Agroborealis

Volume 20, Number 1, January 1988

Agricultural and Forestry Experiment Station

School of Agriculture and Land Resources Management

University of Alaska Fairbanks

Roses and the Search for Life

Today many state and national leaders in government and industry are calling for new knowledge, information, science, and technological innovation as important requirements for creating diversified and competitive economies. This issue of Agroborealis *reports research at the Agricultural and Forestry Experiment Station that has potential for increasing the competitiveness of Alaska's agriculture. The series of reports about the production and marketing of roses are examples.*

Several years ago a legislative appropriation was provided to investigate the use of surplus industrial heat to warm soils in Alaskan greenhouses for the production of such high-value crops as roses. Unfortunately, sources of surplus industrial heat have not become available for potential rose growers in Alaska. Nevertheless, the technologies developed through this research have been adopted by a grower in Fairbanks to produce roses commercially in a greenhouse heated with conventional energy sources.

Future innovations for Alaska's agriculture will require research to reduce the costs of production, and may involve such new technologies as molecular biology and genetic engineering. The significance of these new technologies is highlighted in an exhibition entitled "The Search for Life" which opened recently at the National Museum of American History at the Smithsonian Institution in Washington, D.C. This multimedia exhibition illustrates the genetic technologies that are bringing about revolutionary changes in plant science.

At the entrance of the exhibit is a bouquet of red roses similar to those now grown in Alaska. The roses provide a striking introduction to the ways in which plant characteristics express a genetic code. It is interesting to speculate about the breakthroughs that might occur if genetic technologies could be harnessed to develop new plant materials for improving the competitiveness of Alaska's agriculture.

James V. Drew

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

ISSN: 0002-1822

Agroborealis

January 1988

Volume 20 . . . . Number 1

Agricultural and Forestry
Experiment Station

School of Agriculture and
Land Resources Management

University of Alaska Fairbanks

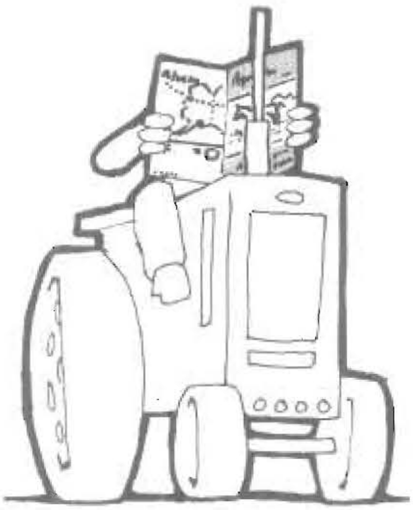
Scientists from the Agricultural Research Service, U.S. Department of Agriculture, cooperate with the Agricultural and Forestry Experiment Station, University of Alaska Fairbanks.

Agroborealis is published by the Agricultural and Forestry Experiment Station, University of Alaska Fairbanks. A written request will include you on the mailing list. Please address all correspondence regarding the magazine to: Publications, Agricultural and Forestry Experiment Station, University of Alaska Fairbanks, Fairbanks, Alaska, 99775-0080.

Managing Editor . . . . Mayo Earnest
Composition . . . . Teri Lawson
Printed by Printing and Duplicating Services, University of Alaska Fairbanks.

Table of Contents

ABOUT THE COVER . . . *The roses shown on this cover of Agroborealis were grown in the Agricultural and Forestry Experiment Station research greenhouse on the University of Alaska Fairbanks campus. Research on growing and marketing such roses in interior Alaska has been underway for several years. The studies are now concluded, and the results have enabled a fledgling cut-rose industry to begin supplying local florists in Fairbanks.*



AFES Notes

Dr. G. Allen Mitchell rejoined AFES in September 1987 as associate dean, SALRM, associate director, AFES; and associate professor of agronomy. Dr. Mitchell has previously served UAF as an agronomy specialist with the Cooperative Extension Service, and as assistant professor of agronomy with AFES. Dr. Mitchell has an M.S. and Ph.D. in soil science with emphasis in soil fertility from the University of California, Riverside. He brings experience to AFES from several land-grant institutions, including the University of Arkansas where he was director of both the Northeast and Southeast Extension and Research Centers, and head of the Agriculture department; and from the University of Georgia where he was assistant professor of agronomy.

Dr. Mitchell hopes to improve AFES service to agriculture and forestry by increasing the focus on applicable research and working closely with the newly appointed division heads at Fairbanks. In addition to maintaining closer ties between researchers at Palmer and Fairbanks, Dr. Mitchell looks forward to closer cooperation between AFES and the Cooperative Extension Service.

Dr. Bonita Neiland, professor of botany and land resources and director of instruction and public service for SALRM, retired in June 1987 after 26 years of service.

Dr. Neiland joined the faculty of the University of Alaska in 1961 as assistant professor of botany teaching such courses as plant ecology and plant physiology. She also developed a successful research program in plant ecology and supervised numerous graduate student research programs in plant succession, vegetation analysis and revegetation in Alaska's forest and bog ecosystems. In 1970 she attained the rank of professor of botany and land resources and served as head of the Department of Land Resources and Agricultural Sciences. In 1975, she became the acting assistant dean for instruction of the newly created School of Agriculture and Land Resources Management and in 1977 became its first director of instruction and public service.

Dr. Neiland came to Alaska from the University of Oregon where she was assistant professor of botany. She attended the University of Oregon where she received her B.S. degree in Biology and M.A. degree in Plant Ecology. She also received a Diploma in Rural Science from the University of Wales as a Fullbright Fellow in 1952 and completed a Ph.D. in Plant Ecology from the University of Wisconsin in 1954.

Dr. Neiland was recently awarded a certificate of recognition by the Resident Instruction Section of the Division of Agriculture, National Association of State Universities and Land Grant Colleges, in appreciation for her valuable leadership and distinguished service as Director of instruction and public service SALRM, University of Alaska Fairbanks 1977-87.

Dr. Neiland is especially appreciated for her tireless efforts in initiating, developing, and strengthening what is now the School of Agriculture and Land Resources Management. It was her dream to develop a program that would give students a broad perspective of the field of natural resources management. That dream has been realized. Our students leave the University of Alaska capable of filling a wide range of positions with many natural resource agencies and organizations.* Dr. Neiland is known to all who worked with her for her fairness and her sensitivity to the needs of students and faculty. She brought to her work a dedication and level of energy that will be difficult to replace.

Dr. Neiland's colleagues and former students,wishing to recognize her work and dedication, have established a scholarship fund in her honor with the full support of the University of Alaska Fairbanks. The Bonita J. Neiland Fund for Natural Resource Scholars will be used to support the

*See inside back cover.

. . . **Continued on page 10**

Wholesale Pricing of Locally Grown Cut Roses In Fairbanks, Alaska

By

Heather C.H. McIntyre* and Marilyn Griffith**

Introduction

The most commonly grown crops in the greenhouse industry in Alaska are flowering annual and bedding plants. Houseplants, containerized plants, and vegetables are also produced for local markets within the state (Brown et al. 1986). Cut flowers account for nearly half the wholesale value of floricultural crops in the United States, yet, until recently no cut flowers were produced by the greenhouse industry in Alaska even though a demand for high quality, locally grown products exists (Brown et al. 1986). One greenhouse operation in Fairbanks started production of cut roses in 1987, but this producer suspends production during the winter months.

Producers of cut flowers in Alaska are at an economic disadvantage compared with growers in southern regions of the United States. Operational costs for year-round greenhouse production are substantially higher in northern locations where seasonal changes in temperature and sunlight are dramatic and where wages, heating fuel, and electricity are expensive. Nevertheless, added cost of shipping flowers to Fairbanks from the west coast of the United States still results in a lower-priced product than locally grown roses, the price of which must include the higher production costs incurred in interior Alaska. In order to compete with suppliers of shipped flowers, it will be necessary for Alaska growers to produce and market locally grown flowers as superior products capable of commanding higher prices.

In 1984, florists and supermarket managers in Fairbanks purchased approximately 175,000 to 200,000 cut roses from growers outside of Alaska. We have estimated the per capita rose consumption to be 2.5 roses per person per year (McIntyre and Griffith, *Agroborealis* this issue). Roses may be a suitable cut flower crop for production in Alaska because cut roses are a high-value crop, because a high volume is sold, and because it is possible to improve dramatically the quality of cut roses through careful product handling. Roses shipped into Alaska are normally cut at a tight bud stage and transported dry. Both these techniques tend to reduce vase life. Roses which are grown for local markets can be harvested after the buds have opened slightly and can be kept continuously hydrated, thus increasing both the vase life and the likelihood the flower will open.

A survey of Fairbanks consumers reveals vase life to be the major indicator of cut rose quality and as an important factor affecting frequency of purchase (McIntyre and Griffith, *Agroborealis* this issue). While 76 percent of the con-

The objective of marketing research at the University of Alaska is to provide information for Alaskan growers such as John Collette of Happy Creek Greenhouses.

***Agricultural Assistant, Agricultural and Forestry Experiment Station, Fairbanks.**

****Assistant Professor, Plant Physiology, Agricultural and Forestry Experiment Station, Fairbanks. Current Address: Biology Department, University of Waterloo, Waterloo, Ontario, Canada.**

sumers expect a flower arrangement to last five days or longer, only 21 percent of consumers find that shipped roses lasted that long. On the other hand, 67 percent of consumers who received locally grown roses during test marketing in 1985 reported that the flowers had a vase life of five days or longer. In addition, 46 percent of the Fairbanks consumers indicate they are willing to pay $.50 per flower more for locally grown roses when the local rose is guaranteed to have a vase life of five days or more than for shipped roses (McIntyre and Griffith, *Agroborealis* this issue).

While consumer surveys were used to examine the flexibility of the retail market for high-quality, locally grown cut roses, the primary objective of this study was to examine the flexibility of the wholesale market. This was achieved by: 1) comparing wholesale prices of shipped and locally grown roses in the northeastern United States, and 2) comparing wholesale prices for shipped and locally grown roses during test marketing in Fairbanks, Alaska. A secondary objective was to determine the extent and causes of losses at the production and retail levels during test marketing. This information will provide potential rose growers with additional decision-making tools when evaluating the profitabilty of growing cut roses for the local market.

Wholesale Prices

Shipped and local roses: Northeastern United States

Wholesale prices for cut roses in the northeastern United States were obtained from the Ornamental Crops Report published by the Agricultural Marketing Service of the United States Department of Agriculture. The markets in Boston, New York City, and Philadelphia were used to compare prices of shipped and locally grown roses because the costs of producing roses in those areas are greater than the combined costs of production and shipping to those areas from California or South America. Locally grown cut roses are generally marketed as a distinct, high-quality product, thus separate prices are published for locally grown and shipped roses (Federal-State Marketing Service 1985).

In 1985, the wholesale price for a locally grown long rose averaged $.41, $.13, and $.23, higher than the price paid for a shipped long rose in Boston, New York City, and Philadelphia, respectively (fig. 1). The range in mean weekly price differential between a locally grown and shipped long rose was $.15 to $1.05 in Boston, $.07 to $.42 in New York City, and $.00 to $1.02 in Philadelphia.

All three northeastern markets showed similar seasonal price fluctuations (fig. 1). The highest cut rose prices occur at Valentine's and Mother's days when consumer demand is highest; and the lowest prices occur during the summer when demand for roses is low and supply is high.

Shipped Roses: Fairbanks

During the course of this study, wholesale prices for fancy, long, medium, and sweetheart roses (see table 1 for

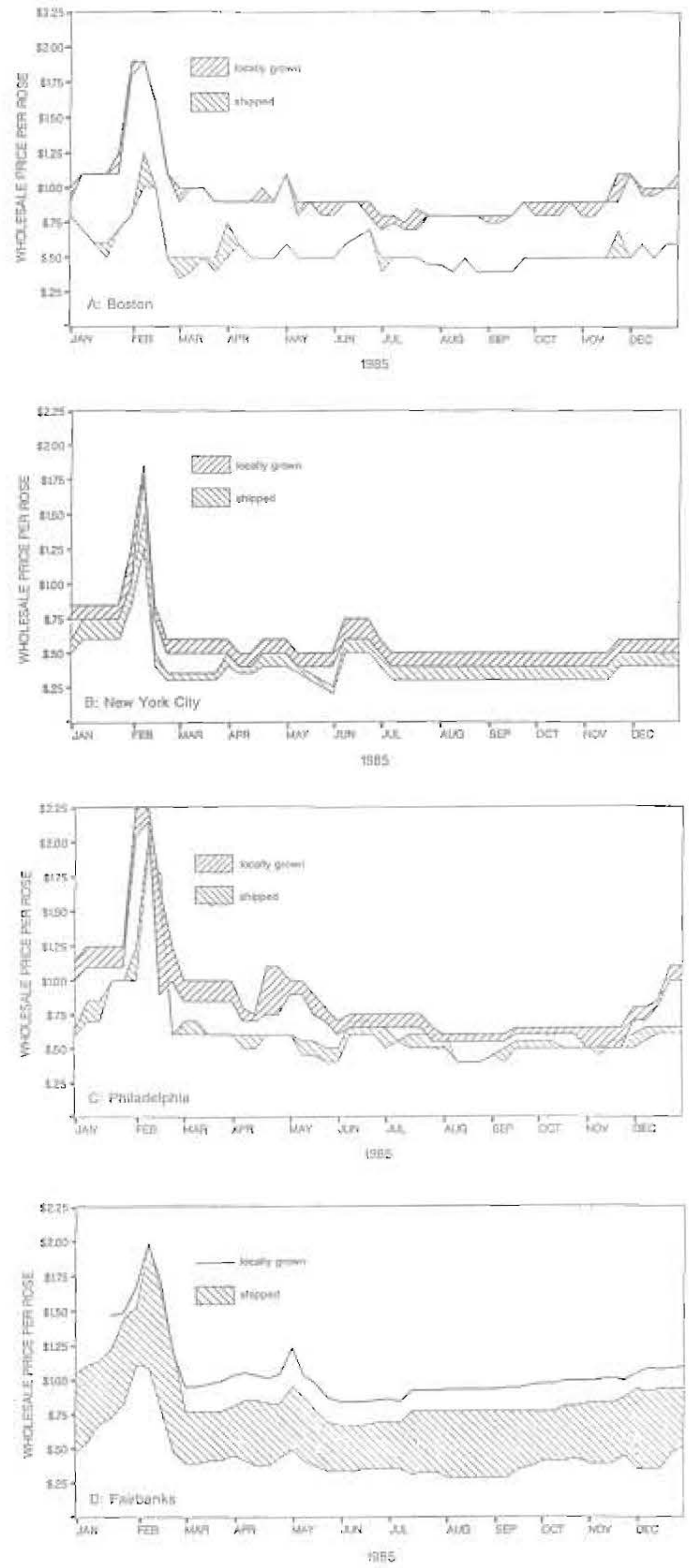


Figure 1. Range in the 1985 wholesale price of shipped and locally grown long roses. Data for Boston, New York City, and Philadelphia prices are from Ornamental Crops Reports (Federal-State Marketing News Service 1985). Prices for locally grown roses in Fairbanks are from this study (see text for calculation of prices).

Table 1. Range in wholesale price per rose for 1985.[1]

	Wholesale price ($/each)			
	Fairbanks	Boston	New York	Phila.
Locally grown roses[2]				
Fancy[3]	.89-2.03	.80-2.00	.50-2.25	.65-2.35
Long	.84-1.98	.70-1.90	.40-1.85	.55-2.25
Medium	.79-1.93	.40-1.75	.25-1.75	.30-2.00
Sweetheart	.69-1.83	.30-1.25	.12-1.00	.25- .90
Shipped roses[4]				
Fancy	.37-1.97	.50-1.50	.40-1.75	.40-2.25
Long	.29-1.97	.35-1.25	.20-1.50	.40-2.10
Medium	.25-1.55	.35-1.25	.20-1.25	.30-1.75
Sweetheart[5]	.15-1.14	—	.10-1.00	.20- .90

[1]High end of range coincided with Valentine's Day; low end of range coincided with summer months.
[2]Locally grown roses refer to cut roses which are grown and sold in the same geographic area. Data from Federal-State Market News Service 1985 and this study.
[3]Roses are graded by stem length as follows: fancy, 24 to 26 inches long; long 18 to 24 inches long; medium, 14 to 18 inches long; sweetheart, 12 to 14 inches long.
[4]Shipped roses refer to cut roses which are grown in California or South America and include shipping costs to markets in Fairbanks, Boston, New York, or Philadelphia. Data from Federal-State Market News Service 1985 for Boston, New York, and Philadelphia. See text for calculation of prices for Fairbanks shipped roses.
[5]No shipped sweetheart roses reported for Boston.

grade descriptions) were monitored weekly for three markets on the West Coast of the United States. Wholesale cut rose prices were obtained from the California Ornamental Crops Report in San Francisco (Federal-State Market News Service 1985) and from two wholesale outlets located in Portland, Oregon, and Seattle, Washington. Air freight quotes from Western, United, and Alaska Airlines were used to calculate the range of charges incurred in delivering roses to Fairbanks from San Francisco, Denver, Portland, or Seattle. Shipping costs ranged from $.09 to $.21 per bloom for a fancy or long stemmed rose, from $.06 to $.15 for a medium rose, and from $.05 to $.10 for a sweetheart rose. The range in wholesale price of shipped roses in Fairbanks was calculated by adding the lowest shipping cost to the lowest weekly quote per grade and by adding the highest shipping cost to the highest weekly price per grade (fig. 1 and table 1).

