability as evidenced by foliar nutrient content of N, P, and K or crop protein levels with the use of Basic-H in Minnesota.☐

Table 4. Effect of Basic-H on Toral oat yield, NO_3-N, N, P, K, S, Ca, and Mg concentrations and N, P, K, and S uptake 31 August 1984 (means of 6 measurements).

	No Basic-H	Basic-H	C.V.(%)
Yield (T/A)			
Straw	3.83a[1]	3.82a	15.5
Seed	2.16a	2.19a	13.5
Concentration (%)			
NO_3-N			
Straw	.045a	.030a	36.3
Seed	.001a	.001a	0.0
N			
Straw	.42a	.33a	18.6
Seed	2.23a	2.19a	9.7
P			
Straw	.12a	.15a	60.8
Seed	.54a	.53a	10.9
K			
Straw	2.53a	2.51a	8.4
Seed	0.52a	0.51a	4.2
S			
Straw	.113a	.111a	6.3
Seed	.180a	.185a	8.6
Ca			
Straw	.33a	.35a	10.7
Seed	.12a	.11a	10.6
Mg			
Straw	.153a	.152a	6.5
Seed	.152a	.153a	8.8
Uptake (lb/A)			
N	128a	121a	16.9
P	.33a	.36a	3.5
K	216a	216a	22.3
S	15a	15a	14.8

[1]Letters in the tables are used in accordance with Duncan's multiple range test. Any two values within a row not followed by the same letter are not significantly different at the 5 percent level of probability.

Table 5. Effect of Basic-H on the soil pH and available N, P, and K 31 August 1984.

	No Basic-H	Basic-H	C.V. (%)	S.D.[2]
pH				
Water	5.37a[1]	5.39a	1.4	0.07
0.10N $CaCl_2$	4.63a	4.66a	1.0	0.06
Lbs. avail/A				
NH_4-N	41.5a	39.9a	2.8	2.5
NO_3-N	2.2a	1.0a	137	2.0
Total N	43.7a	40.0a	6.0	3.3
P	6.4a	2.7a	61.1	3.3
K	207a	226a	17.6	41

[1]Any two values within a row not followed by the same letter are not significantly different at the 5 percent level of probability.
[2]Standard deviation.

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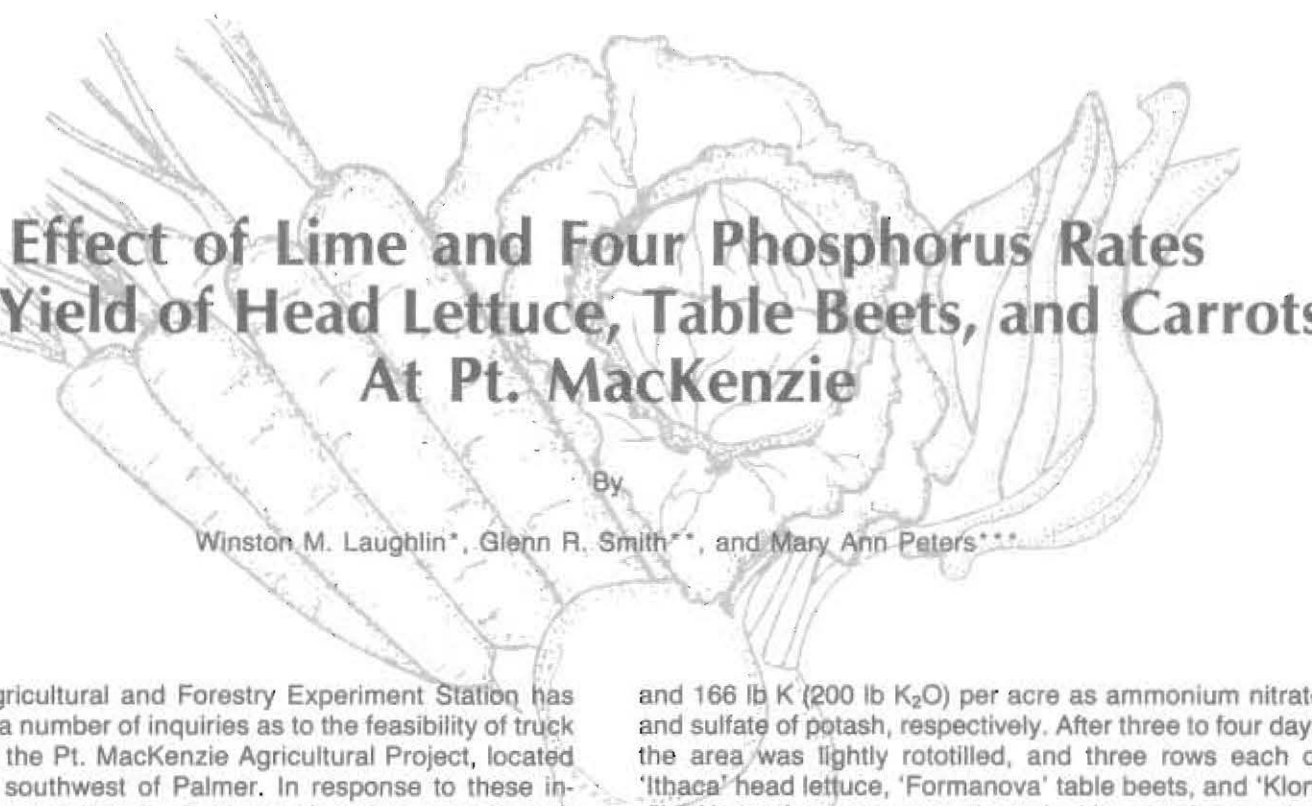

Effect of Lime and Four Phosphorus Rates On Yield of Head Lettuce, Table Beets, and Carrots At Pt. MacKenzie

By

Winston M. Laughlin*, Glenn R. Smith**, and Mary Ann Peters***

The Agricultural and Forestry Experiment Station has received a number of inquiries as to the feasibility of truck crops for the Pt. MacKenzie Agricultural Project, located 40 miles southwest of Palmer. In response to these inquiries, we conducted a field experiment on our research tract in the Pt. MacKenzie area. Three vegetable crops which ordinarily present no insect problems were chosen as being representative. Both head lettuce and carrots are important truck crops in the Matanuska Valley, and a limited number of table beets are also grown.

Experimental Procedure

A portion of this research tract was cleared during the winter of 1981. Then a rotary plow was used twice on the area. During the summer, roots were removed and a field cultivator used twice to loosen and bring roots to the surface. This procedure thoroughly mixed the soil and probably avoided much of the adverse effects sometimes occurring in first crops on newly cleared soil. A 2 × 4 factorial experiment was laid out in a randomized complete block with six replications. Treatments were the presence and absence of lime (0 vs 4 T/A) and four phosphorus (P) rates (100, 200, 300, and 400 lb P_2O_5, supplying 44, 88, 132, and 176 P per acre, respectively). On 11 August 1981 the plot area was rototilled and the lime applied. The lime was incorporated to a depth of about six inches by rototilling. Individual plots were 10 by 15 feet. Fertilizer treatments were applied annually by broadcasting in the middle of May 1982, 1983, and 1984. Phosphorus was supplied as treblesuperphosphate. All plots received annually 100 lb nitrogen (N) and 166 lb K (200 lb K_2O) per acre as ammonium nitrate and sulfate of potash, respectively. After three to four days the area was lightly rototilled, and three rows each of 'Ithaca' head lettuce, 'Formanova' table beets, and 'Klondike Nantes' carrots were planted with a garden seeder. In succeeding years plantings were made so that no crop grew in the area in which it had grown the previous years. Head lettuce was thinned to 6-inch spacings in 1982 and to 1-foot spacings in 1983 and 1984. Before harvest, 1 foot of row was removed at plot boundaries making each plot row 9 feet long. Each year four cuttings of mature lettuce heads were made at weekly intervals throughout the month of August, and the number and total weight of the heads were recorded. Early in September the table beets and carrots were harvested, and the fresh foliage and root weights were recorded.

The soil in the plot area is a Kashwitna silt loam. Soil samples were taken from each plot to a 6-inch depth prior to fertilization in May 1982 and after the final harvest in September 1984. The soil pH was determined with a pH meter using one part soil to two parts of water. The ammonium and nitrate nitrogen were extracted from the soil with 2N NaCl and determined with Technicon autoanalyzer with 630 and 520 mμ filters respectively (T.I.S. 1973), and the two values were combined. Bray No. 1 extractant was used to extract the P which was measured by a spectrophotometer at 600 mμ (Gaines and Mitchell 1979). Potassium was extracted with 1 N ammonium acetate at pH 7.00 and determined with an atomic absorption spectrophotometer at 766.5 mμ (Perkin-Elmer Corp. 1973).

There are no meteorological records for this area available prior to June 1984. June, July, and August of 1984 each had a monthly precipitation of about two inches. We have estimated the area received about the same precipitation in each month of 1982 and much less in 1983.

The data were subjected to a split-plot type analysis of variance for a repeated measures experiment. In the analysis of variance the whole plot effects were P and lime and the P × lime interaction. The subplot on repeated

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measures effects were year and all interactions involving years. In the significance tests for the year and year interaction effects, conservative tests using minimum degrees of freedom for the required F values for significance, allowing for autocorrelations among years, were utilized.

In all tables Duncan's mulitple range test is used. Means within a column followed by the same letter are not significantly different at the 5 percent level of probability.

Results and Discussion

Soil Test Values

Application of lime in August 1981 increased the soil pH and depressed the available P by the following May (table 1). After the last harvest in September 1984, P applications had had no significant effect on the soil pH or the available N. Increasing P rates tended to increase the available P, but was significant only with 176 lb P per acre. After 3 years of P fertilization, available P has not increased over that before fertilizer was applied even at the highest (176 lb P per acre) annual applications. Since the crop removes only a relatively small proportion of the P applied, this lack of increase in available P emphasizes that this soil is capable of rendering large quantities of P unavailable to the soil extractant and probably to the plants as well. To satisfy this "fixing" capacity of P, several years of high P fertilization may be required. In September 1984 available K had increased over the 1982 values and tended to decrease with increasing P rates. This decrease probably results from the increased plant growth requiring more K when more P was available. The decrease in available N and K with lime application may also be explained by increased crop removal.

Table 1. Effect of lime and the effect of phosphorus and lime on the soil pH and available N, P, and K prior to fertilization in May 1982 and after harvest in September, 1984.

		Pounds available per acre		
	pH	N	P	K
Lime (T/A)		Effect of lime May 1982[1]		
0	5.88b	30a	15.2a	134a
4	6.20a	32a	8.0b	125a
LSD 5%	0.12	—	6.4	—
P (lb/A)		Effect of P September 1984[2]		
44	5.52a	135a	6.9b	548a
88	5.59a	171a	7.4b	481ab
132	5.55a	123a	9.5ab	452b
176	5.55a	130a	14.0a	444b
Lime (T/A)		Effect of lime September 1984[3]		
0	5.14b	183a	11.1a	542a
4	5.96a	98b	7.8a	421b
LSD 5%	0.07	49	—	52

[1]Means of 24 measurements.
[2]Means of 12 measurements.
[3]Means of 24 measurements.

Head Lettuce

Figures 1 and 2 show the P × year interaction. The number of mature heads in 1982 were about double those in 1983 and 1984 and this likely resulted from the closer 1982 spacing which was too close for good head formation. Each increasing P rate increased both the number of heads and their yield in 1982. Although the number of heads and yield in 1983 and 1984 increased with increasing P, the difference between P rates was not always enough to be significant.

Lime application doubled the number of mature lettuce heads and tripled their yield (Table 2). The greatest yield of mature lettuce obtained in 1982 with the highest P rate and the average yield with lime over all three years are considerably less than the 20 to 40 ton yields obtained from experimental plots on Bodenburg soil near Palmer.

Table Beets

Figures 3, 4, and 5 graph the P × lime × year interaction. When no lime was applied, 1982 foliage and total beet yields were increased by the highest P rate (176 lb per acre). Without lime, 1982 root and 1983 foliage and root yields were increased by P rates exceeding 44 lb per acre. Foliage and root yields were increased in 1984 by each increasing P rate through 132 lb per acre when no lime was applied P to the table beets in the absence of rather than in the presence of lime. When lime was applied, 1984 foliage and 1982 root and total beet yields were depressed by 176 and 88 lb P per acre, respectively; foliage yields in 1982 and 1983 and root and total yields in 1983 and 1984 were not influenced significantly by increasing P rates. Thus when no lime was applied, table beets apparently responded to P to a greater extent each succeeding year. But when lime was applied, there was no P response. This lack of P response may result from the lime, rendering the applied P less available to the plant. The increased overall yield results primarily from the lime.