Most rose suppliers on the West Coast vary their prices on a weekly basis according to supply and demand. However, at least one supplier maintains a constant price year-round. In the West Coast markets, wholesale prices of long roses fluctuated from a high range of $1.00 to $1.76 per bloom at Valentine's Day, to a low range of $.20 to $.56 per bloom in August and September of 1985 (fig. 2). During June and July, one supplier sold all grades of roses at $.35 per bloom. The greatest difference in price between grades occurred at Valentine's Day.

In Fairbanks, the wholesale price of a shipped long rose averaged $.67 in 1985, with seasonal highs of $1.97 at Valentine's Day and Mother's Day, and lows of $.29 in August and September (fig. 1). Florists in Fairbanks normally purchase roses from West Coast suppliers two to four times per week. There is usually a three- to five-day delay between the time the order is placed and the time the roses arrive in Fairbanks, but several florists indicate they can obtain roses within 24 hours when necessary. The ready availability of shipped roses negates any possible supply advantage associated with locally grown roses except when air cargo shipments are delayed.

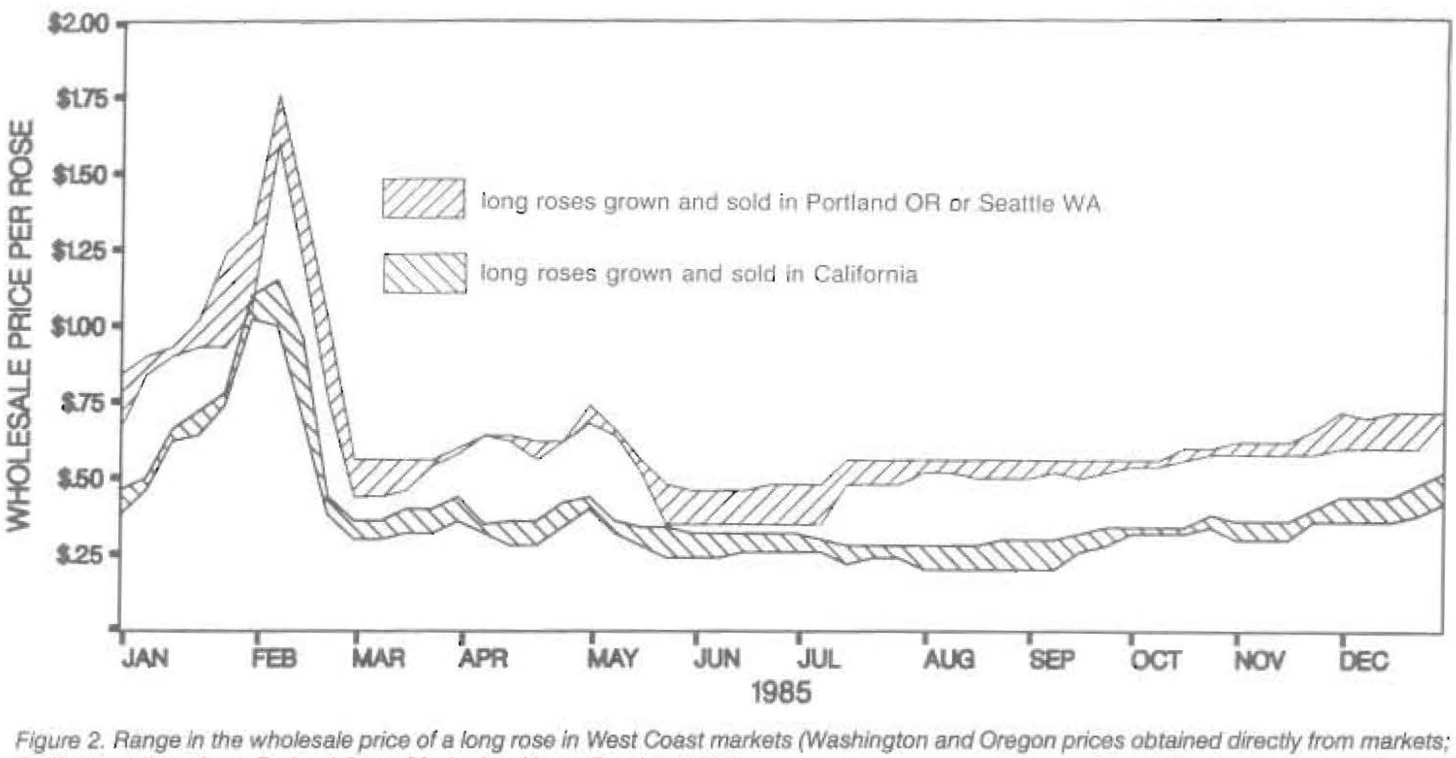


Figure 2. Range in the wholesale price of a long rose in West Coast markets (Washington and Oregon prices obtained directly from markets; California prices from Federal-State Marketing News Service 1985).

Local Roses: Fairbanks

Twelve cultivars of hybrid tea roses and two cultivars of sweetheart roses (*Rosa hydrida* L.) were produced in a greenhouse located at the University of Alaska Fairbanks. Roses were grown in soil beds heated to 72 to 77 degrees Fahrenheit, and supplemental heat and light were used in the winter months. During the daily harvest, cut roses were placed directly into a preservative solution (Floralife adjusted to pH 3.5 with citric acid). The blooms were graded by flower quality and stem length into fancy, long, medium, and sweetheart categories (Roses Inc. 1979). From January 15 until April 23, 1985, the sweetheart grade included all roses 12 to 14 inches long, as well as working grade roses which did not meet stem straightness requirements for the top three grades. After May 22, 1985, the sweetheart grade included only straight-stemmed roses of sweetheart cultivars that were 12 inches and longer. Roses were stored at 38 degrees Fahrenheit and graded again to ensure quality standards before being sold to the florists. Flowers which were not sold to florists because of problems in quality or in wholesale markets were defined as production losses. Production losses were calculated on a weekly basis by comparing the weekly production total (PT) with the weekly total of fancy, long, and medium hybrid tea roses sold to the florists (FT):

Weekly production losses = [(PT-FT)/PT] x 100

Production losses fluctuated dramatically during the year (fig. 3) and can be attributed to changes in the wholesale market of shipped roses and to errors in harvesting flowers. Losses as high as 48 percent occurred between April 23 and May 22, 1985, as a result of changes in the wholesale market. After Easter, a large supply of inexpensive, good-quality roses was available from Colorado, possibly due to improper timing for an Easter flush. Local florists purchased these flowers in quantity and marketed them at reduced prices. Consequently, it was more difficult for florists to sell all but the top quality (fancy and long) locally grown roses. This change in the market resulted in the loss of sales of medium and sweetheart grade roses for one month. High losses in cut rose production at other times of the year were a result of harvesting either immature or overmature blooms; such losses usually occurred when using inexperienced labor.

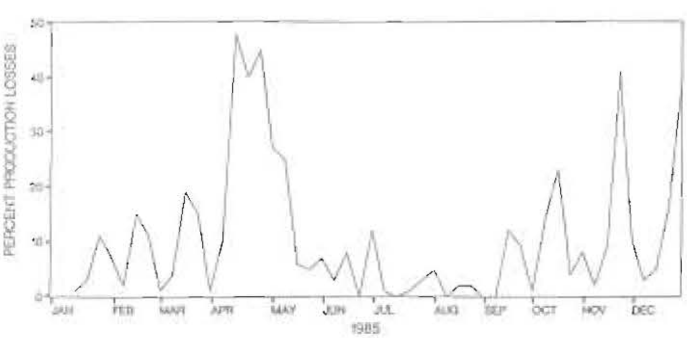


Figure 3. Variation in weekly production losses of cut roses (including fancy, long, and medium grades) grown and marketed in Fairbanks. See text for calculation of production losses.

Test Marketing Locally Grown Roses in Fairbanks

Test marketing was conducted by creating an artificial price structure for the locally grown roses. The average wholesale price for a shipped fancy rose in Fairbanks was calculated weekly by averaging California, Oregon, and Washington wholesale prices and adding $.09 for shipping. All florists in Fairbanks, Alaska, were invited to bid for the right to sell locally grown roses, and the two florists with the highest bids were chosen to participate in the study. The range in florists' bids was $.10 to $.60 per fancy rose above the average wholesale price for a shipped fancy rose.

From January 15, 1985, to January 15, 1986, the cut rose production was divided evenly and sold to the two florists. The wholesale price for a locally grown fancy rose was set weekly by adding the second highest bid of $.40 to the average wholesale price of a fancy rose shipped to Fairbanks from the West Coast markets. Wholesale prices for long, medium, and sweetheart roses were set at $.05, $.10, and $.20, respectively, below the wholesale price of a fancy rose. The florists were asked to provide sales and pricing information for locally grown roses each week and to evaluate the project at the close of the study.

A total of 385 fancy, 4485 long, 5003 medium, and 3617 sweetheart roses were sold to the florists during the year-long marketing study. Because of the artificial wholesale price structure, the wholesale prices of locally grown roses reflected fluctuations in the West Coast wholesale markets, including normal seasonal and holiday trends. In Fairbanks, the range in wholesale price for a locally grown fancy rose was $.89 to $2.03, whereas the range in wholesale price for a locally grown sweetheart rose was $.69 to $1.83 (table 1). In comparison, a locally grown fancy rose sold for $.80 to $2.00 in Boston, $.50 to $2.25 in New York City, and $.65 to $2.35 in Philadelphia in 1985. Locally grown sweetheart roses sold for $.30 to $1.25 in Boston, $.12 to $1.00 in New York City, and $.25 to $.90 in Philadelphia (Federal-State Marketing News Service 1985).

While the wholesale prices of locally grown fancy and long roses in Fairbanks were similar to those in the Northeastern United States, prices set for locally grown sweetheart roses in Fairbanks were much higher than prices elsewhere. A grower could expect the wholesale price for locally grown sweetheart grade flowers to be more than $.20 below the wholesale price for locally grown fancy roses.

Florists' markup percentages were calculated weekly for each grade of cut roses:

Markup percent = [(RP-WP)/WP] x 100

where: RP = retail price
WP = wholesale price

We made no attempt to influence the retail selling price. Despite fluctuations in the wholesale market, both participating florists retailed locally grown roses at relatively constant prices throughout the year. The combination of constant retail prices and fluctuating wholesale prices resulted in an increased markup for the florists during the summer months (fig. 4). The decreased markup experienced during the peak holiday season (Valentine's Day and Mother's Day) may be offset by an increase in the volume of roses sold. The markup was highest for the locally grown fancy and long roses and lowest for the sweetheart roses for both florists (data not presented). The decreased markup for sweetheart grade roses resulted from retailing this grade for $1.00 to $2.00 per bloom less than long roses while the wholesale price was only $.15 less.

Both florists chose to retail locally grown roses at the same price as shipped roses. This practice yielded differences in markup for locally grown roses between florists (fig. 4). Since the wholesale price for a locally grown fancy rose was $.40 higher than the wholesale price of a shipped rose, this resulted in a lower markup for locally grown roses compared to shipped roses. However, this strategy also enabled the florists to introduce the local product and establish a market.

Consumer surveys conducted in Fairbanks showed that most consumers require experience in handling the locally grown roses in order to evaluate such characteristics as vase life and ability to open (McIntyre and Griffith). Ultimately, the profit made with the locally grown roses must be comparable to that with shipped roses if the local product is to retain a share of the market. Based on their experience the florists participating in the study felt they would be able to retail the locally grown roses at higher prices than shipped roses. Surveys of consumers in Fairbanks have shown that the florists could expect to increase the retail price of locally grown roses by $.50 per bloom if the roses have a consumer vase life of five days or more (McIntyre and Griffith).

Losses of locally grown roses at the retail level were also calculated weekly by comparing the number of blooms not sold by florists (NS) to the total number of roses received by the florists (FR):

Retail losses = [(FR-NS)/FR] x 100

Retail losses for locally grown roses were similar for both florists participating in the study. Weekly losses averaged 8.8 percent with a range of 0 to 20 percent for one florist, and 4.2 percent with a range of 0 to 19 percent for the other florist. Both florists indicated that seasonal changes in consumer demand were responsible for periods of high losses. For example, an increased supply of locally grown roses was available for the Christmas holiday; however, increased sales of poinsettias and other flowers reduced the consumer demand for roses.

Both florists developed a clientele of repeat customers who specifically requested locally grown roses. Some were new customers; some were old customers who changed their buying habits and purchased locally grown roses more frequently than they had purchased shipped roses. Both florists promoted the locally grown roses to their customers, although only one florist advertised the availability of locally grown roses on a regular basis. The florists both were willing to purchase locally grown roses on either a seasonal or a year-round basis. One florist thought it would still be necessary to purchase some shipped roses during the summer in order to maintain their wholesale contacts if local roses were available only seasonally.

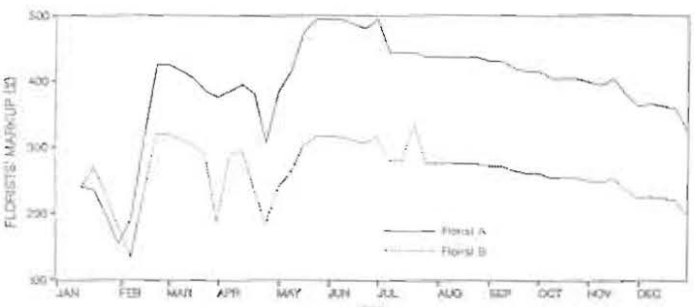


Figure 4. Range in florists' markup percentage for a long rose grown and sold on the wholesale and retail markets in Fairbanks. See text for calculation of markup. Each line represents one of the two participating florists.

Conclusions

Established markets for shipped and locally grown roses in the northeastern United States provide a precedent for charging higher wholesale prices for locally grown roses. Maintaining and promoting quality differences between locally grown and shipped roses is the key to developing a market for higher priced, locally grown roses. Prices increase dramatically only for Valentine's Day sales in all the wholesale markets examined. Thus a decision to grow roses through the winter in Alaska should be made on the basis of the volume of roses to be sold to an established market and not on the basis of large price increases for holidays other than Valentine's Day.

Calculation of the florists' markups indicated that fancy, long, and medium flowers could be sold at a greater markup per bloom than sweetheart varieties. Placing emphasis on the production of top grades is consistent with the goal of marketing a higher quality, locally grown product for a higher wholesale and retail price. The florists' markups were also higher during the summer than during the winter. This suggests that a seasonal operation may be a suitable way to start rose production in Alaska, thus avoiding high production costs associated with year round greenhouses.

Alaskan growers are still likely to be affected by fluctuations in wholesale markets of shipped roses, as seen by the production losses incurred when inexpensive, high quality roses produced in Colorado were available to Alaskan florists in the spring of 1985. Losses will also result from use of inexperienced labor, and from changes in consumer demand at the retail level.

Florists may charge higher retail prices for locally produced roses compared to shipped roses in order to maintain markups comparable to the shipped flowers. However, retail consumers have indicated they are willing to pay more for roses grown in Alaska provided the flowers are high quality and exhibit an extended vase life.□

References

Brown, D.M., P.S. Holloway, and C.A. Kirts. 1986. A survey of the Alaska greenhouse industry and related enterprises: results and analysis. Circular 57. Agricultural and Forestry Experiment Station, University of Alaska-Fairbanks. 40 pp.

Federal-State Market News Service, California Department of Agriculture. 1985. California Ornamental Crops Report. San Francisco: USDA, AMS.

Federal-State Market News Service, Massachusetts Department of Agriculture. 1985. Boston Ornamental Crops Wholesale Market and Shipping Point Prices. Boston: USDA, AMS.

Federal-State Market News Service, New York Department of Agriculture. 1985. New York City Ornamental Crops Report. New York City: USDA, AMS.

Federal-State Market News Service, Pennsylvania Department of Agriculture. 1985. Philadelphia Ornamental Crops Report. Philadelphia: USDA, AMS.

McIntyre H.C.H., and M. Griffith. The importance of vase life in marketing locally grown roses. *Agroborealis*: this issue.

Roses Incorporated. 1979. Rose grades and standards. Michigan: G. Hasslett. 2 pp.

Acknowledgments

We thank the florists of College Floral and Rose and Thistle for participating in this study. Our appreciation is also extended to the wholesalers in Portland, Oregon, and Seattle, Washington, who provided us with weekly wholesale market prices. Thanks also go to Grant Matheke, Pat Wagner, and Maureen Heffernan for their assistance in data collection. Funding for this project was provided by the state of Alaska through its legislative appropriation to the University of Alaska Fairbanks Agricultural and Forestry Experiment Station.

Authors' note: Information presented in the foregoing article, "Wholesale Pricing of Locally Grown Roses in Fairbanks, Alaska," and in the following article, "The Importance of Vase Life in Marketing Locally Grown Roses" was collected during a one-year market study designed to determine if locally grown roses can be marketed as a superior product compared to shipped roses.

Continued from page 4

educational efforts of students in the School of Agriculture and Land Resources Management. Dr. Patricia S. Holloway is chairperson of the Neiland Fund Committee. She may be contacted for further infomation at SALRM, O'Neill Resources Building, University of Alaska Fairbanks, AK 99775-0100.