Lime application increased both foliage and root yields in 1983 and 1984 when 44 lb P per acre was applied; root and total yields in 1983 and 1984 when 88 and 132 lb P per acre were used; and root and total yields in 1983 when 176 lb P per acre was applied. Thus in the Pt. MacKenzie area relatively high table beet yields can be attained by either high lime or by heavy P applications along with adequate N and K. The best yields are about half those ex-

Table 2. Effect of lime on the number of heads and yield of mature head lettuce at Pt. MacKenzie, 1982-1984.

Lime (T/A)	Number of mature heads[1]	Mature Lettuce[1] (T/A)
0	12.7b	4.96b
4	25.9a	12.30a
LSD 5%	1.8	0.90

[1]Each value represents the means of 72 measurements.

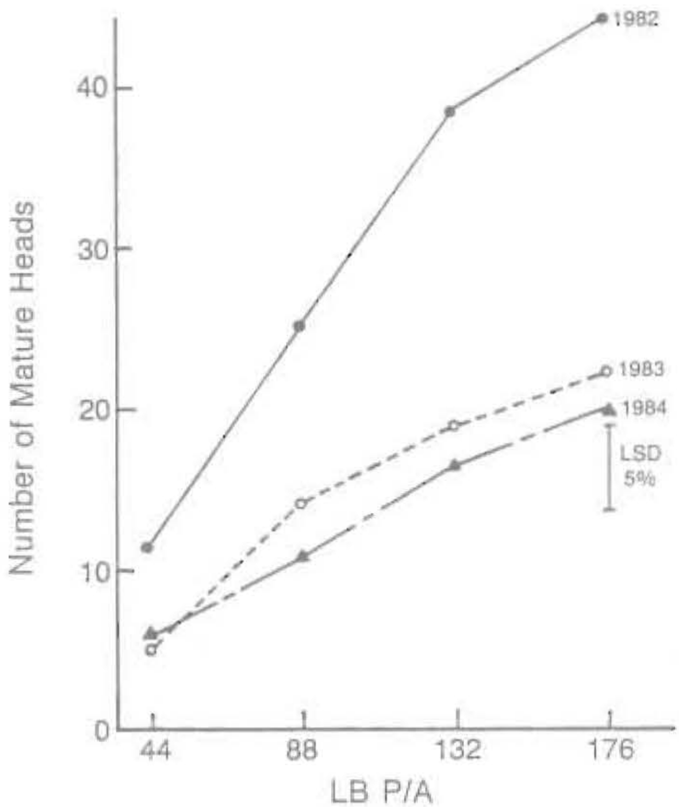

Figure 1. Effect of P on number of mature lettuce heads, 1982-1984.

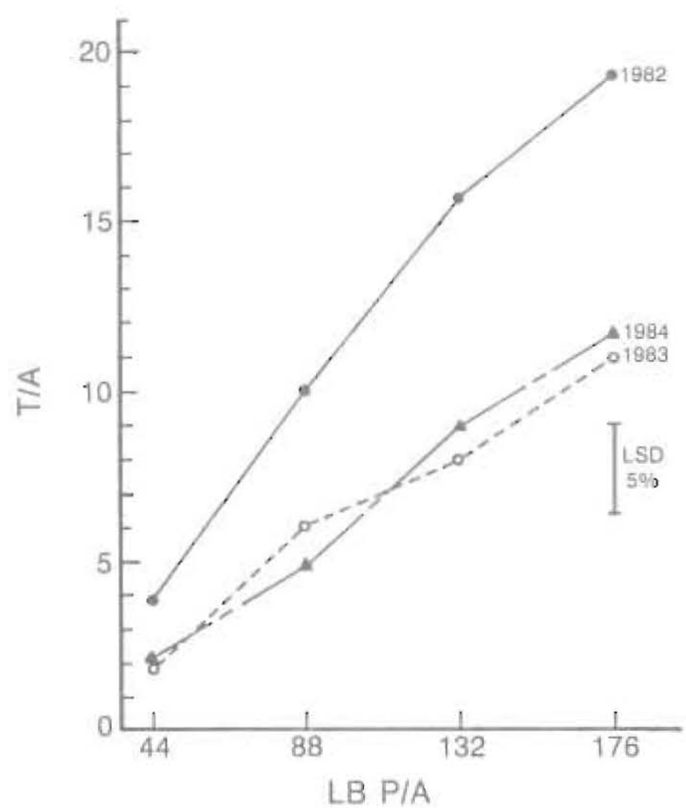

Figure 2. Effect of P on yield of mature head lettuce, 1982-1984 (six-inch spacing in 1982 and 12-inch spacing in 1983 and 1984).

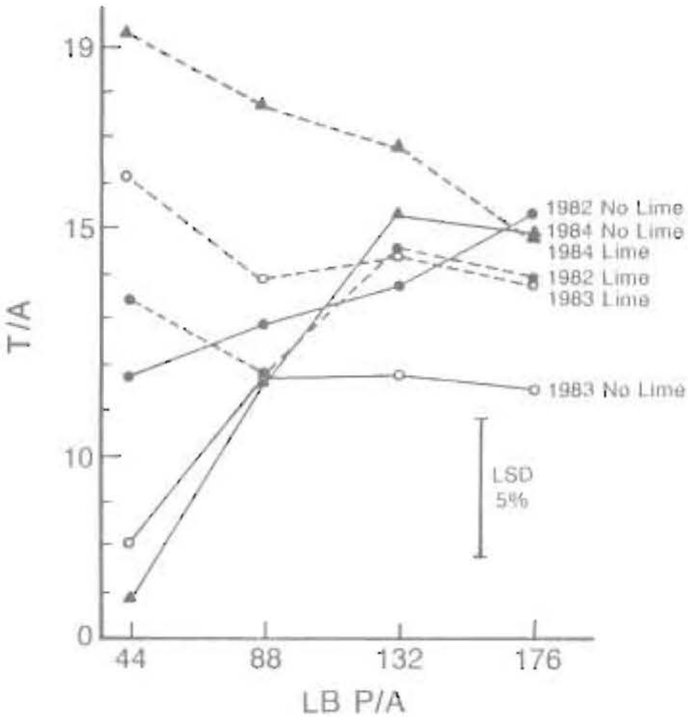

Figure 3. Effect of P and lime on table beet foliage yield, 1982-1984.