Dr. W.W. "Bill" Mitchell, professor of agronomy, retired December 1987 after 25 years of service with AFES. He received his B.A. and M.A. degrees from the University of Montana and his Ph.D. degree in agrostology from Iowa State University in 1962. He taught at colleges in Montana and Nebraska prior to joining the Alaska Experiment Station at the Palmer Research Center in the Matanuska Valley.

Dr. Mitchell's early research concentrated on biosystematic studies of native grasses and on ecologic and range studies of some Alaskan grassland types. He helped elucidate the occurrence of hybridization between some Alaskan grasses and the occurrence and distribution of different chromosome races within species. With the advent of the Prudhoe Bay oil discovery, he participated in an ecologic survey along the proposed TransAlaska Pipeline route and subsequently conducted revegetation studies along the route and in the Prudhoe Bay oil field. He also conducted research on rehabilitation of oil-contaminated soils. These efforts involved him thereafter in revegetation and oil-spill repair matters in the state. He conducted other revegetation research on Amchitka Island of the Aleutian Chain in connection with the Cannikin nuclear test shot and on minespoils in three different coal fields in Alaska.

More recently his work with grasses has emphasized forage research, including management practices, variety development and, to a lesser extent, turf research. Dr. Mitchell helped define the forage potential of the native bluejoint grassland type through proper management practices and the application of annual and perennial grasses on newly cleared lands in an agricultural project to revive the dairy industry in Alaska.

His efforts resulted in the release of six grass cultivars utilizing native Alaskan and other north-latitude germplasm. One of these was the first variety made available commercially for use that was known to be of true Arctic origin; it and others of his releases are being used successfully

. . . Continued on page 20

The Importance of Vase Life In Marketing Locally Grown Roses

By

Heather C. H. McIntyre* and Marilyn Griffith**

Rose growers in areas with moderate climates have several economic advantages over potential growers in northern regions of the United States. The major operational costs for year-round greenhouse production are labor, heat, and electricity. All three factors are high in northern locations where the seasonal changes in temperature and sunlight are dramatic and where wages, heating fuel, and electricity are expensive. The cost of transporting roses to Fairbanks, Alaska, from the western United States ($0.09-$0.21 per long stemmed rose) does not offset the higher cost of cut rose production in Alaska. In order for local rose growers to compete in the local rose market with suppliers of shipped roses, it will be necessary to market locally grown roses at a higher price.

It may be economically feasible for a grower to produce roses in Alaska if there is a discernible improvement in the quality of locally grown roses compared to shipped roses and if consumers are willing to pay more for higher quality roses. The greatest potential for improving the quality of locally grown roses lies in the area of product handling. Shipped roses are normally cut at a tight bud stage and transported dry. Both of these conditions tend to reduce the vase life. On the other hand, roses grown for local markets can be harvested after the buds have opened slightly and kept continuously hydrated, thus increasing the vase life and the likelihood the flower will open.

The objective of this study was to determine whether locally grown roses can be marketed locally as a superior, although more expensive, product compared to shipped roses. To meet this objective, we asked consumers in Fairbanks 1) to compare the quality of locally grown roses and shipped roses, 2) to quantify the vase life of locally grown and shipped roses in their homes, and 3) to indicate whether they would pay more for locally grown roses.

*Agricultural Assistant, Agricultural and Forestry Experiment Station, Fairbanks.
**Assistant Professor, Plant Physiology, Agricultural and Forestry Experiment Station, Fairbanks. Current Address: Biology Department, University of Waterloo, Waterloo, Ontario, Canada.

Market research determined that top quality locally grown roses such as these produced at Happy Creek Greenhouses in Fairbanks can be sold at a premium price.

Materials and Methods

Cut rose production

Fourteen cultivars of cut roses (*Rosa hybrida* L.) were produced in a greenhouse located at the University of Alaska Fairbanks. Roses were grown in soil beds heated to 22 to 25 degrees Celsius, and supplemental lighting was used in the winter months. At harvest, cut roses were placed directly into a solution of Floralife (pH adjusted to 3.5 with citric acid) and stored at 3 degrees Celsius. The cut roses were sold to two florist shops for retail distribution in Fairbanks, throughout 1985. These flowers are referred to herein as locally grown roses.

Consumer surveys

A series of surveys were used to describe the local consumer population and to determine consumer perceptions of locally grown roses versus shipped roses. Prior to the sale of local roses, five out of seven local florists distributed 136 two-page surveys to their customers (premarket survey). A similar consumer survey was distributed to 200 customers of the participating florists (florist survey) and to 432 Fairbanks residents selected randomly (random survey) midway through the market study. The random sample of Fairbanks residents was obtained from the telephone directory. The response rates were 33, 23, and 26 percent for the premarket survey, florist survey, and random survey, respectively. (Copies of the surveys are available from the authors upon request.)

The consumer vase life of locally grown roses was quantified from responses to a 'post card survey' which the participating florists included whenever locally grown roses were sold exclusively. A total of 1265 postcards were distributed to consumers who purchased locally grown roses, and 285 post cards were returned for a response rate of 23 percent.

Demographics of Fairbanks North Star Borough

The Fairbanks community demographics (FNSB 1985) differ substantially from national demographics (Bureau of the census 1980) and may have an effect on consumer purchasing characteristics. The population of Fairbanks is younger, with a higher percentage of men (table 1). In addition, the median, per capita, and family income levels are higher than the national average.

Survey respondent demographics

Survey respondents did not reflect accurately the general Fairbanks community. A higher percentage of women and a higher percentage people with greater than sixteen years' education responded to the surveys than would otherwise describe the Fairbanks population (comparison of community and survey respondent demographics is available from the authors upon request).

Table 1. Comparison of demographic data for residents of Fairbanks North Star Borough[1] and the USA, 1980.

Census category	Fairbanks North Star Borough[2]	United States[3]
Median age (years)	26	30
Sex distribution		
males	54%	49%
females	46%	51%
Income		
median	$23,647	$16,461
median family	$26,927	$19,587
per capita	$ 9,823	$ 7,313
family $25,000-49,000	37%	30%
family>$50,000	16%	5%

[1]1984 census estimated population of 69,633.
[2]Fairbanks North Star Borough (1985).
[3]Bureau of the Census (1980).

Data analysis

Statistical analyses were performed on survey data using the SPSSx software package on a Vax 8600 computer. Chi square comparisons (alpha = 0.05) were used to determine whether consumer responses differed among the premarket, florist, and random surveys. Data from the three surveys were combined when no significant differences occurred. Differences between proportions of the surveyed populations were tested for significance using the z statistic (alpha = 0.05). Ninety-five percent confidence intervals were calculated for all proportions.

Results and Discussion

Rose market in Fairbanks

Rose consumption. A survey of floral outlets in the Fairbanks area prior to the market study was used to estimate the local demand for roses. Florists and supermarket managers estimated 1984 sales of cut roses at 175,000 to 200,000 blooms. The majority (85 percent) were sold through retail florists with the remainder sold through supermarkets. Warren and Lewis (1981) estimated that 94,000 roses were sold in Fairbanks in 1978. Annual per capita rose consumption increased from 1.7 in 1978 to 2.5 in 1984.

The purchase of luxury products such as roses would be expected to be proportionate to income levels. However, even though 54 percent of Fairbanks families have annual incomes greater than $25,000, compared to 35 percent of families nationally, the apparent per capita cut rose consumption is very similar. In Fairbanks 2.5 blooms per person per year are purchased versus 2.1 blooms nationally.

Indicators of Quality. Participants in the surveys were asked, "What is the most important indicator of quality when you purchase roses?" and were given bloom size, fragrance, stem length, stem diameter, and vase life as possible responses. The majority of respondents (59 ± 8 percent) identified vase life as the most important indicator of quality when purchasing roses. Fragrance and bloom size were important to 39 ± 8 and 36 ± 7 percent of the respondents, respectively. Stem length and diameter appear to play minor roles with only 6 ± 4 and 4 ± 3 percent of respondents indicating these qualities important. (Percentages do not add up to 100 because of multiple responses by some respondents.)

Frequency of purchase. The frequency of purchase of cut fresh flowers and roses was assessed by asking consumers, "How often do you purchase fresh cut flowers (other than roses)?" and "How often do you purchase roses?" The response categories were: once per week, once per month, once per 6 months, once per year, and less than once per year (table 2). Differences between consumers surveyed through florist shops and those surveyed randomly were tested using chi-square (alpha = 0.05). Consumers purchase fresh cut flowers significantly more frequently than roses (table 2). Florists' customers purchase

Table 2. Frequency of purchase of roses and cut flowers.[1]

Product Consumer survey	n^2	Once per week	Once per month	Once per 6 months	Once per year	Less than once per year
		Frequency of flower purchase				
		(% consumers surveyed ± 95% confidence interval)				
Roses						
florist[3]	81	4±4	28±10	37±11	17±8	14±7
random[4]	89	2±3	8±6	38±10	27±9	25±9
Cut flowers						
florist	86	14±7	41±10	38±10	5±4	2±3
random	105	1±2	31±9	51±10	9±5	8±5

[1]Includes all cut flowers other than roses.
[2]n = number of surveys with a valid response.
[3]Combined data from both premarket and florist surveys, N = 90.
[4]Random survey, N = 114.

Table 3. Factors affecting frequency of purchase by consumers[1] of cut roses in Fairbanks North Star Borough.

Frequency of purchase	n^2	Cost	Vase life	Cost and vase life	Other
		Factors affecting frequency of purchase			
		(% consumers surveyed ± 95 % confidence interval)			
Once per month or more	32	44±17	19±14**	22±14**	16±13
Less than once per month	133	34±8	13±6**	42±8	11±5

[1]Results from premarket, florist, and random surveys combined, N = 204.
[2]n = number of surveys with a valid response.
**Significantly different from cost within row using z statistic, alpha = 0.025.

both roses and cut flowers significantly more frequently than a random sample of Fairbanks consumers. Fifty-five percent of florists' customers buy cut flowers at least once per month, while only 32 percent of the random sample indicate a comparable frequency. Similarly, 32 percent said that they buy roses at least once every month, while only 10 percent of the random sample purchased roses as often.

Respondents were asked why they don't purchase roses more frequently and were given three possible reasons: too expensive, short vase life, and other. The responses were grouped into four categories to account for consumers whose response included both cost and vase life. The consumers were categorized as frequent purchasers, those who buy roses at least once a month, and as less frequent purchasers, those who buy roses less than once a month. For frequent purchasers, the most important reason for not purchasing roses more frequently is cost (table 3). However, for less frequent purchasers, both cost and vase life influence the frequency of rose purchase. Van Tilburg (1984) has also reported greater price sensitivity among habitual buyers of cut flowers.

Comparison of shipped vs. locally grown roses.

Indicators of quality of locally grown roses. Survey participants were asked if they had seen the locally grown roses, and if they felt these roses differed from the normally available shipped roses in bloom size, scent, ability to open, lack of bent neck, color, or vase life. Participants were divided into two groups for analysis: those who had purchased locally grown roses for themselves or received them as a gift were considered direct consumers; those who had seen locally produced roses displayed or had purchased them as a gift were considered indirect consumers. These two groups were compared to determine what factors influenced consumers when evaluating the quality of locally grown roses (table 4). A significantly higher proportion of direct consumers said the locally grown roses were better than shipped in vase life, lack of bent neck, and ability to open. Equal proportions of direct and indirect consumers felt that scent, color, and bloom size were better for locally produced roses. Vase life was the most noticeable difference for 92 percent of direct consumers; however, vase life was considered important by only 64 percent of those with indirect exposure. Therefore, vase life can be used most effectively as a marketing tool when the consumer has had previous experience with the product.

Consumer vase life of shipped vs. locally grown roses. When asked, "What do you think is a reasonable length of time for a flower arrangement to last?" 24±6 percent said the flowers should last at least 3 to 5 days, while 76±6 percent expected them to last 5 days or longer. Participants were then asked how long roses had lasted for them. Only 21 percent said that shipped roses lasted 5 days or longer (table 5).

Postcards distributed with locally grown roses sold in 1985 asked consumers to record the vase life for roses they had received. This information was used to determine consumer vase life for locally grown roses. Sixty-seven percent of respondents who received or purchased locally grown roses found they lasted longer than 5 days (table 5). In a similar study conducted by Goldsberry et al. (1985), 67 percent of roses produced and sold by Colorado State University had a consumer vase life greater than or equal to 4 days. A chi-square comparison indicated a highly significant difference (probability > 0.995) between consumer vase life of shipped and locally grown roses. The rose con-

Table 4. Consumer comparison of locally grown and shipped roses.[1]

Consumer type[2]	n^3	Vase life	No bent neck	Ability to open	Color	Scent	Bloom size
		Locally grown roses are better than shipped roses in what way?					
		(% consumers surveyed ± 95% confidence interval)					
Direct	13	92±14	77±23	62±26	85±20	69±25	54±27
Indirect	77	64±11**	43±11**	36±11*	71±10	69±10	56±11

[1]Results from premarket, florist, and random surveys combined, N = 204. Percentages do not add up to 100 because of multiple responses.
[2]see text for definition of direct and indirect consumer.
[3]n = number of surveys with a valid response.
*,**Significantly different within columns using z statistic, alpha = 0.05 and 0.025, respectively.

Table 5. Comparison of consumer vase life of locally grown and shipped roses.

Source of roses	n[1]	Consumer vase life: longer than 1 day	longer than 3 days	longer than 5 days	longer than 7 days
		(% consumers surveyed ± 95% confidence interval)			
Shipped[2]	43	100	65 ± 14	21 ± 12	5 ± 6
Local[3]**	276	100	83 ± 4	67 ± 6	39 ± 6

[1]n = number of surveys with valid response.
[2]The question "From your experience, how long have long stemmed roses lasted?" was asked only in the premarket survey to prevent confusion between shipped and locally grown roses, N = 45.
[3]Consumers were asked to record this information when they purchased locally grown roses, N = 285.
**Significantly different from shipped roses when tested by chi-square, alpha = 0.005.

sumers found that the vase life of locally grown roses generally met their expectations by lasting 5 days or longer, whereas the shipped roses did not meet their expectations because they lasted 5 days or less.

Willingness to purchase locally grown roses. When asked if they would be willing to go out of their way to purchase locally grown roses, the majority of respondents (87 ± 5 percent) to all three surveys replied "yes." A higher percentage (98 ± 4 percent) of florists' customers would do so to purchase fresh roses. This was verified by both participating florists who said a number of new customers specifically wanted to purchase locally grown roses. In addition, the majority (86 ± 4 percent) of those who responded indicated that they would specify "Alaskan Grown" the next time they purchased roses. There was a strong correlation between unwillingness to buy locally produced roses and short vase life. The few consumers whose locally grown roses lasted less than 3 days indicated that they would not purchase the product again.

Pricing locally grown roses. Survey participants were told "roses in Fairbanks normally retail for $2 to $5 per flower." Participants were then asked, "Would you be willing to pay more for locally grown roses if they would open and last an average of 5 days or longer?" Sixty-seven percent (± 14 percent) of all florist customers surveyed and 59 ± 10 percent of all consumers responding to the random survey indicated they would pay more for locally grown roses. This decreased price sensitivity for the florist market compared to mass merchandising market is consistent with studies by Powell (1976). Customers who felt vase life was important indicated a significantly greater willingness to pay more for locally grown roses (74 ± 17 percent, N = 45) than did respondents from the random survey (65 ± 12 percent, N = 114 tested by z static, alpha = 0.025).

The flexibility in retail price of locally grown roses was assessed by asking, "How much *more* would you be willing to pay?" The response categories were: $.05, $.10, $.25, $.50, $1, and $1.50 per rose. Cumulative percentages show a significant drop between $.50 and $1 more per rose (table 6). These results should be treated with caution, however, because the data were obtained from the stated intentions of rose consumers and not by marketing the locally grown roses at prices different from shipped roses. In addition, the willingness to pay an additional $.50 per rose may vary with the actual selling price (e.g. $2 or $5) of the rose. □

Table 6. Effect of increasing retail price on the proportion of consumers willing to purchase locally grown roses.[1]

Increase in price per bloom: $0.05	$0.10	$0.25	$0.50	$1.00	$1.50
(% consumers surveyed ± 95% confidence interval)					
61 ± 8	59 ± 8	56 ± 8	46 ± 8	22 ± 7	3 ± 3

[1]Consumers who responded yes to the question "Would you be willing to pay more for locally grown roses..." were asked, "How much MORE would you be willing to pay?" Results from florist and random surveys combined, total number of surveys returned = 159, number of surveys with a valid response = 114.

References

Bureau of the Census. 1980. General Population Characteristics, U.S. Summary. U.S. Government Printing Office, Washington, D.C.

Burket, S.D., and G. Benedick. 1980. Fresh Cut Roses, Report to the President on Investigation No. TA-201-42, Section 201, Trade Act of 1974. USITC Pub. 1059.

FNSB 1985. Community Research Center Special Report No. 11. FNSB 1980 Census, Volume 2: Social & Economic Characteristics.

Goldsberry, K.L., N. Baker, and M. Michaels. 1985. Determining the desires of supermarket cut flower customers: a six year evaluation. Part I: Establishing a cut flower program. Res. Bull. 421, Col. Greenhouse Growers' Ass., Inc., in cooperation with Col. State University.

Powell, J.V. 1976. Changing marketing patterns for flowers and plants in the United States. *Acta Hort.* 55: 285-294.

van Tilburg, A. 1984. Consumer Choice of Cut Flowers and Pot Plants. Agric. Univ. Wageningen Papers 84-2.