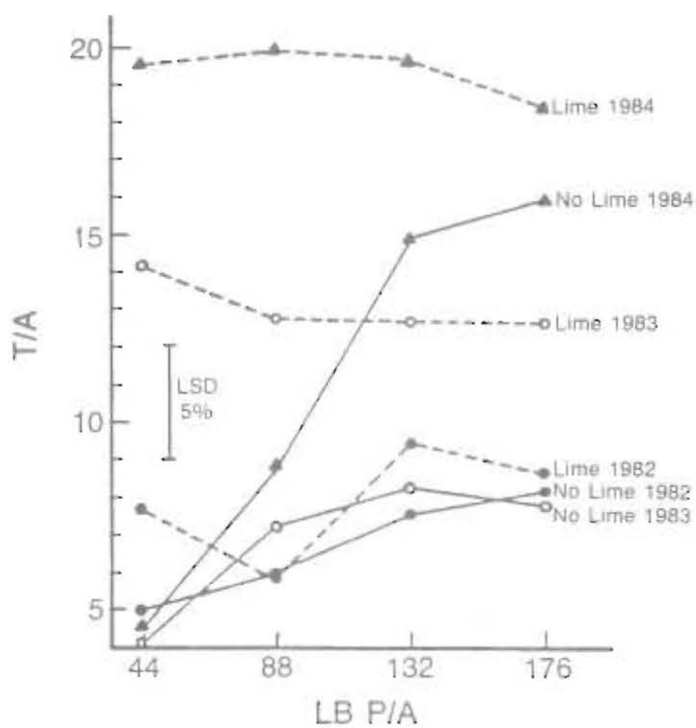

Figure 4. Effect of P and lime on table beet root yield, 1982-1984.

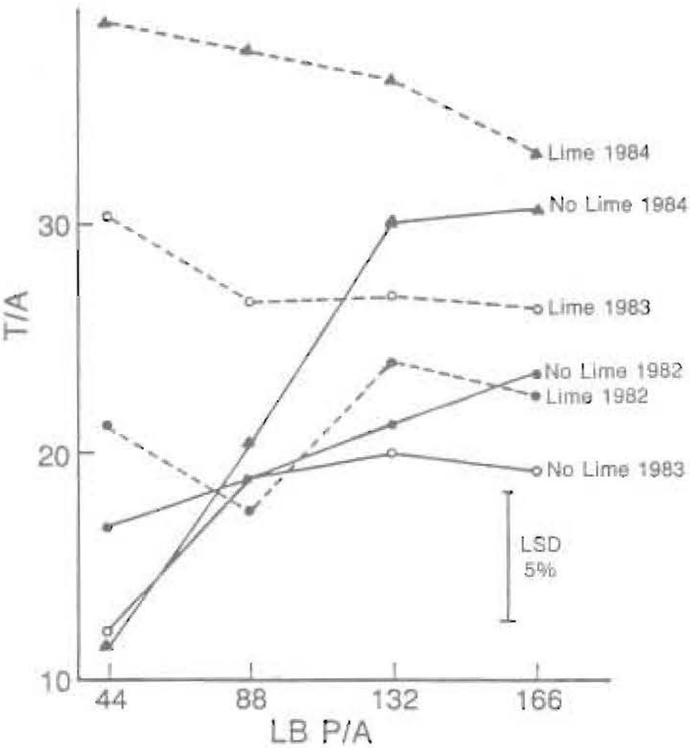

Figure 5. Effect of P and lime on total table beet yield, 1982-1984.

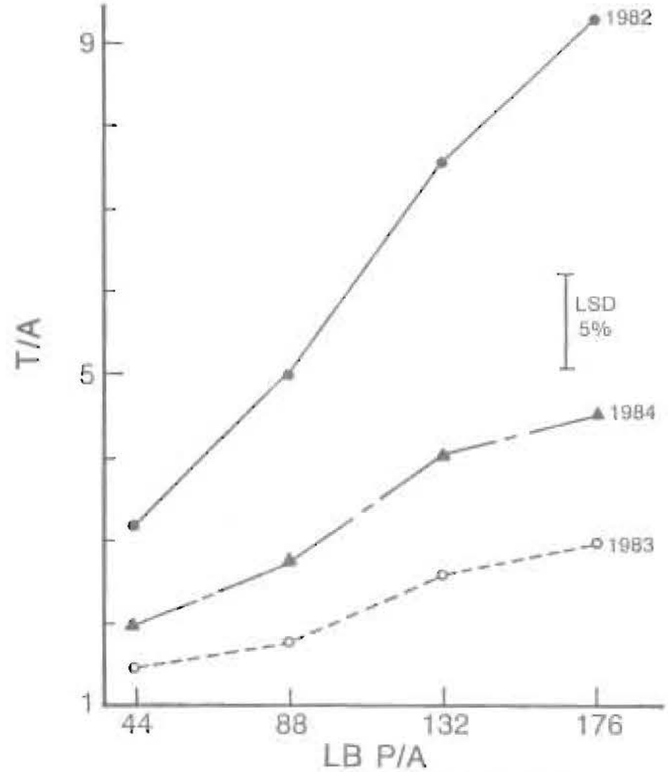

Figure 6. Effect of P on carrot foliage yield, 1982-1984.

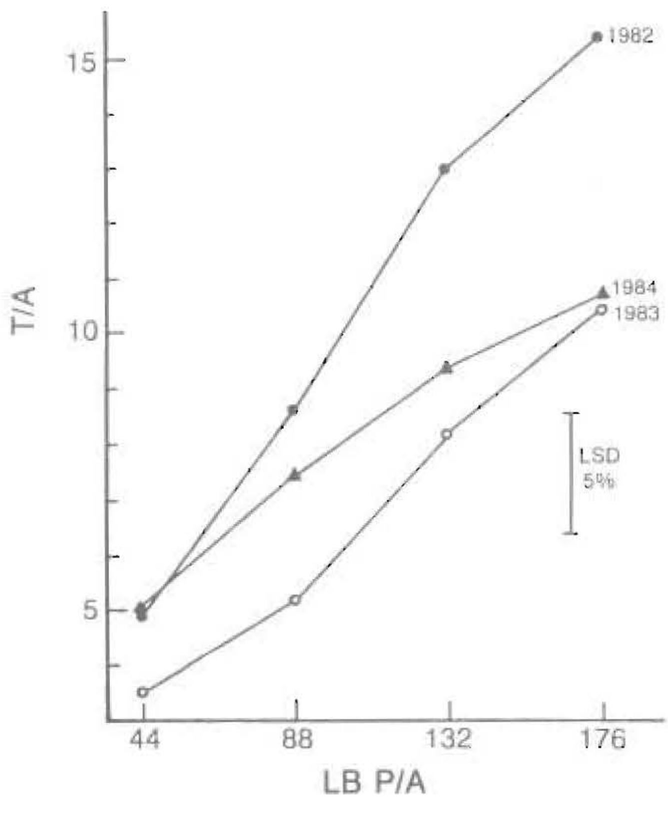

Figure 7. Effect of P on carrot root yield, 1982-1984.