Warren, C.A., and C.E. Lewis. 1981. Marketing Alaska's Roses. *Agroborealis* 13: 10-14.

Acknowledgments

We thank College Floral, Rose and Thistle, Santina's, Northern Lights, and Pay Dirt Gardens for their assistance in distributing consumer surveys. Thanks also to Dana Thomas and Xuan Pham Quang for statistical advice; Gerald McBeath, Cathy Birklid, and Kirk Baker for assistance in developing the consumer survey; and Grant Matheke, Pat Wagner, Maureen Heffernan, and Sharinda Hummel for assistance in data collection. Funding for this project was provided by the State of Alaska through its legislative appropriation to the University of Alaska Fairbanks' Agricultural and Forestry Experiment Station.

Maximizing the Vase Life of Cut Roses Grown in Alaska

By

Grant E. M. Matheke* and Marilyn Griffith**

Introduction

In areas where production costs for cut roses are high due to increased costs for heating, lighting and/or labor, growers must be able to market their flowers locally at a higher price than shipped roses. A study conducted recently in Alaska showed that consumers would purchase locally grown cut roses more frequently and pay a higher price per bloom if the flowers could be expected to last five days or longer (McIntyre and Griffith this issue). Thus Alaskan growers may be able to compete with the shipped product by maximizing the vase life of the locally grown roses.

The objective of this study was to maximize the vase life of cut roses produced in Fairbanks, Alaska. To meet this objective, this study was designed to: 1) identify a preservative solution for cut roses which performed well in local tap water, 2) to quantify the vase life of locally grown cut roses, and 3) to compare the vase life of locally grown roses to imported roses sold in Fairbanks.

Materials and Methods

Rose production

Roses (*Rosa hybrida* L.) were grown in heated soil beds (72 to 80 degrees Fahrenheit) in a greenhouse at the University of Alaska Fairbanks. Supplemental lighting using high-pressure sodium vapor lamps (123 W/m^2) was provided from October to March to maintain a minimum photoperiod of 16 hours. Roses used for a preliminary screening of preservative solutions were harvested in December 1984 and January 1985. Experiments comparing the vase life of roses in the preservative solutions selected after the preliminary screening were conducted in June and July 1985 and February and March 1986. An experiment to determine the maximum cold storage period without significant degradation of subsequent keeping quality was carried out in March 1986, and a comparison of the vase life of locally grown and imported roses was carried out in February 1986. Flowers were placed in preservative solutions immediately after they were harvested (Mahr and Hanan 1980).

Preservative solutions

Tap water was the solvent for all preservative solutions. Local tap water has a pH of 7.7 and a conductivity of 300 mmho. The specific ion content is: N, 1.7 ppm; P, 0.4 ppm; K, 4.6 ppm; Ca, 43.4 ppm; Mg, 13.3 ppm; Na, 7.8; and chlorides, 18.4 ppm. The specific preservatives tested are: Floralife (Floralife Inc., Hinsdale, Illinois), Florever (Smithers Oasis, Kent, Ohio), and combinations of cobalt nitrate, 8-hydroxyquinoline, citric acid, and sucrose. A preliminary screen of preservative solutions was carried out in order to eliminate those preservative solutions which performed poorly in local tap water. A solution containing 360 ppm cobalt nitrate and 3 percent sucrose, pH 6.9 (Murr et al. 1979, Venkatarayappa et al. 1980, 1981), was eliminated from further testing because it resulted in petal edge necrosis of the roses. A solution of 360 ppm cobalt nitrate, 200 ppm 8-hydroxyquinoline, and 3 percent sucrose, pH 3.8, formed a precipitate and proved ineffective in prolonging vase life. Preservatives which proved useful following the preliminary screen are listed in Table 1.

Determination of vase life

Flowers were conditioned in the preservative solution at 39 degrees Fahrenheit for 4 hours, then recut at least 1

*Agricultural Assistant, Agriculture and Forestry Experiment Station, Fairbanks.
**Assistant Professor, Plant Physiology, Agricultural and Forestry Experiment Station, Fairbanks. Current address: Biology Department, University of Waterloo, Waterloo, Ontario, Canada.

Table 1. Preservative solutions[1] used in vase life studies of cut roses grown in Alaska.

Preservative	Concentration	pH
Floralife + citric acid	9.5 g/l Floralife 0.6 g/l citric acid	3.5
Floralife	9.5 g/l Floralife	6.0
Florever + citric acid	4.7 g/l Florever 1.1 g/l citric acid	3.5
Florever	4.7 g/l Florever	6.3
Tap water		7.7

[1]The solvent for all solutions was tap water. See Materials and Methods for tap water composition.

Table 2. Effect of preservatives on the vase life of cut roses harvested in June and July, 1985, in Alaska.

	Rose Cultivar			
Preservative	Golden Fantasy	Romance	Royalty	White Satin
	mean vase life (days)			
Floralife + citric acid	5.5b[1]	9.0a	11.7a	9.0a
Floralife	7.0a	7.0b	8.3b	5.7b
Florever + citric acid	4.3bc	5.5c	7.7b	5.7b
Florever	3.5c	4.3c	8.0b	5.0b
Tap water	5.0b	4.0c	7.0b	5.7b

[1]Values in columns with different letters are significantly different (Duncan's multiple range test) at the 5 percent level, n = 3.

inch above the original cut, and stripped of all leaves except the upper three. Flowers used to determine the maximum cold storage period without degradation of keeping quality were kept at 39 degrees Fahrenheit from 1 to 8 days. The stem length was constant within each experiment and ranged from 16-23 inches. After recutting, each flower was transferred to a graduated cylinder containing 250 ml preservative solution. The flowers were illuminated for 12 hours daily with 670 W/cm2 from Sylvania cool white fluorescent lamps. The testing room conditions were: temperature between 66 and 75 degrees Fahrenheit, relative humidity between 40 and 80 percent, and a low velocity air exchange (Halevy and Mayak 1981). Observations of flower condition, foliage condition, and bent neck were made every 24 hours. The end of useful vase life was determined by wilting of the petals, by discoloration or blueing of the petals, or by the occurrence of bent neck.

Water balance

Each cylinder of preservative solution was weighed daily with and without the flower. The fresh weight of individual flowers was calculated as the weight of the flower + cylinder + solution minus the weight of the cylinder + solution alone. Water uptake was calculated as the difference between consecutive measurements of the cylinder + solution. Transpiration was measured as the difference between consecutive measurements of the weight of the flower + cylinder + solution (Venkatarayappa et al. 1980). Water balance was defined as water uptake minus transpiration. Reports of other studies indicate that water loss by evaporation from the cylinders was negligible (Murr et al. 1979, Venkatarayappa et al. 1980).

Data analysis

In all experiments, each flower represented a replication. The number of replications and the varieties tested varied between experiments and are presented with the results. The effect of preservative solutions and cold storage on vase life was analyzed using a one-way analysis of variance (ANOVA). The vase life of local and imported roses was also analyzed using a one-way ANOVA. Differences in vase life between varieties are well documented and were not analyzed. Mean separation was determined by Duncan's multiple range test. Daily measurements of fresh weight increase, water uptake, transpiration, and water balance were analyzed using a nested ANOVA to test for significant differences between preservative solutions and between the day of measurement and the interaction between preservative solution and day of measurement (both were nested within preservative). Because of unequal cell sizes resulting from differences in the vase life of individual flowers among preservatives, the Tukey-Kramer modification for unequal cell sizes of Tukey's HSD was used for mean separation.

Results

Selection of preservative by vase life

Floralife, pH 6.0, and Floralife + citric acid, pH 3.5, were the only preservative solutions tested which significantly improved vase life beyond the tap water control in flowers harvested during the summer (table 2). Cut roses of the cultivars 'Romance,' 'Royalty,' and 'White Satin' lasted longer in pH adjusted Floralife than Floralife alone. The shorter-lived yellow cultivar 'Golden Fantasy' performed best in Floralife without citric acid.

Additional experiments using solutions of Floralife and Floralife + citric acid were conducted to compare the vase life of flowers produced under winter conditions. The rose cultivars examined were 'Eterna,' 'Golden Fantasy,' 'Royalty,' and 'White Masterpiece.' Although the vase life was slightly greater in the pH adjusted Floralife for all four cultivars tested, the only significant difference was found in the long lived cultivar 'Royalty' (table 3). All Floralife + citric acid and Floralife treatments of locally grown roses resulted in a vase life of five days or longer.

Selection of preservative by flower fresh weight

The fresh weight increase of opening 'Romance' roses treated with Floralife was significantly greater than roses treated with Florever and the tap water control, but it was

Table 3. Effect of preservatives on the vase life of cut roses harvested in March, 1986, in Alaska.

	Rose Cultivar			
Preservative	Eterna	Golden Fantasy	Royalty	White Masterpiece
	mean vase life (days)			
Floralife + citric acid	12.7a[1]	9.0a	15.2a	7.4a
Floralife	11.0a	8.8a	10.6b	6.6a

[1]Values in columns with different letters are significantly different (Duncan's multiple range test) at the 5% level, n = 5.

Table 4. Effect of storage at 4 degrees Celsius on the vase life of 'Royalty' roses[1] preserved in Floralife + citric acid.

Storage time	Vase life	Storage time	Vase life
days		days	
1	12.0 b[2]	5	8.3 cd
2	9.7 bcd	6	15.0 a
3	10.7 bc	7	11.0 bc
4	10.3 bcd	8	7.7 d

[1]n = 3 for all storage treatments except the 6-day where n = 2.
[2]Values in columns with different letters are significantly different (Duncan's multiple range test) at the 5% level.

not significantly different from all other treatments (fig. 1a). For 'White Satin,' the fresh weight increase in Floralife + citric acid was significantly greater than all other treatments except Florever + citric acid (fig. 1b). The fresh weight increase of 'White Satin' in pH adjusted Florever was also significantly greater than in Florever alone. There were no significant differences in the fresh weight increase of either 'Golden Fantasy' or 'Royalty' roses treated with any of the preservatives (fig. 1c and 1d). In experiments using local tap water, Florever did not prolong vase life, nor did it improve the fresh weight increase usually observed in roses as they open (table 2 and fig. 1).

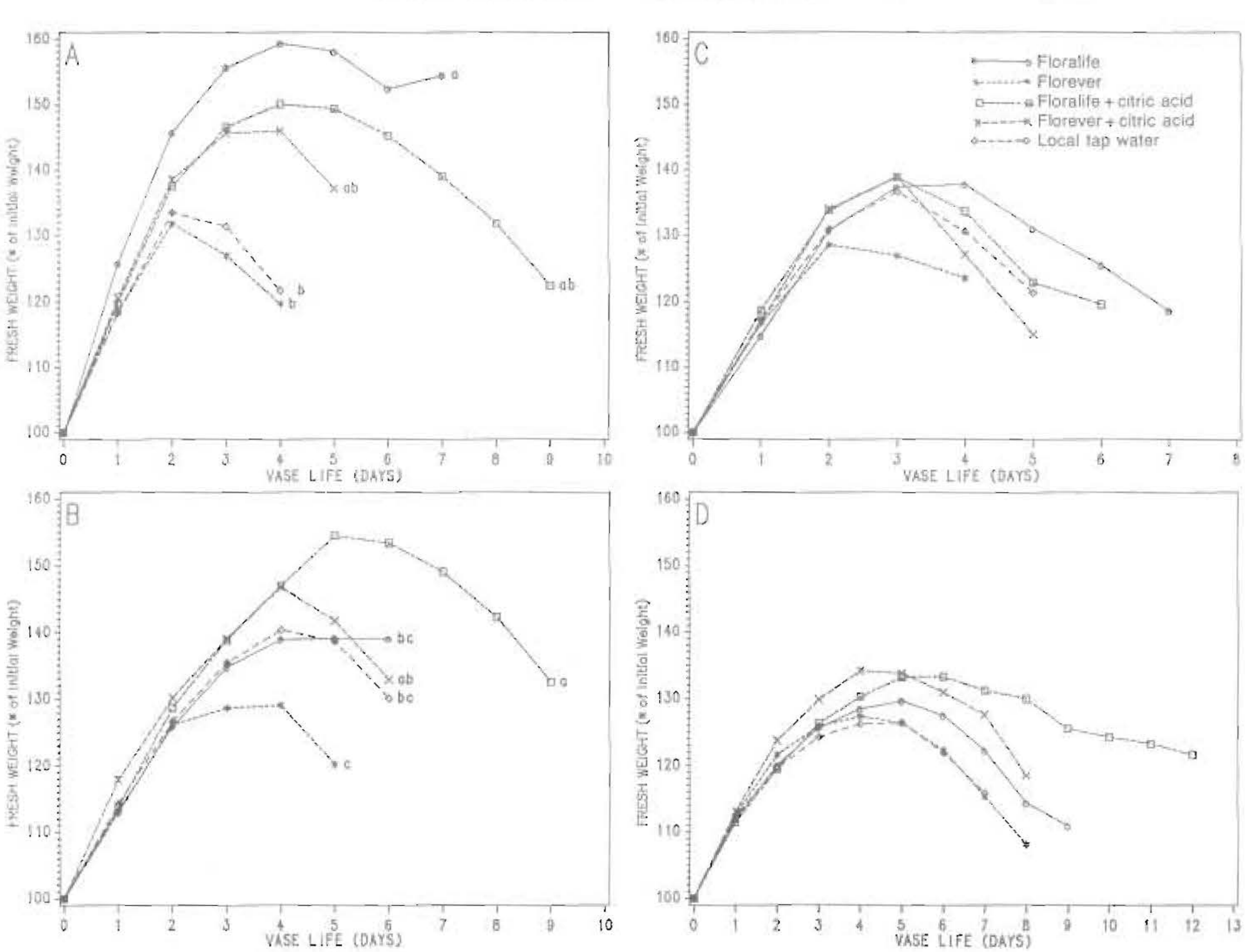


Figure 1. Effect of preservative solutions on the increase in fresh weight of opening cut roses (n = 3). Roses were harvested in June and July, 1985, in Fairbanks, Alaska. Rose cultivars were: A) 'Romance,' B) 'White Satin,' C) 'Golden Fantasy,' and D) 'Royalty.' Preservative concentrations are shown in Table 1. Curves with different letters are significantly different (Tukey's HSD as modified by Tukey-Kramer for unequal cell sizes) at the 5% level.

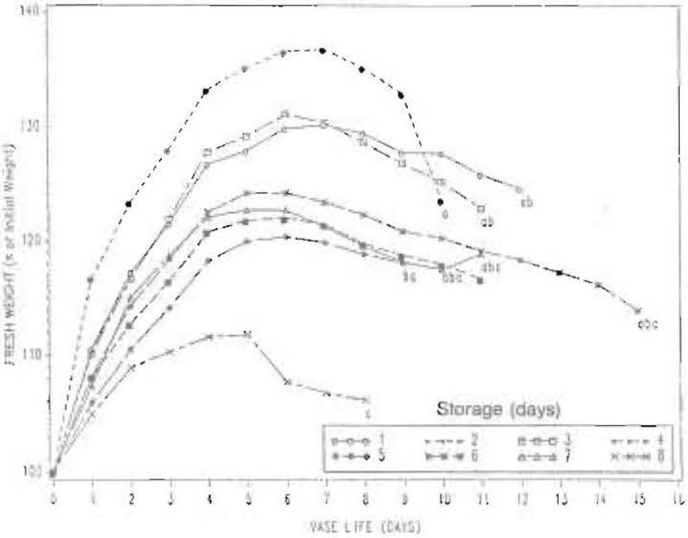


Figure 2. Effect of storage at 39 degrees Fahrenheit on the increase in fresh weight of opening 'Royalty' roses (n = 3 except for roses stored 6 days where n = 2). Roses were stored in a solution of Floralife + citric acid. Curves with different letters are significantly different (Tukey's HSD as modified by Tukey-Kramer for unequal cell sizes) at the 5% level.

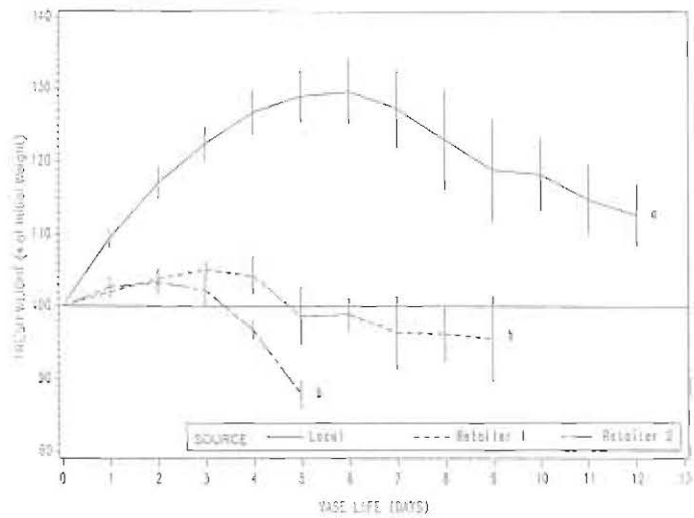


Figure 3. Comparison of the increase in fresh weight of opening 'Royalty' roses grown locally and 'Royalty' roses purchased from two retailers in Fairbanks, Alaska (n = 6). All roses were placed in Floralife + citric acid. Error bars represent standard error of the mean. Curves with different letters are significantly different (Tukey's HSD as modified by Tukey-Kramer for unequal cell sizes) at the 5% level.