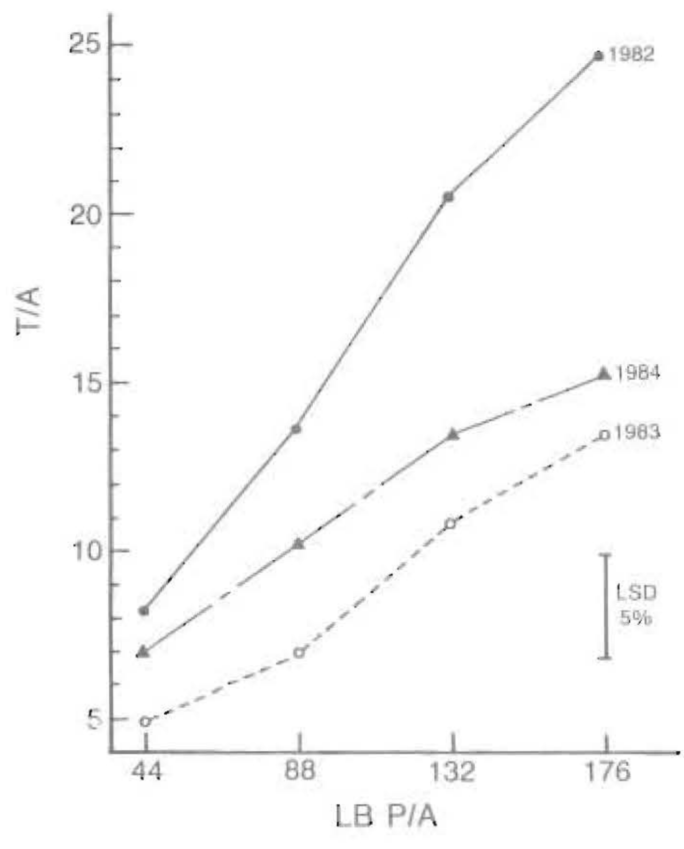

Figure 8. Effect of P on total carrot yield, 1982-1984.

perienced on experimental plots in the Matanuska Valley with no lime and a relatively low P rate.

Carrots

Figures 6, 7, and 8 show the P × year interaction. Each increasing P rate increased foliage, root, and total carrot yield in 1982 and root yields in 1984. Although each increasing P rate increased foliage and total carrot yields in 1983 and both foliage and root yields in 1984, the differences between adjacent P rates were not always great enough to be significant.

Figure 9 depicts the lime × year interaction. Carrot foliage yields in none of the three years, root yields in 1982 and 1983, and total yields in 1983 and 1984 were not influenced significantly by lime application. The application of lime increased root yields significantly only in 1984 and total carrot yields only in 1982.

Carrot yields were only one-half to one-fourth those obtained from Palmer experimental plots.

Conclusions

Head lettuce, in addition to a high rate, also requires a heavy lime application in the Pt. MacKenzie area. Table beet and carrot production may not be as dependent upon lime as lettuce, but very high P rates are required. The carrots did not respond to liming. When lime is applied to table beets, the P response decreases and, for one year, the highest P rate actually decreased the yield. The yield of these experimental plots were markedly less than that of fertilizer plots in the Matanuska Valley where neither lime or high P rates are required.

This soil is capable of rendering large quantities of P unavailable to plants. After three years of annual P fertilization, available P as shown by the soil test has not increased, even at the highest annual application of 176 lb P per acre.□

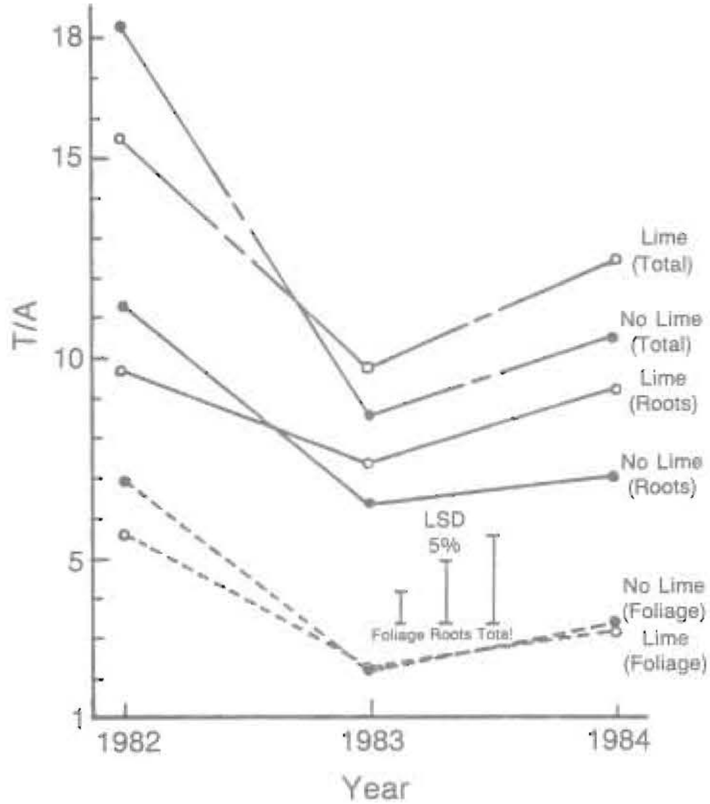

Figure 9. Effect of lime on carrot yield, 1982-1984.

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Denitrification in Floodplain Successional Soils of the Tanana River in Interior Alaska

By

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Introduction

Despite its abundance in the atmosphere, nitrogen (N) has long been recognized as a limited nutrient for plant growth in both agricultural and forested ecosystems. Atmospheric dinitrogen (N_2) is chemically unavailable to most living organisms, yet nitrogen fixation, a biological process converting N_2 to ammonium (NH_4^+) is carried out by only a few microorganisms (bacteria, blue green algae, and actinomycetes), contributes the major pool of N available to plants. Once N_2 is incorporated into organic matter it continues to be recycled through numerous biochemical transformations by many different organisms. Several processes can involve the loss of nitrogen from an ecosystem; nitrification, the microbial transformation of NH_4^+ to nitrate (NO_3^-) which can subsequently be lost through leaching, and denitrification, an anaerobic bacterial reduction of NO_3^- or nitrite (NO_2^-) to gaseous N_2. Denitrification is possibly a major pathway of N loss from these ecosystems. Although this process has been studied extensively in agricultural systems, relatively few studies have addressed denitrification in forested ecosystems (Melillo et al. 1983, Goodroad and Keeney 1984a, Pang and Cho 1984, Robertson and Tiedje 1984).