Effect of cold storage on vase life

In order to determine the maximum storage life of locally produced roses, 'Royalty' roses were harvested, placed in a solution of Floralife + citric acid, and held in cold storage at 39 degrees Fahrenheit for 1 to 8 days before beginning vase-life studies. Roses held in cold storage for 7 days exhibited no significant decrease in vase life (table 4). The fresh weight increase of roses stored for 8 days was significantly less than that of roses stored from 1 to 3 days (fig. 2). Therefore the maximum wet cold storage time for locally grown roses appeared to be about 7 days because the fresh weight gains during flower opening appeared to decrease markedly after 7 days (fig. 2). The vase life of cut roses is influenced markedly by growing conditions in the greenhouse before harvest, and this may account for the long vase life attained by the roses stored for 6 days.

Comparison of vase life of locally grown vs. shipped roses

The vase life of locally grown 'Royalty' roses was compared to shipped roses of the same cultivar obtained from two retail outlets in Fairbanks Alaska in February 1986. The mean vase life of locally grown roses in Floralife + citric acid was 12.2 days (n = 6), and was significantly longer (Duncan's multiple range test, 5 percent level) than the mean vase life of roses purchased from either retailer (9.1 or 5.3 days). The fresh weight increase (fig. 3) and water balance of locally grown roses was also significantly greater than shipped roses from both sources. One noticeable difference between the flowers was that shipped roses failed to open fully. Only 58 percent of the roses obtained from one of the retailers opened past the loose bud stage. Even though all roses obtained from the second retailer opened past the loose bud stage, none of the flowers opened fully. In contrast, all locally grown roses opened fully before the end of their useful vase life.

Discussion

Selection of a preservative

Floralife and Floralife + citric acid were the only preservative treatments which significantly lengthened the vase life of locally grown roses and increased fresh weight gains of the flowers when compared with the tap water control (table 2). The benefits of low pH water (pH 3 to 4) for most preservative solutions has been documented (Halevy and Mayak 1981). However, Durkin (1986) reported that Floralife did not perform well at a pH lower than 4 because the preservative formed aluminum hydroxide precipitates in waters high in bicarbonates. In addition, the biocides in Floralife were selected to perform best at pHs ranging from 4.5 to 5.0, and so vase life was reduced at a pH of 3.5 due to poor microbial control. When Floralife alone was used in Fairbanks tap water, a precipitate formed, the pH was 6.0, and a microbial growth developed on the cut ends of flowers. No precipitate or microbial growth was noted in Floralife + citric acid solutions at pH 3.5. Locally grown roses exhibited a shorter vase life in Floralife + citric acid, pH 4.5, when compared with Floralife at pH 3.5. On the basis of this evidence, it appears that in local tap water, Floralife + citric acid, pH 3.5, is the best preservative among those tested.

Vase life of locally grown roses

The vase life of roses grown in Fairbanks varied by cultivar. 'Royalty' exhibited a mean vase life in Floralife + citric acid of 12 to 15 days, while 'Eterna' lasted 13 days, and 'Romance' and 'White Satin' lasted 9 days. 'Golden Fantasy' exhibited a vase life of 6 to 9 days, while 'White Masterpiece lasted 7 days (tables 2 and 3). 'Royalty' roses could be stored up to 7 days at 39 degrees Fahrenheit without a significant effect on keeping quality. With the use of an appropriate preservative, all cultivars tested would provide a vase life in excess of the five days required to achieve consumer preference for locally grown roses (McIntyre and Griffith 1988).

The summer environmental conditions in Fairbanks are thought to be especially good for rose production because of moderate temperatures and a photoperiod which reaches a maximum of 21 hours in June. However, the vase life of Alaskan grown roses is the same as the vase life of fresh (not shipped) roses grown in lower latitudes which are placed directly into preservative solutions upon harvest (Faragher et al. 1984, Mahr and Hanan 1980).

Comparison of flower quality of locally grown vs. shipped roses

Locally grown roses have received public acceptance in test marketing in Fairbanks, Alaska, because of their long vase life, ability to open, fragrance, and lack of bent neck (McIntyre and Griffith 1988). A comparison of locally grown and shipped 'Royalty' roses confirmed some of the consumers' perceptions. Locally produced roses had a longer vase life (table 2), gained more fresh weight (fig. 3), were more resistant to blueing, and opened more fully when compared to shipped roses.

The reduced quality of shipped roses can be attributed to several factors. Flowers transported long distances may be harvested at an earlier bloom stage to reduce damage from adverse conditions during shipping (Halevy and Mayak 1979) and to improve storage life (Faragher et al. 1984). The flowers purchased from one Fairbanks retailer were in a tighter bud stage than the locally grown roses at harvest. Cutting roses at an early stage of development reduces petal growth and petal reflexing (Faragher et al. 1984) and may reduce vase life by increasing susceptibility to bent neck (Kohl 1961, Parups and Voisey 1976). The dehydration-rehydration cycle of shipped roses can reduce subsequent water uptake rates, fresh weight gains, and vase life (Besemer 1977, Durkin 1979, Durkin 1983). In addition, cold storage reduces final flower diameter, petal opening, and subsequent vase life, and can cause increased blueing (Bredmose 1979, Faragher et al. 1984, Halevy et al. 1978, Halevy and Mayak 1979, Halevy and Mayak 1981, Parups and Voisey 1976).□

References

Besemer, S.T. 1977. Handling of cut roses: Conditioning after harvest, use of antitranspirants and various consumer solutions. *Florists Review 106*: 80-81, 128-32.

Bredmose, N. 1979. The influence of subatmospheric pressure of storage life and keeping quality of cut flowers of 'Belinda' roses. *Acta Agric. Scand. 29*: 287-90.

Durkin, D.J. 1979. Effect of Millipore filtration, citric acid and sucrose on peduncle water potential of cut rose flowers. *J. of the Amer. Soc. for Hort. Sci. 104*: 860-63.

Durkin, D.J. 1983. Handling cut rose flowers. *Florists Review 173*: 40-42, 44.

Durkin, D.J. 1986. Studies on the handling of cut rose flowers. *Roses Incorporated Bulletin (March)*: 68-76.

Faragher, J.D., S. Mayak, T. Tirosh, and A.H. Halevy. 1984. Cold storage of rose flowers: Effects of cold storage and water loss on opening and vase life of 'Mercedes' roses. *Sci. Hort. 24*: 369-78.

Halevy, A.H., T.G. Byrne, A.M. Kofranek, D.S. Farnham, J.F. Thompson, and R.E. Hardenburg. 1978. Evaluation of postharvest handling methods and transcontinental truck shipments of cut carnations, chrysanthemums and roses. *J. Amer. Soc. Hort. Sci. 103*: 151-55.

Halevy, A.H., and S. Mayak. 1979. Senescence and postharvest physiology of cut flowers, part 1. *Hort. Rev. 1*: 204-36.

Halevy, A.H., and S. Mayak. 1981. Senescence and postharvest physiology of cut flowers, part 2. *Hort. Rev. 3*: 59-143.

Kohl, H.C. 1961. Rose neck droop. *Cal. State Florists Assn. 10*: 4-5.

Mahr, J., and J.J. Hanan. 1980. Tests on preservative solutions for cut roses and carnations. *Col. Greenhouse Growers Assn. Bull. 365*: 1-3.

McIntyre, H.C.H., and M. Griffith. 1988. The importance of vase life in marketing locally grown roses. *Agroborealis*, this issue.

Murr, D.P., T. Venkatarayappa, and M.J. Tsujita. 1979. Counteraction of bent-neck of roses with cobalt nitrate. *Can. J. Plant Sci. 59*: 1169-71.

Parups, E.V., and P.W. Voisey. 1976. Lignin content and resistance to bending of the pedicel in greenhouse-grown roses. *J. Hort. Sci. 51*: 253-59.

Venkatarayappa, T., M.J. Tsujita, and D.P. Murr. 1980. Influence of cobaltous ion (Co^{++}) on the postharvest behavior of Samantha roses. *J. Amer. Soc. Hort. Sci. 105*: 148-51.

Venkatarayappa, T., D.P. Murr, and M.J. Tsujita. 1981. Effect of Co^{++} and sucrose on the physiology of cut Samantha roses. *J. Hort. Sci. 56*: 21-25.

Acknowledgments

The authors would like to thank Patricia Wagner, Heather McIntyre, Maureen Heffernan, and Scott Pettit for technical assistance, and Dana Thomas for statistical advice. Research on rose production was initiated by Dr. Donald Dinkel.

Continued from page 10

under the severe conditions of the Arctic. Another is adapted to the northern coastal and maritime regions and has found application in such other countries as Iceland. His latest releases were directed at meeting such groundcover demands as those on minespoils and rights of way, and as forages in cool-season, acid-soil situations. In the year just prior to retirement, he served as acting assistant director of the Alaska Agricultural and Forestry Experiment Station.

Dr. Leslie J. "Buzz" Klebesadel, professor of agronomy, retired July 1987 after 30 years of service at the Alaska Agricultural Experiment Station in Palmer. Born and raised on a dairy farm in Sauk County, Wisconsin, he earned B.S., M.S., and Ph.D. degrees at the University of Wisconsin, majoring in agronomy and soils. He worked as an agronomy aid at Alaska's Matanuska Research Farm in 1949 and 1953 and joined the experiment station staff in 1957 as an assistant professor (UA) and research agronomist (USDA) under a cooperative agreement program.

When the joint state/Federal program was terminated in 1968, Dr. Klebesadel shifted to Federal status as scientist-in-charge and location leader of the USDA-Agricultural Research Service scientific staff and program in Alaska. He served in that capacity until 1981 when he elected to relinquish supervisory responsibilities to return to a full-time research role.

In 1958, Dr. Klebesadel helped establish and launch the University of Alaska's Palmer Community College (later Matanuska-Susitna Community College). As its first director, he helped to design the curriculum, hire faculty, establish liaison with the university administration, and direct operations. During the establishment of that institution, his wife, Mary Jane, served as first registrar of the community college. He later developed and taught a course on adaptation and management of forage crops in Alaska at the College, and he has regularly provided guest lectures in numerous other agricultural courses taught there.

Dr. Klebesadel recognized the need for a plant materials center in Alaska in the 1950s, prepared the justification for its creation and operation, and worked cooperatively with others to bring about its successful establishment in the Matanuska Valley.

In 1974, he was named to a seven-member task force of forage specialists to visit numerous agricultural and scientific locations in the Soviet Union. Objectives were to explore opportunities for research cooperation and to establish contacts with northern USSR institutes to determine new sources of useful plants adapted to Alaska's northern environmental conditions. He also fostered cooperation with other circumpolar research laboratories to exchange northern-adapted plant germplasm toward mutual benefits.

Dr. Klebesadel's research has focused primarily on establishment and management of forage crops, seed production, and winterhardiness. He has assisted in collection and evaluation of native grasses and legumes from throughout Alaska, and in selection of superior, adapted plant strains for forage, turf, and conservation purposes. He studied photoperiodic influences on plant behavior and has identified physiological characteristics that govern winter survival. Dr. Klebesadel also identified originally midtemperate-adapted plant ecotypes within several species that have undergone beneficial adaptive genetic and physiologic modification through numerous generations of natural selection in Alaska's unique subarctic climatic conditions. He has reported research results at local, statewide, national and international conferences and has published about ninety reports in scientific and popular outlets.

Roscoe Taylor, professor of agronomy, retired December 1987 after 34 years of combined service with AFES and the USDA Agricultural Research Service. He received his B.S. degree from South Dakota State University in 1948 and his M.S. from Iowa State University in 1950 with training and experience in cereal crop breeding.

Mr. Taylor has extensive experience in crop breeding and production research in Alaska involving both grain and forage crops. His work in developing adapted cereal varieties emphasized earliness and disease resistance for Alaskan grain production conditions. His most recent work has been with cereal breeding involved the development of barley varieties possessing urgently needed disease resistance, early-maturing oat varieties suitable for grain and forage, and early-maturing wheat varieties with improved grain yield and quality.

He is responsible for the development of five barley varieties, two oat, two wheat, and one rye, all of which are adapted to Alaska's short growing season. Mr. Taylor aided in the development and maintenance of one variety each of bluegrass, red fescue, bromegrass, alfalfa, and red clover.

Mr. Taylor assisted in securing a series of monetary grants from the Rockefeller Foundation in the 1950s and '60s that augmented budgets, added staff, and expanded research programs at the station. He served as investigation leader, coordinating innovative and pioneering plant explorations throughout Alaska for the purpose of collecting and evaluating native grasses and legumes.

He served as head of the station's agronomy staff from 1956 to 1968. Though his research was headquartered at the Matanuska Research Farm, he enlisted many grower-cooperators in other agricultural areas to evaluate cereal varieties and selections under the specific soil and climatic conditions of those off-station locales.

. . . Continued on page 24

Pruning Strategies For Greenhouse Rose Production in Alaska

By

Grant E.M. Matheke* and Marilyn Griffith**

Introduction

Pruning is an important horticultural practice in the production of cut roses because it reduces plant height, facilitates the removal of weak growth, and produces a more vigorous plant by inducing the development of renewal canes from the base of the plant. In addition, pruning can also be used to reduce flower production when demand is low. Pruning followed by pinching (removal of the terminal portion of a cane) is used to maximize yields during such periods of high demand as Valentine's Day. Pruning can be carried out in several ways. In gradual or "knife" pruning, plants are cut back slowly as flowers are harvested. This procedure results in the steady production of new breaks and yields a continual supply of cut roses. Alternatively, direct-pruned plants (complete cutback) are all cut at the same time either by hedge pruning to a specified height or by selectively pruning the canes at various heights depending on their diameter. Direct-pruned plants regenerate new shoots and flowers synchronously, so that the process creates a cyclic pattern of flower production. Either gradual or direct pruning may be combined with a pinch in order to obtain a flush of flowers during periods of high demand.

The effect of pruning on cut rose production has been studied with greenhouse plants grown at lower latitudes (Bivens and Hasek 1973; Depauw 1975; Holley 1973a,b; Kohl and Smith 1969,1970; Moe 1971; Zieslin and Mor 1981). Bivens and Hasek (1973) and Holley (1973b) report no significant differences between subsequent winter yields after either gradual or direct pruning. Bivens and Hasek (1973) did note that direct pruning resulted in a reduction of 16 percent of total yield because of the time direct pruned plants were out of production. However, they felt direct-pruning was still advantageous because it resulted in an increase in renewal canes of 24-34 percent over gradual pruning. Zieslin and Mor (1981) report no significant differences in winter flower production between selective pruning and hedge pruning when the plants are pruned 40 inches or more above the ground. Hedge pruning results in a considerable reduction in labor over selective pruning and lends itself to mechanization. However, low hedge pruning at 6 to 24 inches from the soil surface dramatically reduces yields of cut roses (Kohl and Smith 1970, Moe 1971, Zieslin and Halevy 1976, Zieslin and Mor 1981).

The rate of plant growth and cut rose production is governed by a number of factors, including light, temperature, fertilization, irrigation, variety, and such cultural practices as pruning and pinching (Langhans 1969). One factor which may affect rose production in Alaska is solar radiation, which decreases dramatically from 21 hours of incident light in late June to 12 hours in late September. A second factor which may influence rose production at the University of Alaska is the use of heated soil beds to raise the plants. DePauw (1975) found that hedge pruning can be done as late as August 15 with adequate time to develop strong plants for winter-spring production in Colorado but that yield was reduced when plants were pruned in August. The objective of our study was to determine the effect of hedge pruning at different times on the production schedule and yield of roses cut from plants grown in heated soil beds in Fairbanks, Alaska.

Experimental Procedure

Rose production.

Roses (*Rosa hybrida* L.) were grown in a greenhouse at the University of Alaska Fairbanks. The plants were transplanted into a soil bed amended with peat (pH 6.2 to

***Agricultural Assistant, Agricultural and Forestry Experiment Station, Fairbanks.**
****Assistant Professor of Plant Physiology, Agricultural and Forestry Experiment Station, Fairbanks. Current address: Biology Department, University of Waterloo, Waterloo, Ontario, Canada.**

7.0) and heated to 72 to 80 degrees Fahrenheit. The roses were grown under natural daylight from March 22 to September 30, 1985. Subsequently, the plants received supplemental lighting from high pressure sodium vapor lamps (123 W/m2) for 18 hours per day from October 1 to December 3, 1985, and for 22 hours per day from December 4, 1985, to February 21, 1986.

Nutrient levels were maintained by applying soluble fertilizers with every irrigation. The fertilization program included alternating applications of 20-20-20, 25-10-10, and 25-0-25. Foliar fertilizer (27-15-12) was applied weekly, and foliar manganese chelate was applied every 3 weeks. Soluble trace elements were applied every 6 months. Other trace elements were applied when low levels were detected in nutrient analyses of leaf and soil samples. The CO_2 concentration in the greenhouse was elevated to 1200 ppm using purified CO_2 from October 21, 1985 to February 21, 1986.

Rose plants available for the pruning study were arranged in five rows composed of seven variety plots per row (table 1). A single variety plot measured 3 x 4.5 feet and contained twenty individual bushes. In 1985, all the rose plants in a single row were pruned to 41 inches on one of five assigned dates, beginning with the easternmost row (row 5) on July 1 and ending with the westernmost row (row 1) on September 1, 1985. After pruning, the plants were soft pinched above three or four five-leaflet eyes for three weeks and then allowed to flower. In addition, all rows were pinched on November 1-4, 1985, to time harvests for the Christmas holiday, and again on January 2-6, 1986, to time harvests for Valentine's Day.

Data collection and analysis

Flowers were harvested daily for the duration of the study. Total flower yields included all roses meeting fancy, long, medium, or sweetheart grade standards, and were recorded daily by row and by variety for an 8-month period from June until the following February. Flower-production data collected for the time of pruning cannot be compared statistically since each of the five rows of roses used for the pruning study was composed of different rose varieties and treatments were not replicated. Instead the production data are presented on a weekly basis and are used to compare trends and timing of rose flushes.

Flower Yields Following Hedge Pruning

Each row of roses was out of production for approximately six weeks following hedge pruning and pinching (fig. 1). Cut rose production in rows pruned on July 1 and on August 1 peaked 9 weeks after pruning, whereas the first peak in production for rows pruned on July 15, August 15, and September 1, occurred 10 weeks after pruning. Once each row produced a flush of roses, the row flushed again every 6 to 8 weeks if not pinched. In lower latitudes, the period from pinch to flower harvest generally takes 8 weeks (Langhans 1969). The length of this period is influenced by factors which affect growth. Higher temperatures, more light, sufficient irrigation, and appropriate variety selection all contribute to increased growth rates and fewer weeks to flowering.

Roses pruned on July 1 and August 15 peaked in late October, and were in cycle for the Christmas pinching on November 1, 7 weeks before the holiday (fig. 1). Roses pruned on July 15, August 1, and September 1, were in cycle for Christmas production without pinching. All rows flushed about 10 days before Christmas, except the row pruned on August 1. This row flushed 5 days before Christmas. Since the maximum flower production for the Christmas market occurred 1 week earlier than desired, the pinch for Valentine's Day was scheduled 6 weeks before the holiday. All rows were at peak production 4 to 7 days before Valentine's Day. In all rows, the holiday yields accounted for approximately one-third of the total production between July 1 and February 14 (table 2). Christmas production represented 17 to 23 percent of the yield and Valentine's Day production 13 to 17 percent.

Hedge pruning created a pronounced fluctuation in the number of roses produced per week. More than 100 cut roses per row were harvested each week during periods of peak production (fig. 1). Between flushes, however, very few flowers were harvested. The highest cut-rose yields were obtained from plants hedge pruned on July 1. The row hedge pruned on July 1 was out of production for 5 weeks, whereas the rows hedge pruned on July 15 or later were out of production for 6 weeks. By pruning later in the summer, additional production losses were probably incurred as a result of lower light levels. The plants pruned July 1 produced denser foliage as well as higher flower yields. Although these results are derived from an unreplicated study, the data suggest that hedge pruning should be con-

Table 1. Rose plants used for pruning studies by row[1] and variety.

Row 1	Row 2	Row 3	Row 4	Row 5
Sonia	Showstopper	Eterna	Romance	Aalsmeers Gold
Showstopper	Samantha	Golden Fantasy	White Masterpiece	Romance
Angelique	Golden Emblem	Royalty	Sonia	Mercedes
Royalty	White Satin	Eterna	Angelique	Samantha
Mercedes	Golden Emblem	Aalsmeers Gold	Golden Fantasy	White Satin
Samantha	Golden Fantasy	White Satin	Sterling Silver	Samantha
White Satin	Royalty	Golden Fantasy	Royalty	White Masterpiece

[1]Rows were oriented north-south, and the top of the table represents north. Row 1 was the most westerly row.

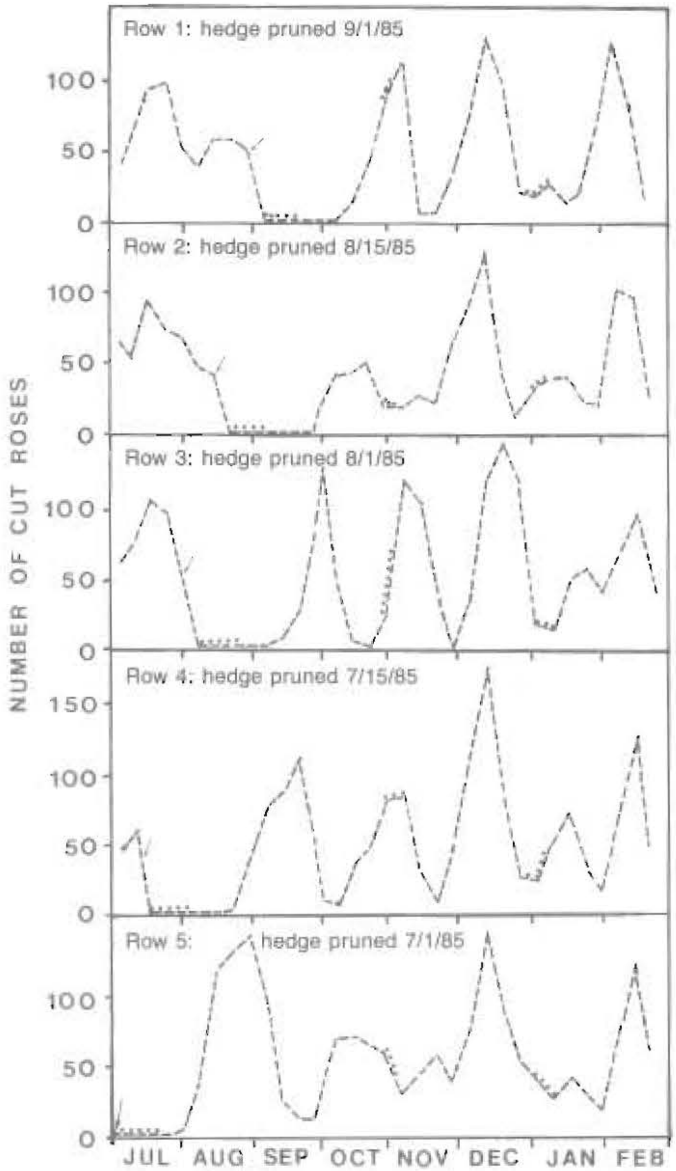


Figure 1. Cut flower production following hedge pruning of rose plants. Pruning dates are indicated by arrows. Periods during which the plants were soft-pinched are indicated by (...).

ducted by early July when incident light levels in Alaska are higher.

Discussion

Commercial growers of cut roses often use summer or fall pruning and subsequent pinching as a means of maximizing winter flower yields when the flowers are in high demand for holiday markets. Even though pruning and pinching reduce the total yield of flowers, the cost of the lost flowers is usually offset by the higher rate of return for flowers produced during peak holiday periods (Langhans 1969).

By producing flowers when either the price per bloom or the volume of flowers sold is likely to increase, a grower can optimize his profits. Direct or hedge pruning can be used in combination with a pinch in order to obtain a flush of flowers at periods of peak demand when the grower can expect higher prices or higher volumes. Hedge pruning before early July can also serve to rejuvenate rose plants and minimize production losses. Finally, hedge pruning can be used to stagger flower production by variety or by section of the greenhouse in order to minimize production costs per bloom. Thus hedge pruning is most advantageous when used to complement a well-defined production and marketing program and when performed by early July.

One drawback to hedge pruning in Alaska is the pricing structure for cut roses. The highest price per rose normally occurs on holidays due to increased consumer demand. Although the price of cut roses increases nationwide on Thanksgiving, Christmas, Valentine's Day, Easter, and Mother's Day (Goodrich 1969), the wholesale price of roses shipped to Fairbanks increases on only two holidays: Valentine's Day and Mother's Day (see McIntyre and Griffith, Wholesale Pricing of Locally Grown Cut Roses in Fairbanks, Alaska, this issue). It may be difficult to justify pruning to maximize holiday rose production in Alaska based on only two holiday markets.

The advantage of gradual pruning over direct hedge pruning is that the plants are never taken out of production. This technique can be used to obtain steady, year-

Table 2. Production of roses for holiday markets using hedge pruning[1].

	Row Number				
Rose Production by Row	1	2	3	4	5
Date of hedge pruning	9/1/85	8/15/85	8/1/85	7/15/85	7/1/85
No. roses produced between 7/1/85 and 2/14/86	1548	1389	1713	1635	1791
No. roses produced during Christmas flush	309	265	330	383	303
No. roses produced during Valentine's Day flush	266	224	210	247	261
Roses produced during the two holidays, (%) of total	37	35	32	39	31

[1]1All plants were pruned to 41 inches and soft-pinched for 3 weeks before being allowed to flower.

round production of cut roses. When compared with a gradual pruning done the previous year, hedge pruning reduced 6-month rose yields by 19 percent when the pruning took place on July 1 (data not presented). Although these data were gathered in different years, using a different collection method, the results are comparable to the 16 percent reduction in yields for direct pruning reported by Bivens and Hasek (1973) in a replicated study. When roses were pruned gradually using the greenhouse conditions and rose varieties described here, a soft-pinch 6 weeks in advance could be used to produce a flush of flowers timed for holiday markets or for special events in Alaska.

Gradual pruning, however, is more labor intensive, requires skilled labor, and reduces the development of renewal canes (Bivens and Hasek 1973). The development of renewal canes could be induced by the application of plant growth regulators (Ohkawa 1979, Parups 1971, Zieslin et.al. 1972), but this again would require additional skilled labor. In order to take advantage of the benefits of both gradual and hedge pruning, Bivens and Hasek (1973) recommend hedge pruning half of each variety every year. This schedule would allow for periodic plant renewal and would ensure continuous production at a reduced rate during periods of low demand.□

References

Bivens, J.L., and R.F. Hasek. 1973. Investigation of two greenhouse rose pruning practices. *Flower and Nursery Report* (November):2-3.

Depauw, B. 1975. Effect of time of pruning on subsequent growth of greenhouse roses. Colorado Flower Growers Association Bulletin 300:1-3.

Goodrich, D.C. 1969. Prices and Costs. IN: J.W. Mastalerz and R.W. Langhans, eds. *Roses: A Manual on the Culture, Management, Diseases, Insects, Economics and Breeding of Greenhouse Roses.* Roses Inc., Michigan. 331 pp.

Holley, W.D. 1973a. Effect of time of pruning on subsequent growth of greenhouse roses. Colorado Flower Growers Association Bulletin 282:1-3.

Holley, W.D. 1973b. Pruning and development of roses. Colorado Flower Growers Association Bulletin 273:1-3.

Kohl, H.C., and D.E. Smith. 1969. Rose plant renewal. Roses Incorporated Bulletin April:16-17.

Kohl, H.C., and D.E. Smith. 1970. Rose plant renewal. Roses Incorporated Bulletin September: 24-25.

Langhans, R.W. 1969. Timing, Pruning and Supporting. IN: J.W. Mastalerz and R.W. Langhans, eds. *Roses: A Manual on the Culture, Management, Diseases, Insects, Economics and Breeding of Greenhouse Roses.* Roses Inc., Michigan. 331 pp.

Moe, R. 1971. Factors affecting flower abortion and malformation in roses. *Physiologia Plantarum* 24:291-300.

Ohkawa, K. 1979. Promotion of renewal canes in greenhouse roses by 6-benzylamino purine without cutback. *HortScience* 14:612-613.

Parups, E.V. 1971. Use of 6-benzylaminopurine and adenine to induce bottom breaks in greenhouse roses. *HortScience* 6:456-457.

Zieslin, N., A. H. Halevy, Y. Mor, A. Bachrach, and L. Sapir. 1972. Promotion of renewal canes in roses by ethephon. *HortScience* 7:75-76.

Zieslin, N., and A.H. Halevy. 1976. Flower bud atrophy in 'Baccara' roses. III. Effect of leaves and stems. *Scientia Horticulturae* 4:73-78.

Zieslin, N., and Y. Mor. 1981. Plant management of greenhouse roses: The pruning. *Scientia Horticulturae* 14:285-293.

Acknowledgments

The authors would like to thank Patricia Wagner, Heather McIntyre, Maureen Heffernan, and Scott Pettit for technical assistance. Research on rose production at UAF was initiated by Dr. Donald Dinkel. Funding for this research was provided by the state of Alaska through its legislative appropriation to the University of Alaska's Agricultural and Forestry Experiment Station.

Continued from page 20

Mr. Taylor has made very significant contributions to Alaskan agriculture and to northern agriculture in general. Few grain fields in the state have not seen one of his varieties. One of his barley varieties, 'Otal', comprises a significant portion of barley grain currently being grown in Canada.

Mr. Taylor is retiring to Alaska and Arizona where he plans to maintain an interest in breeding research.

Thomas J. Malone, forest research technician with AFES, in cooperation with the USDA Forest Service collected seed for the Nordic Tree Improvement Cooperative in British Columbia, the Northwest Territories, Yukon, and Alaska. The Nordic Cooperative consists of Denmark, Finland, Greenland, Iceland, Norway, and Sweden. Efforts in Canada concentrated on lodgepole pine, an introduced species important to Nordic countries. In Alaska, efforts concentrated on the three native conifers, white and black spruce and tamarack. Alaskan collections will be used for research trials in the Nordic countries as well as Alaska. Although the majority of collections were taken from good-quality stands throughout the ranges of the species,

. . . Continued on page 30

Food Irradiation and Alaska's Food Industries

By

Ruthann B. Swanson*, Carol E. Lewis**, Charlotte I. Hok***, and Deben K. Das****

Introduction

Canning, freezing, drying, and pasteurization are familiar food-preservation processes. Recently, another food-preservation process, irradiation, has gained attention in the American press. A study to evaluate the use of food irradiation is presently being conducted in Alaska by the Institute of Northern Engineering, University of Alaska Fairbanks. The purpose of this study is to determine the potential social and economic risks and benefits that may occur in Alaska from the application of food irradiation technology to Alaska's seafood and agricultural products.

This technology has been a subject of worldwide research and development for over 40 years. It is used to preserve various products in many countries. For example, potatoes are treated in Japan to inhibit sprouting, fresh strawberries are treated in the Netherlands to prevent molding, mangoes are treated in South Africa for insect disinfestation, and shrimp are irradiated in Australia to extend shelf life (VanKoij 1986). In the United States, it is primarily used to sterilize nonfood products, although selected food products have been approved for irradiation by the United States Food and Drug Adminstration (FDA).

Food Irradiation Project Background

The United States Congress in 1986 authorized research programs in six states, with the objective of transferring irradiation technology to the private sector for commercialization if net benefits prove to be positive. The states of Florida, Hawaii, Iowa, Oklahoma, and Washington as well as Alaska are evaluating the process. The funds appropriated by Congress were transferred to the individual states through the U.S. Department of Energy (DOE).

The Alaskan study team is an interdisciplinary group of researchers which includes food scientists, economists, engineers, and management specialists. An advisory panel representing government, industry, and the general public has been assembled to provide additional input and expertise. At the conclusion of the feasibility study, the team, with input from the advisory panel, will make recommendations to the state of Alaska and DOE. The Office of the Governor of the state of Alaska will make a final decision regarding the implementation of the recommendations.

The Irradiation Process

Food irradiation is a preservation process like canning, freezing, pasteurization, and heat sterilization, or chemical treatment that can be used to extend the shelf-life of food. Today, most food products, even when marketed fresh, have been processed to some extent. Chemical treatment of potatoes to inhibit sprouting, dipping of papayas in hot water to kill insects, and pasteurization of milk to kill naturally occurring disease-carrying and spoilage microorganisms are examples. In some cases, irradiation has the potential to replace existing processing techniques. In others, irradiation may be used in combination with these conventional processes. However, irradiation is not a panacea, and it cannot be used succesfully with all foods. Milk, for example, is unsuitable for irradiation processing.

Foods that are exposed to an ionizing radiation source are described as irradiated. During this process, radiation is passed through the food product (fig. 1). Bacteria, yeast, and molds are destroyed, and insects can be killed or sterilized. In addition, further ripening and sprouting of fruits

*Visiting Assistant Professor of Food Science, Institute of Northern Engineering, University of Alaska Fairbanks.

**Associate Professor of Resource Management, School of Agriculture and Land Resources Management, University of Alaska Fairbanks.