Among forest successional communities there are gradations of soil physical, chemical, and biological parameters which can influlence denitrification rates and thus affect the loss of N from the ecosystem. Therefore, a successional setting is ideal for investigating how these variables control denitrification. This paper describes the preliminary results of a series of experiments designed to measure the *in situ* and potential rates of denitrification within floodplain successional soils of the Tanana River in interior Alaska.

Acetylene addition to alder in situ *core tubes, September 1986.*

Methods and Materials

The study site was located about 19 miles southwest of Fairbanks, Alaska, in the Bonanza Creek Experimental Forest. Selected communities included a 5-year-old willow, poplar, alder stand, a 27-year-old alder stand, and a 165-year-old white spruce stand representing early, mid, and late successional stages (stand ages documented by L. Viereck, personal communication[1]). Soil core samples from each site were analyzed for potassium chloride (KCL) extractable NH_4^+-N and NO_3^--N, pH, percent organic matter (loss on ignition), and bulk densities to establish initial soil conditions. Three techniques were used to measure denitrifying activity: *in situ* gas traps, to be used as a biological indicator of soil atmosphere conditions, *in situ*

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core tubes, and laboratory intact cores; the latter two which were both used to estimate rates of undisturbed soil. In addition, one laboratory assay was used to measure potential denitrification.

Gas traps used to sample the soil atmosphere were constructed from close-ended 2.99-inch-diameter, 0.78-inch-plexiglass cylinders. The bottom of each had twelve 0.19-inch diameter holes. The traps were fitted with plastic capillary tubing which extended from the inside of the cylinder to the surface of the forest floor. In June 1985, three replicate gas traps (four depths each; 1.96, 3.93, 7.87, 19.68 inches from the surface of the forest floor) were inserted equidistant on each randomly selected transect perpendicular to the Tanana River. Transects spanned the width of each forest stand. Gas traps were sampled with 0.17-ounce evacuated tubes (Vacutainers®) at 2-week intervals throughout the summer of 1985 and 1986. Samples were stored at 41°F until analyzed for nitrous oxide (N_2O) content.

Ten replicate, open-ended ABS tubes (6.35 inches in diameter and 4.76 inches high) were placed at uniform intervals, at depths of 2.38-3.17 inches below the surface of the forest floor along each established transect. These were used to measure *in situ* denitrification. Vacuum stopcock grease was applied to the rim of the tube, with subsequent placement of a plexiglass square fitted with a rubber septum covering the entire exposed opening. Acetylene, generated by the addition of calcium carbide to distilled water, was added to the tubes at a concentration of 10 to 20 percent of the headspace volume. Incubations were from 3 to 5 hours, at which time triplicate 0.17-ounce gas samples were collected with Vacutainers® for N_2O analysis (fig. 1). The core tubes were inserted into the soil on 22 July 1986, in the alder and white spruce stands. Two transects were placed in the sandbar soil to sample both the old sediment and the newly deposited sediment. The new sediment layer was removed to sample the old sediment/new sediment interface but was replaced after sample incubations were completed. Core tubes were sampeld every 2 weeks until September 9, 1986.

Cores collected along a transect (established as previously described) at each site were brought to the laboratory for intact core and potential denitrification measurements. Cores kept intact were placed in half-pint canning jars that had tops equipped with rubber septa, while cores used for potential assays each had organic mat and mineral soil separated with subsequent mixing of each fraction. Subsamples, 0.176 to 3.52 pounds of the mixed composites were placed in similar half-pint canning jars. Soil samples were then made into a slurry by the addition of a nitrate-dextrose-chloramphenicol medium (Smith and Tiedje 1979) equal in mass to that of soil sample used. Potential assay samples were made anaerobic by flushing samples with N_2 five times, after which samples were incubated for 2 hours at room temperature. Potential assays and one half of the intact core assays were amended with a headspace addition (10 percent V/V) of acetylene. Total airspace volume in each of the sampling jars was calculated by the addition of water.

Concentrations of N_2O were measured by electron capture (^3H) gas chromatography using an Analytical Instrument Development Inc. gas chromatograph fitted with a 6-foot Poropak Q column. The limit of detection was 0.552 ppm N_2O-N.

Results

Levels of KCL extractable N and percent organic matter were higher in the forest floors than in the mineral soil under each forest type (table 1). The alder forest floor had the highest nutrient concentrations. Low extractable N and percent organic matter were observed in all mineral soils.

Gas trap analysis of the soil atmosphere showed detectable amounts of N_2O only on 27 May 1986. More than 40 percent of the gas traps in the alder and sandbar stands were saturated with water on this sampling date and were inoperable, while all the gas traps in the white spruce stand were functional. Concentrations of N_2O in the headspace of white spruce gas traps averaged 0.91 ppm ($\pm$0.71), 2.17 ppm ($\pm$3.02), 0.75 ppm ($\pm$0.55), and 2.84 ppm ($\pm$3.63) at 1.96, 3.93, 7.87,and 9.68 inches respectively. Of the four operable gas traps in the alder stand, detectable amounts of N_2O were observed in one trap at 1.96 inches (3.14 ppm). In the sandbar stand (six operable traps), two traps at 1.96 inches showed N_2O levels of 3.14 ppm. Ambient atmospheric N_2O concentration is 0.333 ppm.

Table 1. Soil characteristics, sampled 9 September 1986.

Soil	NH_4^+-N[1]	NO_3^--N[1]	Organic matter[1]	pH[2]	Bulk density[3]
	(ppm)		(%)		(lb/in^{-3})
Sandbar	3.3(2.8)	0.16(0.09)	1.2(0.4)	6.56(0.02)	3.42(0.07)
Alder					
Mineral Soil	4.4(3.9)	0.02(0.03)	4.1(0.4)	6.66(0.02)	2.45(0.15)
Forest Floor	38.4(36.0)	14.30(7.4)	78.0(9.0)	6.80(0.05)	0.20(0.02)
White Spruce					
Mineral Soil	5.9(3.8)	0.07(0.04)	2.5(0.7)	7.02(0.09)	2.64(0.12)
Forest Floor	11.2(8.5)	0.02(0.02)	44.7(2.8)	6.75(0.06)	0.20(0.02)

[1]Mean ($\pm$SE) of 5 replicates at each site. [2]Mean ($\pm$SE) of 12 replicates at each site. [3]Mean ($\pm$SE) of 6 replicates at each site (K. VanCleve, personal communication, Forest Soils Laboratory, AFES, SALRM, UAF.)