***Laboratory Assistant, Institute of Northern Engineering, University of Alaska Fairbanks.

****Assistant Professor of Mechanical Engineering, Institute of Northern Engineering, University of Alaska Fairbanks.

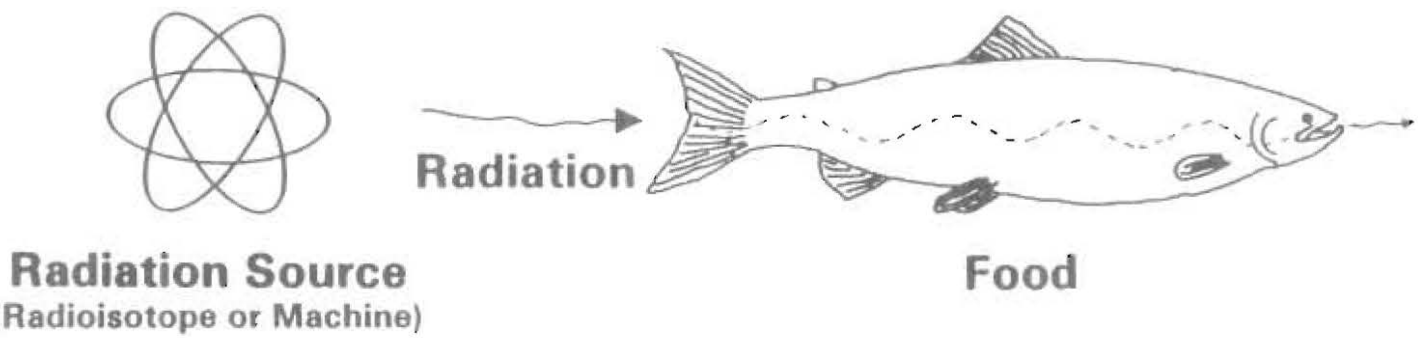
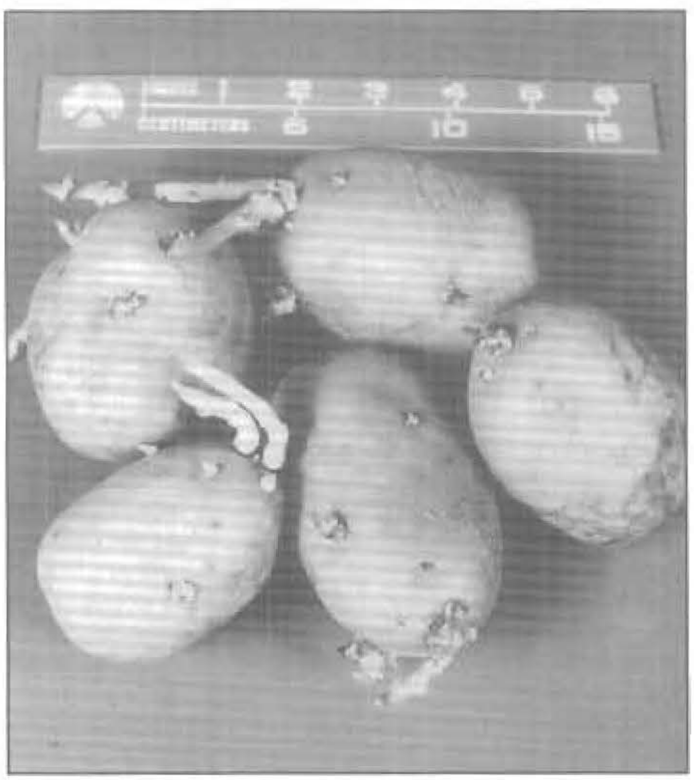


Figure 1. How irradiation works.

and vegetables can be retarded (fig. 2). Temperature of the food is raised only a few degrees during irradiation processing; fresh foods, therefore, retain their appearance, texture, and flavor. A few (6 out of 10,000,000) chemical bonds in the food are broken causing small quality changes in some foods. Irradiated dried peas and beans cook faster, irradiated meat is tenderized, and irradiated potatoes do not turn green after exposure to light, indicating that solanin, a naturally occurring toxin, is not formed (Loaharanu and Urbain 1982). Breaking bonds in the food also produces new compounds, known as radiolytic products, from the food's natural components. Some consumers fear that these compounds are unnatural or hazardous. In fact, most of these products have been found in the same or other foods that have not been processed using irradiation. Some radiolytic products are also produced when foods are cooked or processed traditionally (Josephson and Brynjolfsson 1987).

Irradiated foods are not radioactive, and the consumer is never exposed to radiation (Josephson and Brynjolfsson 1987). Recent studies show no harmful effects from eating irradiated foods even when 100 percent of the individual's diet was irradiated food (Brynjolfsson 1987). Scientifically conducted animal studies also show no toxic effects (CAST 1963). Under today's processing conditions, the irradiation process has little effect on the overall nutritive value of the



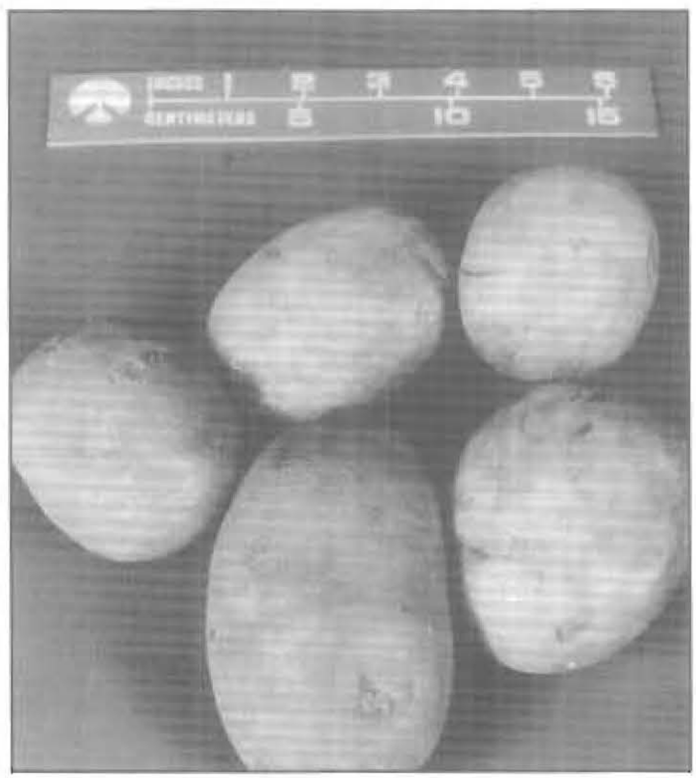


Figure 2. Effect of irradiation on conventionally processed supermarket potatoes after 1 month storage at room temperature; irradiated potatoes have not sprouted (Photographs courtesy of H. Farrar, IV and G. Subbararaman).

food, although the level of some vitamins may be lowered slightly. The irradiation effect is no greater (and may be less) than that found when other commercial processing methods are used (IFT 1986, Josephson et al. 1978).

There are two major benefits from using the irradiation process on food products. One benefit is increased shelf-life that will allow commodities to be shipped greater distances as fresh products without degradation of product quality. A second is decreased levels of naturally occurring, disease-carrying microorganisms that are of public-health concern, such as *Salmonella*, *Campylobacter*, and *Clostridium*.

Labeling

Foods treated with irradiation look like or, in some cases, look better (Bruhn and Noell 1987) than traditionally handled foods; therefore, labeling is required so that the consumer is aware that the food has been processed by irradiation (FDA 1986). The logo in Figure 3 is the international irradiation (radura) symbol used to identify irradiated foods. At the present time, the statements "treated with radiation" or "treated by irradiation" also must be used on the label. These labeling guidelines apply to all irradiated foods, including bulk foods, sold directly to consumers. When combination food products (cake mixes, salad dressings) contain irradiated ingredients, the product does not have to be labeled because such small quantities are involved and because it is obvious that the product has been processed (FDA 1986). Any product that is irradiated for wholesale distribution must also be labeled. The statement "treated with radiation, do not irradiate again" or "treated by irradiation, do not irradiate again" is required (FDA 1986).

Figure 3. International food irradiation logo (FDA, 1986).

Irradiated Food Products in the United States

The FDA has approved irradiation of a variety of food products for sale in the United States (Lecos 1986). This does not imply that these foods are currently available to retail consumers, nor that irradiated Alaskan commodities will be available for purchase in the near future.

Approved products in United States

The FDA determines which food products can be irradiated and at what levels and for what purposes in the United States (Lecos 1986). The agency has approved irradiation treatment of the food products listed in Table 1. Except for spices and dehydrated vegetables, the irradiation dose levels approved by the FDA are at pasteurization[1] levels. Therefore, although spoilage and disease-carrying microorganisms are reduced, the foods are not sterile. Proper handling and such storage as refrigeration and freezing remain very important in preventing the multiplication of surviving microorganisms. The USDA Food Safety and Inspection Service has requested that FDA approve the irradiation of poultry to kill *Salmonella*, a common source of foodborne illness (food poisoning), and other disease-carrying bacteria present (USDA-FSIS 1986). A similar petition to allow irradiation of fish for commercial sale is expected in the near future.

Current uses

American astronauts have been eating irradiated food in outer space since the Apollo missions (IFT 1983). In at least one American hospital, a variety of irradiated food products are served to some patients who cannot tolerate disease-carrying organisms. The patients prefer the irradiated foods over those not so treated (Aker 1984). However, the average

[1]defined as a process which reduces the number of naturally occurring microorganisms which cause spoilage and/or disease. The process does not sterilize, i.e., eliminate all such microorganisms.

Table 1. Foods approved for irradiation in United States.

Food	Year Approved	Purpose
Wheat, wheat flour	1963	Insect control
White potatoes	1964	Sprout inhibition
Pork	1985	Trichinella spiralis control; parasite causes trichnosis
Dehydrated herbs, spices, seeds, teas, vegetable seasonings	1986	Kill insects and control micro-organisms
Fresh fruit and vegetables	1986	insect control; Maturation inhibition

(Lecos 1986, FDA, 1986.)

American consumes little irradiated food, although irradiated spices and dehydrated vegetables are increasingly available. There is some speculation that irradiated fresh fruits and vegetables may soon reach American grocers' shelves. Despite its limited use with food products, many products that Americans use every day are irradiated. A few representative examples are listed in Table 2.

Labeled, irradiated, tropical fruits have been test-marketed in the United States (Bruhn and Noell 1987, Puzo 1986). Appearance and quality of the fruits encouraged consumers to buy the irradiated products (Bruhn and Noell 1987). Although response was positive in these market tests, extensive test-marketing has not been done in the United States.

Food Safety

Food safety is a major concern for the consumer and the food industry alike, and, for the past 40 years, food irradiation research has emphasized safety. The U.S. and British governments, like many consumers, have expressed concern about the safety of irradiated foods. As a result, the U. S. Congress and the British Ministry of Health requested independent reviews of food irradiation research. Foods treated with irradiation are considered safe to eat if: (1) no significant toxic effects or radioactivity are produced by processing, (2) nutritional quality is not significantly decreased when the irradiated food is compared to the fresh product or the same food processed using conventional methods such as canning and freezing, and (3) harmful microorganisms and microbial toxins are not present.

Researchers involved in the United States' review concluded:

> from all the available scientific evidence that foods exposed to ionizing energy under the conditions proposed for commercial application are wholesome, that is, safe to eat. Their nutritional adequacy compares favorably with that of fresh foods or with that of foods processed by well established conventional methods. (CAST 1986)

British scientists also concluded that irradiated foods are safe, wholesome, and nutritious (ACINF 1986).

The World Health Organization (WHO 1981), the U.S. Food and Drug Adminstration (FDA 1984, 1986), Canadian Government (1987), and the American Medical Association (AMA 1985) have also endorsed the process. Over 20 countries (including Canada, the Netherlands, Japan, France, and Australia) have approved the process for foods intended for human consumption. The food irradiation process is regulated in the United States under Federal food safety and good manufacturing guidelines (Engel 1987, FDA 1986). International standards for the operation of food irradiation facilities have been established by the United Nations (CAC 1984).

Table 2. Commonly used items that are irradiated in the United States.[1]

Baby bottle nipples	Nonstick cookware
Tampons	Baby powder
Water	Food packaging materials
Food containers	Cosmetics
First aid packs	Burn ointments

[1]40 irradiators are operating in the United States (Markovic 1985).

Irradiation Facilities

The use of radiation sources in Alaska is not new. At present, there are about 70 isotope sources, and licenses have been granted for approximately 1200 X-ray sources. These radiation sources are used for medical, industrial and research purposes (Heidersdorf, personal communication[1]). For example, Providence Hospital in Anchorage provides radiation therapy using a gamma isotope source. X-ray sources are used not only for medical purposes but also in airport security stations throughout the state.

The source

Three types of radiation sources are recommended for food processing: machine-generated 5 MeV X-rays and 10 MeV accelerated electrons and gamma rays from isotope sources (CAC 1984). Cobalt-60 and cesium-137 are the gamma isotope sources commonly used in the food-irradiation process. However, machine technologies are being improved and are beginning to compete with the use of traditional isotope sources.

Source transportation

Regulations and procedures for transporting gamma sources in Alaska are in place (Alaska Radiation Protection Regulations 1978) because these sources are currently used for medical, industrial, and research purposes. The regulations are as stringent as those for interstate transport (U.S. NRC 1984). Interstate transportation of all radioisotopes is governed by the U. S. Department of Transportation as well as by the Nuclear Regulatory Commission (NRC). When machine sources are employed, there is no transportation involved because there is no source to be transported (Rodrigues 1985). Thus, transportation concerns are moot.

Potential Benefits to Alaska

There are a number of potential benefits that could accrue to both the seafood and agricultural industries and to Alaskan consumers by extending the shelf-life of higher-

[1]Heidersdorf, S.D. 1987. State of Alaska Radiological Physicist. Spring 1987. Juneau AK.

valued products and increasing the value of now discarded by-products. Problems associated with small markets within the state, long distances to markets outside the state, and limited or expensive transportation networks, have hampered development of Alaska's food industries.

•The Alaskan consumer may benefit from an increase in the quality and selection of available foods. Reduction of pathogens of public health concern would also improve the safety of available foods. Not only are the numbers of spoilage microorganisms reduced by irradiation but the levels of naturally occurring disease-carrying microorganisms, such as *Salmonella* are also reduced (USDA-FSIS 1986).

•Extended shelf life may allow fresh Alskan products to be shipped into new in-state, national, and international markets without degradation of quality. This could benefit the seafood industry by increasing Alaska's share of the premium fresh-fish market outside of the state and by increasing the availability of fresh fish in in-state markets. Marketing of underutilized fish species with limited shelf-life may also become feasible (Kramer, personal communication[1]). It may also allow fresh Alaskan reindeer products to enter the growing national and international game meat markets (Drum, personal communication[2]).

•Increasing the shelf-life of fresh products could aid the Alaskan food industry by reducing market gluts, minimizing price fluctuations, providing more consistent supplies and reducing spoilage due to oversupplied markets. This should benefit both the seafood harvester (Nickerson et al. 1983) and the vegetable producer.

•Utilization of now-discarded by-products from the seafood and agricultural industries would eliminate some environmental concerns and increase total product value. Seafood processing "wastes" are dumped into the ocean in many Alaskan fishing communities (Monsen 1987), and slaughter plant by-products (Olson, personal communication[3]) are also discarded. Such by-products have extensive uses in the cosmetic, pharmaceutical, and animal feed industries (AECL 1987) outside of Alaska. A research and development project to identify the quality effects on Alaska-produced commodities could be the next phase in the evaluation of the irradiation process.

Request for Input

At the conclusion of the irradiation feasibility study, the research team will make a recommendation to the state of Alaska and the Department of Energy on the desirability of a research and demonstration irradiation facility in Alaska. Public comment is an important part of the study. Readers interested in making their views known to the study team should send written comments to:

Public Comment
Institute of Northern Engineering
539 Duckering
University of Alaska Fairbanks
Fairbanks, AK 99775.

[1]Kramer, D. 1987. Alaska Marine Advisory Program. June 1987, Fairbanks, Alaska.

[2]Drum, D. 1987. Indian Valley Meats, Inc., October 1987, Indian, Alaska.

[3]Olson, J. 1987. Mt. McKinley Meat and Sausage Co. October 1987, Palmer, Alaska.

References

Aker, S.N. 1984. On the cutting edge of dietetic science. *Nutrition Today* (July/August):24.

ACINF. 1986. Report on the safety and wholesomeness of irradiated foods. Department of Health and Social Security, London.

AECL. 1987. Gamma processing equipment. AECL-Industrial Radiochemical Co., Ontario.

AMA. 1985. Position paper: Statement of the American Medical Association. American Medical Association, Chicago, IL.

Alaska Radiation Protection Regulations. 1978. Intrastate transportation of radioactive material, AAC 85.320. Alaska Department of Health and Social Services, Juneau, AK.

Bruhn, C.M. and J.W. Noell, 1978. Consumer in-store response to irradiated papayas. *Food Technology* *41*:83.

Brynjolfsson, A. 1987. Results of feeding trials of irradiated diets in human volunteers: summary of the Chinese studies reported at the FAO/IAEA seminar for Asia and the Pacific on the practical application of food irradiation. *Food Irradiation Newsletter* *11*(1):33.

CAC. 1984. Codex general standard for irradiated foods-Worldwide standard. Codex Alimentarius Commission, Vol. XV, Rome.

CAST. 1986. Ionizing energy in food processing and pest control: I. Wholesomeness of food treated with ionizing energy. Report No. 109, Council for Agricultural Science and Technology, Ames, IA.

Canadian Government. 1987. Comprehensive federal government response to report of the standing committee on consumer and corporate affairs on the question of food irradiation and labeling of irradiated foods. Canadian Federal Government, Ontario.

Engel, R.E. 1987. Present and future regulatory trends in food irradiation. Presentation at Institute of Food Technologists, Annual Meeting and Food Expo, June 16-19, 1987. Las Vegas, NV.

FDA. 1984. Irradiation in the production and processing and handling of food; proposed rule. *Federal Register* *49*(31):5713.

FDA. 1986. Irradiation in the production, processing, and handling of food; final rule—21 CFR, part 179. *Federal Register* *51*(75):13378.

IFT. 1983. Radiation preservation of foods: A scientific status summary by the Institute of Food Technologists' Expert Panel on Food Safety and Nutrition. *Food Technolology 37*(2):55.

IFT. 1986. Effects of food processing on nutritive values: A scientific status summary by the Institute of Food Technologists' Expert Panel on Food Safety and Nutrition. *Food Technolology 40*(12):109.