Rates of N_2O production within the *in situ* core tubes were below the limit of detection except for two sampling periods in August 1986. Concentrations of N_2O within the old sediment on 15 August 1986 were 0.047 pounds acre $^{-1}d^{-1}$ (±0.03). On 28 August 1986 measured N_2O concentrations within the old sediment, new sediment, and alder stand were 0.13 (±0.31), 0.016 (±0.010) and 0.013 (±0.002) pounds acre $^{-1}d^{-}$ respectively.

The results of the laboratory intact core assay showed no measurable amounts of N_2O production in soils samples that were not amended with acetylene. Intact core samples from mineral soils and white spruce forest floor amended with acetylene showed little or no detectable dentrification activity (table 2). The alder forest floor intact cores had the highest denitrifying activity in September 1986, while showing little or no activity at other sampling times. The potential denitrification rates were substantially higher than the rates in intact cores, with the highest potentials occurring in the alder forest floor on all four sampling dates. In September, the alder forest floor had the highest observable N_2O production rate, with activity approximately 14, 16, and 3 times that measured during May, June, and July.

Discussion

Denitrification is limited by anaerobiosis, NO_3^-, organic substrates, moisture, temperature, and substrate diffusion rates (Robertson and Tiedje 1984, Myrold and Tieje 1985). As primary succession proceeds on the floodplain from the early sandbar stage to the older white spruce stage, there is a peak in the N, moisture, and organic matter content on the alder forest floor, followed by a small decline in these substrates in the older white spruce stand. The mineral soils of each site had similar amounts of N, moisture, and organic matter but showed considerably lower levels of these constituents than the forest floors. The highest observable denitrification activities measured in both field studies and in potential denitrification assays (designed to remove any of the limiting conditions for denitrificaton) were in the alder forest floor at all sampling times. The white spruce forest floor showed greater activites than any of the mineral soils studied. The increased soil microbial activity would be expected to occur in the forest floors because of the larger reserves of N, organic matter, and moisture, with the alder stand having the greatest activity.

There was no observable N_2O production without acetylene amendments, which suggests that other processes that produce N_2O, such as nitrification and NO_3^- respiration, are not ongoing processes in these soils or occurring at undetectable rates. It also suggests that, when there is denitrification activity in any of the soils studied, N_2 is the major end-product of denitrification.

The small amounts of N_2O detectable in the field gas traps but not detectable in the intact laboratory assays, sampled simultaneously, may have been the result of N_2O release from the soils during the spring thaw. Physical removal of the soil cores from the field and an increase in temperature, may have caused sufficient disturbance to have released any N_2O trapped within the soil core profile. Goodroad and Keeney (1984b) observed high rates of N_2O release during the spring thaw and postulated a similar physically initiated release of N_2O produced biologically the previous fall. Although they measured N_2O concentrations that ranged from 1082 to 2066 ppm within the soil profile, the highest concentrations occurred early in the spring thaw. The N_2O concentrations in the soil profile in this study were measured in late spring and are similar to those that Goodroad and Keeney (1984b) observed at a similar period.

There was high spatial variability in all denitrification assays and in field studies. The coefficient of variation (percent V = S/X × 100) ranged from 5 to 250 percent for the intact and potential assays, with the intact cores generally having the highest percent V. This appears to be a common occurrence with estimates of denitrification even in more homogenous agricultural systems (Robertson and Tiedje 1984) and suggests wide variability in soil microbial activity.

The alder forest floor showed the greatest potential for N loss and also had a September maxium intact core rate of N_2O production. The latter may have been in response to the increase in organic matter and nutrients from leaf litter while temperatures were still warm. Van Cleve et al. (1971) estimated a 20-year-old alder stand ecosystem produces 157.7 pound N acre $^{-1}d^{-1}$, whereas the highest intact core denitrifying activity measured under optimal laboratory conditions in this study was estimated as 3.3 pound N acre $^{-1}d^{-1}$ only 2 percent of the total N pro-

Table 2. N_2O production from intact cores and potential denitrification assays, 1986.

	May		June		July		September	
Soils	Intact[1]	Potential[2]	Intact[3]	Potential[2]	Intact[4]	Potential[4]	Intact[5]	Potential[5]
	(ppb N-N_2O d^{-1})							
Sandbar	0[6]	16(18)	7(14)	12(6)	13(1)	234(20)	0	26(14)
Alder								
Mineral Soil	0	83(11)	26(13)	7(12)	18(10)	212(111)	0	1347(454)
Forest Floor	0	609(298)	26(13)	508(142)	37(30)	3124(945)	645(389)	8530(3921)
White Spruce								
Mineral Soil	0	0	17(30)	2(5)	17(1)	228(66)	0	19(17)
Forest Floor	0	23(11)	17(30)	62(45)	69(5)	415(66)	0	1565(290)

[1]Mean (±SE) of 16 replicates at each site, forest floor and mineral soil not separated. [2]Mean (±SE) of 4 replicates at each site. [3]Mean (±SE) of 8 replicates at each site. [4]Mean (±SE) of 3 replicates at each site. [5]Mean (±SE) of 5 replicates at each site. [6]0-values are below the limit of detection, 0.552 ppm N-N_2O.

duced, assuming a similar production rate. These N_2O production rates are similar to intermediate rates observed by Robertson and Tiedje (1984) in midsuccessional temperate hardwood stands and old field communities (1.74-2.61 pound N acre $^{-1}d^{-}$) and the lowest rates observed by Melillo et al. (1984) in northern hardwood stands (c.f. 5.8 ppm N_2O-N organic matter $^{-1}$ organic h^{-1} matter $^{-1}h^{-1}$ v.s. 6.1 ppm N_2O-N organic matter $^{-1}h^{-1}$).

Conclusions

This preliminary study of denitrification within three primary floodplain successional stands suggests that denitrification activity within these soils is low, with the greater *in situ* and potential activity in the alder forest floor. The potential denitrification assays also suggest that some environmental factors limit N loss in these soils, these may be aerobic soil atmosphere, low NO_3^- concentrations, low-quality organic substrates, low moisture, low temperature, and high diffusion constraints. In order to identify the major controls of denitrification in the floodplain soils, further studies are needed to address these potential limiting factors specifically.□

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ject W-166, "Characteristics and Feed Value of Barley and Western Protein Supplements for Swine." This project is a cooperative research effort of swine nutritionists in the western U.S. to determine the physical and chemical characteristics of barley cultivars and their relationship to feeding value for swine and to determine the chemical characteristics and feeding value of western protein supplements for swine. Currently, research is being conducted to determine the feeding value of Alaska's hull-less barley 'Thual' at three test weights for growing-finishing pigs and a cooperative study with Montana, Nebraska, and North Dakota to determine the value of high- or low-salt herring meal as a protein supplement in starter pig diets. The committee will meet in Fairbanks 15 through 18 June 1987 to develop a new four-year project for cooperative swine nutrition research.

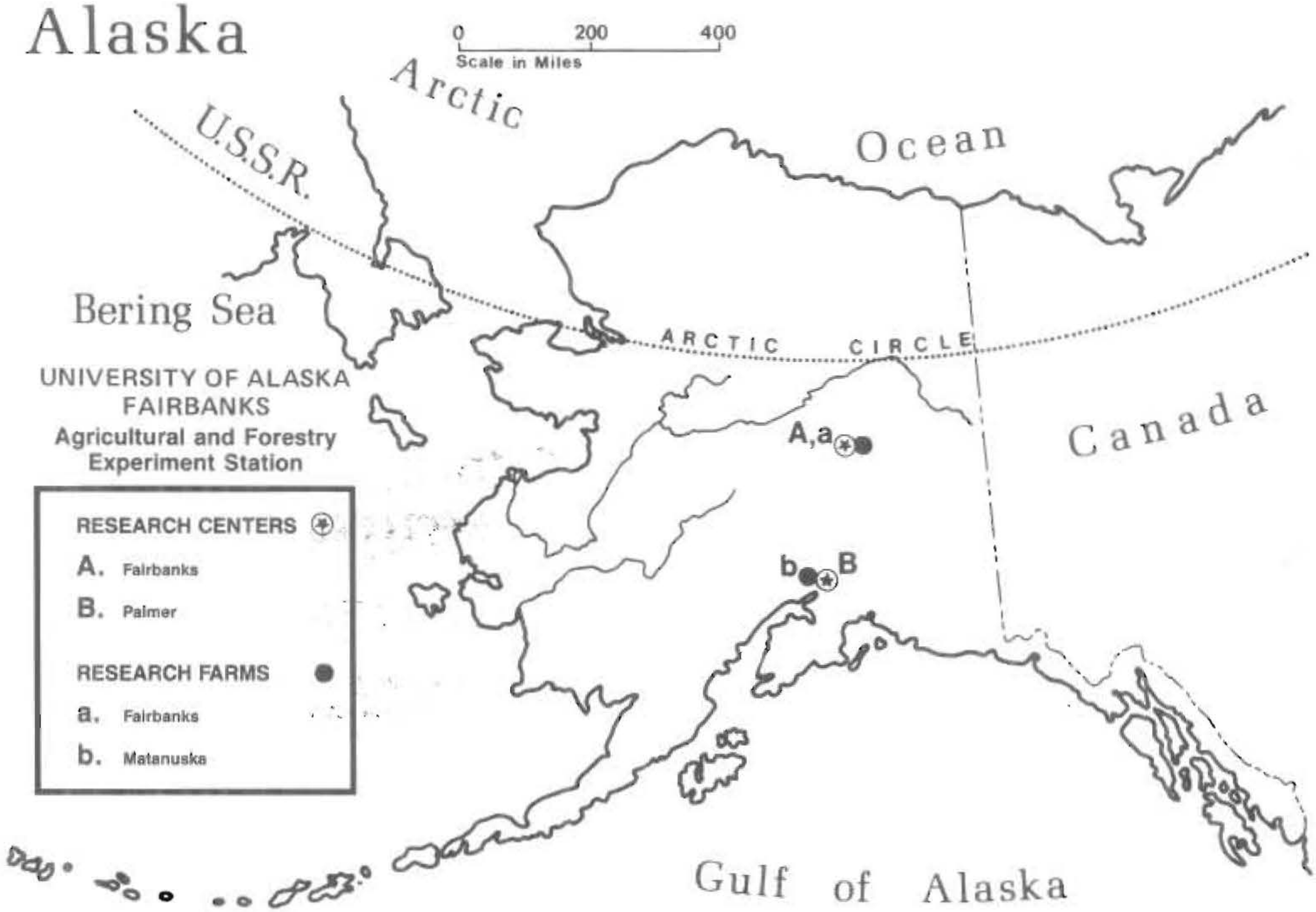
Dr. Ivano Brunner, having obtained his degree recently from the University of Zurich in Switzerland, is currently performing postdoctoral research in the laboratory of **Dr. Gary Laursen.** Dr. Brunner is funded through the Swiss National Science Council and is accompanied by his wife, Franziska, who provides technical assistance for his work.

His studies, the Mycoecology of *Alnus crispa* in Alaska: Taxonomy, Biology, and Ectomycorrhiza in Comparison with the European A. incana and *A. vivadis*, are being performed on plots of alder established by other researchers (Drs. Keith VanCleve, Les Viereck, and John Yarie) as well as those he has established, thus attempting to maximize his results and input for understanding of what alder is really contributing to interior Alaska ecosystems during early serel stages of succession.

Heather McIntyre received a Master of Science degree in May 1986 from the University of Alaska-Fairbanks with a major in horticulture. Her master's thesis, "Horticultural Uses of an Alaskan Peat" examines both lime requirement of Fairbanks peat and nutrient availability of applied fertilizer in peat-amended soils. Ms. McIntyre was a recipient for two years of a graduate fellowship in Resource Problems.

Ms. McIntyre joined the AFES staff in 1983 as an agricultural laboratory assistant for the Horticulture Department.

Patricia Wagner, an agricultural assistant at AFES, recently completed the requirements for the Master of Science degree. Ms. Wagner received her B.A. in zoology from Colorado College in 1967. The title of her thesis for the M.S. is "Manipulation of flowering, fruit set, and fruit ripening in some melons (*Cucurbitaceae*)." Ms. Wagner has been with AFES since 1978. She has worked extensively with flowers and vegetables and has frequently been a coauthor of AFES's annual, published summary of vegetable variety trials. She is also a coauthor of the new AFES publication, Circular 59, "Gardening with Annual Flowers in Interior Alaska." (See About the Cover, page 2.)



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