Josephson, E.S., and A. Brynjolfsson. 1987. Ionizing energy for food processing. Special Publ. No. 15, Council for Agricultural Science and Technology, Ames, IA.

Josephson, E.S., M.H. Thomas, and W.K. Calhoun. 1978. Nutritional aspects of food irradiation: An overview. *Journal of Food Processing and Preservation 2*:299.

Lecos, C.W. 1986. The growing use of irradiation to preserve food. *FDA Consumer* (July/August):12.

Loaharanu, P., and W.M. Urbain. 1982. Certain utilization aspects of food irradiation. In: *Preservation of Food by Ionizing Radiation*, E.S. Josephson and M.S. Peterson, eds., CRC Press Inc., Boca Raton, FL.

Markovic, V. 1985. Modern tools of the trade. *IAEA Bulletin* :33.

Monsen, M. 1987. Optimizing opportunities: Multi-species byproduct utilization. Grant proposal submitted by Alaska Fisheries Development Foundation to National Marine Fisheries Service, July 30, 1987.

Nickerson, J.T.R., J.J. Licciardello, and L.J. Ronsivalli. 1983. Radurization and radicidation: Fish and shellfish. In: *Preservation of Food by Ionizing Radiation*, E.S. Josephson and M.S. Peterson, eds., CRC Press, Inc., Boca Raton, FL.

Puzo, D.P. 1986. First irradiated fruit on market sells quickly. Los Angeles Times. Reprint.

Rodrigues, A.M. 1985. Comparison of machine-generated electrons and x-rays in food irradiation. Presentation at 30th Annual Atlantic Fisheries Technological Conference, August 25-29, 1985, Boston, MA.

USDA-FSIS. 1986. Petition for approval of ionizing radiation to diminish potential of food-borne illness. United States Department of Agriculture, Washington, DC.

U.S. Nuclear Regulatory Commission. 1984. Rules and Regulations, Title 10, Chapter 1, CFR-Energy, Part 71, Packaging and Transportation of Radioactive Material, Subpart 71.5, Transportation of licensed material. Washington, DC.

Van Koij, J.G. 1986. International trends in the uses of food irradiation. *Food Reviews International 2*(1):1.

WHO. 1981. Wholesomeness of irradiated food. World Health Organization Technical Report Series 659. Geneva.

Continued from page 24

because of the research interest, collections were also made in stands near the edge of the species' ranges. One collection of white spruce was from the Firth River drainage on the Alaska-Yukon border. This stand was first described by **Dr. James V. Drew**, dean of the School of Agriculture and Land Resources Management of the University of Alaska Fairbanks, and a colleague when they visited the area as members of a soil survey team during the summer of 1958 when Dr. Drew was Assistant Professor of Agronomy at the University of Nebraska.

During 1987, a forest tree improvement cooperative was established in Alaska. The School of Agriculture and Land Resources Management is among the organizations providing the early direction for the cooperative. Dr. James V. Drew is a member of the executive committee. **Dr. Edmond C. Packee,** assistant professor of forest management, is a member of the technical committee. Tree improvement, the selection of the highest quality genetic stock and maintenance of the gene pool, is an important aspect of any reforestation program and has been quite profitable in the Nordic countries.

Dr. Leroy B. Bruce, assistant professor of animal science, AFES, Palmer Research Center has been appointed to the screening committee for research proposals submitted to the newly created Applied Agricultural Research Account. This is a fund held and administered by the Alaska Division of Agriculture to support applied agricultural research in Alaska. Producers in the agricultural industry, individuals in state and local agencies, and University of Alaska personnel may apply. These grants are to sponsor applied research to find practical solutions to agricultural problems. This type of grant fund is new to the state of Alaska and opens new doors to sponsoring agricultural research in the state.

Dr. Fredric M. Husby, associate professor of animal science, served in 1987 as chairman of the Western Regional Hatch Research Project W-166, "Characteristics and feed value of barley and western protein supplements for swine." Dr. Husby hosted the annual meeting of swine nutritionists in Fairbanks June 15-18, 1987. During this meeting, a five-year proposal for regional swine nutrition research was developed. Within the proposed study, two Alaskan barley varieties ('Otal' and 'Datal') will be produced at six locations in the Western region to determine the effect of production location on chemical composition. In addition, Alaskan fish meal and fish oil will be included in future studies as both protein and energy sources for weaner pig diets.

Dr. Glenn Juday assistant professor of plant ecology, has been on special leave from SALRM. He is writing a book entitled *Natural Areas in North America*. Research for the book has taken Dr. Juday through western Canada including Yukon, Alberta, Saskatchewan, Manitoba, and on to such locations in the U.S. as Indiana, Ohio, Illinois, and Kentucky. In Illinois, he chaired the Natural Areas Con-

. . . Continued on page 41

Equations for Predicting Energy Values Of Alaskan Feedstuffs

By

Leroy B. Bruce* and Mary Lou Herlugson**

Introduction

Livestock rations should be balanced for many parameters, including protein, various minerals, and energy. Energy content is the most important consideration for balancing any farm animal's diet because it is often the most limiting factor in animal performance. This is especially true in Alaska because: 1) long, cold, wet winters result in different energy requirements for Alaskan animals than for those in the lower 48 and 2) Alaskan feedstuffs tend to be lower in energy than those grown elsewhere in the U.S. (as indicated by a four-year summary of Alaska feeds analyzed by the Agricultural and Forestry Experiment Station).

It is extremely important to test and balance rations for energy in Alaska. Energy is the most difficult feedstuff component to determine. The only truly accurate energy evaluation is a metabolism trial: feeding a feedstuff to a number of animals and measuring performance by gain, feed efficiency, and metabolic output by total fecal and urine collection. The trial should be conducted on livestock of the same class for which the feedstuff is intended. The expense of a metabolism trial is extraordinary, in both resources and time and well beyond the means of most producers and many research institutions.

Further, conducting such trials is not practical for a producer due to the amount of time expended before the results of the trial are available. Therefore, several other approaches have been developed to measure energy in feedstuffs. Although not as accurate as metabolism trials, these approaches are much more useful in practical feeding situations. A bomb calorimeter is an instrument in which feed samples are ignited in a pure-oxygen atmosphere, burned completely, and heat, or gross energy produced by combustion, measured. Measurement of gross energy by bomb calorimetry is accurate, but there is almost no correlation between gross energy and metabolizable (or usable) energy in feeds for livestock.

Another approach to estimating energy in feedstuffs is to determine in vitro (meaning in the test tube) dry matter disappearance (IVDMD), by a procedure developed by Tilley and Terry (1963) at the Grassland Research Institute in Berks, England. This is currently used by the Feed Testing Service of the University of Alaska. An IVDMD test is a two-stage procedure which mimics the digestive tract of a cow. A sample of feed is digested for two days in a test tube with a buffered solution and rumen fluid from a donor cow, then digested with hydrochloric acid and pepsin, a proteolytic enzyme, for another two days. On the fifth day, the samples are filtered through a sintered glass crucible and the residue dried overnight. The amount of sample that disappeared (percent IVDMD) is calculated, and metabolizable energy (ME) is predicted by the equation: ME (mcals/lb) $= 0.0211 \cdot \text{IVDMD} - 0.3008$. The whole procedure takes one week, but it is quicker and much less expensive than a metabolism trial.

The IVDMD is a good procedure, but as with all biological assays, it has drawbacks. First, the entire system is based on a cow's digestive process. Therefore, results are most relevant for a cow, and less relevant for other classes of livestock, especially nonruminants. Second, IVDMD results from the same sample run at different times can be very different. When run at the same time with the same rumen fluid, IVDMDs will be much more comparable than will IVDMDs for the same sample run at different times. One of the biggest factors in this variation is the rumen fluid itself. Because it is the microbes in the rumen fluid that digest the sample, anything that affects them will influence IVDMD results. Rumen fluid differs depending on the individual cow sampled, the cow's diet, the cow's health, how much water it did or didn't drink before it is sampled, and a variety of other factors. Other problems occurring

*Assistant Professor of Animal Science, Agricultural and Forestry Experiment Station.

**Research Associate, Animal Science, Agricultural and Forestry Experiment Station.

periodically are electrical power failures. Microbes in the rumen fluid function at 39 degrees Celsius, the microbes begin to die, and the entire IVDMD must be repeated.

IVDMD was a state-of-the-art procedure in the 1960s. In the past 10 years, procedures developed by Van Soest (1963), at Cornell University, have largely replaced the IVDMD. A survey by C.E. Coppock (1975) of Land Grant Universities of the U.S. and the corresponding universities of the Canadian provinces found that of fifty respondents, only two still offered IVDMD in their feed-testing programs. Van Soest's procedures measure chemical components of feedstuffs rather than their apparent digestibilities.

One of his procedures, Acid Detergent Fiber (ADF) measures the less digestible portions of feedstuffs. There is a very strong negative correlation between ADF and feedstuff energy values, and many researchers believe ADF is the most accurate chemical method for predicting quality (Bath et al. 1978). ADF is an accepted procedure of the Association of Official Analytical Chemists (1980), meaning that laboratories across the country could run an ADF on a set of samples and expect to achieve the same value. ADF also has the advantage of being a relatively quick analysis after drying and grinding. A small sample is boiled for one hour in an acid-detergent solution. The sample is then filtered through a sintered glass crucible, and the residue weighed after drying overnight. The portion of the original sample remaining is the ADF.

Many institutions have developed equations using ADF to predict forage quality. The Penn State Soil and Forage Testing Laboratory uses ADF to predict Net Energy for lactation (NE_1), Total Digestible Nutrients (TDN), and Estimated Net Energy (ENE) (Bath et al. 1978). Anderson et al. (1973) and Anderson and Waldo (1975) developed equations for predicting digestible energy based on crude protein and ADF for alfalfa hay. Utah State University Soil, Plant and Water Analysis Laboratory uses ADF and crude protein to estimate market grade and relative value for hays (Fonnesbeck et al. 1980). ADF can also be predicted very accurately by near-infrared reflectance (NIR) (Coleman 1986). For speed of analysis, high repeatability, and high correlation with energy values, we have developed equations using ADF to predict the energy values of Alaska feedstuffs.

Experimental Procedures

The AFES laboratory in Palmer began officially accepting samples for feed testing in September 1982 under a cooperative agreement between AFES and the Cooperative Extension Service. Samples are analyzed for dry matter, calcium, phosphorus, crude protein, ADF, IVDMD, and, since February 1986, for potassium. Metabolizable energy (ME) is predicted from IVDMD. The turnaround time from receipt by the lab until results are mailed to the submitter is generally two weeks. The determining factor in the time required for analysis has most often been the IVDMD.

Data from the 600 samples analyzed between September 1982 and December 1986 were compiled and categorized by type. Categories were: concentrate, oat grain, Thual barley, all other barleys, grass hay (includes brome, bluejoint, and other grasses raised in Alaska), timothy hay, alfalfa hay, oat hay, brome grass silage, small grain silage, turnip roots, and brassica forage. Once the groups were formed, polynomial regressions, from degree one to degree six, were computed on ADF and IVDMD, using ADF to predict IVDMD. Predicted values were compared to analytical values, and the equation that best fit the data was selected. When the reduction attributable to a higher order equation was not significant, the lower order equation was selected if accuracy remained the same. The coefficients generated (table 1) are inserted into the formula:

$$IVDMD = b_0 + (b_1 \cdot ADF) + (b_2 \cdot ADF^2) + (b_3 \cdot ADF^3) + (b_4 \cdot ADF^4)$$

Table 1. Regression equations for converting ADF to IVDMD for various classes of feedstuffs.

	Equation coefficients				
Feedstuff class	b_0(constant)	b_1(ADF)	b_2(ADF^2)	b_3(ADF^3)	b_4(ADF^4)
[a]Hays	-0.37	11.426	-0.5642	0.010835	-0.0000755
[b]Grains	86.68	-1.128			
[c]Silages	-361.13	36.724	-1.1235	0.014048	-0.0000605
[d]Concentrates	87.56	2.806	-0.5610	0.028347	-0.0004519
[e]Brassica forages	95.56	0.608	-0.1253	0.004981	-0.0000676
[f]Turnip Roots	-871.19	164.855	-10.4399	0.290164	-0.0029987
All feeds	90.35	-1.634	0.0550	-0.001242	0.0000082

[a]R = .9909; 68.5% and 92.2%, respectively, of all samples had a predicted IVDMD < 5% and < 10% different from the reported IVDMD; any ADF > 50% indicates a bad value and should not be used.
[b]R = .9981; 74.6% and 98.5%, respectively, of all samples had a predicted IVDMD < 5% and < 10% different from the reported IVDMD; if grain value for ADF is less than or equal to 4% use the concentrate equation.
[c]R = .9966; 75.0% and 97.7%, respectively, of all samples had a predicted IVDMD < 5% and < 10% different from the reported IVDMD.
[d]R = .9989; 90.6% and 98.1%, respectively, of all samples had a predicted IVDMD < 5% and < 10% different from the reported IVDMD.
[e]R = .9988; 77.4% and 100.0%, respectively, of all samples had a predicted IVDMD < 5% and < 10% different from the reported IVDMD.
[f]R = .9988; 90.9% and 90.0%, respectively, of all samples had a predicted IVDMD < 5% and < 10% different from the reported IVDMD.
[g]R = .9960; 64.4% and 92.3%, respectively, of all samples had a predicted IVDMD < 5% and < 10% different from the reported IVDMD; does not include brassica forage and turnip roots.

Table 2. Equations for converting ADF to metabolizable energy in megacalories per pound for various classes of feedstuffs.

	Equation coefficients				
Feedstuff class	b_0(constant)	b_1(ADF)	b_2(ADF^2)	b_3(ADF^3)	b_4(ADF^4)
Hays	-0.31	0.242	-0.0119	0.000229	-0.0000016
Grains	1.53	-0.024			
Silages	-7.93	0.776	-0.0237	0.000297	-0.0000013
Concentrates	1.55	0.059	-0.0119	0.000599	-0.0000096
Brassica forages	1.72	0.013	-0.0026	0.000105	-0.0000014
Turnip Roots	-18.72	3.485	-0.2207	0.006133	-0.0000634
All feeds	1.61	-0.035	0.0012	-0.000026	-0.0000002

All of the equations generated are fourth-degree polynomials (fig. 1), except for grains (fig. 2) which is linear. Finally, data from all groups, except brassica forage and turnip roots, were combined, and regression coefficients were recomputed. This general equation is useful and accurate for feedstuffs that do not fit specifically into one of the other categories. The equations have also been expanded to predict feedstuff ME (table 2). Some livestock feeders prefer to work in terms of TDN or NEg (net energy for gain) and NEm (net energy for maintenance). The equations have also been expanded to predict these values from ADF (table 3).

Results and Discussion

In most cases, these equations predict energy from ADF as effectively as the one currently in use which predicts energy from IVDMD. There are two advantages, however. First is the repeatability of results. ADF is an analytical procedure that is very repeatable, whereas IVDMD is a biological procedure and is subject to variation from many sources. The second is speed. Crude protein and the other minerals in a standard feed analysis take only a few hours

Table 3. Equations for conversion of calculated IVDMD to percent TDN, net NEl in Mcal/lb[a] and ME in Mcal/lb and an equation for converting ME in Mcal/lb to TDN.

IVDMD to TDN	TDN = 1.06(cIVDMD) - A[b]
IVDMD to NEl	NEl = 0.0171(cIVDMD) - 0.4
IVDMD to ME	ME = 0.0211(cIVDMD) - 0.301
ME to TDN	TDN = 50.16(ME) + 15.08 - A[b]

[a]To convert megacalories per pound to megacalories per kilogram divide by 0.4536.

[b]Where A = 0 for grains and concentrates, 4 for silages, and 6 for hays.

to determine after the sample has been dried and ground. When everything runs optimally, an IVDMD takes a week to run. When there is any question about the results, a repeat run takes another week.

The AFES laboratory at Palmer usually begins an IVDMD run on Monday, completes it on Friday, dries the crucibles over the weekend, then weighs residues and calculates results the following Monday. Therefore, if a sample is received at the lab late in the week it can easily be dried, ground, and prepared for next Monday's run, but if a sample is received early in the week, it is too late to go into the IVDMD running the week received, and so is held over to the next week. An ADF, however, can be run in 1.5 hours,

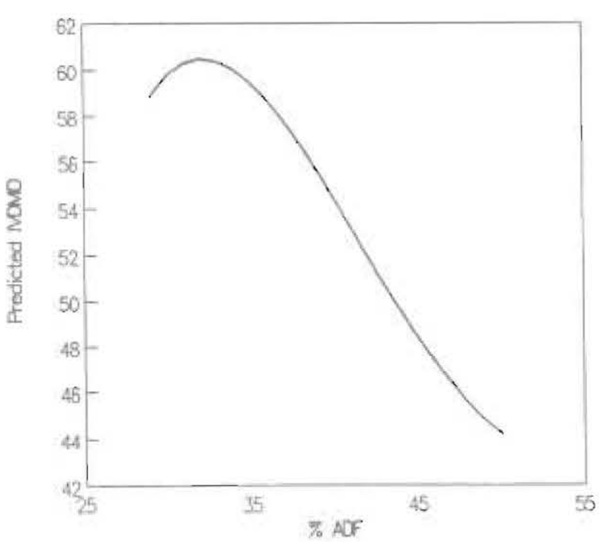


Figure 1. Predicted IVDMD for silage.

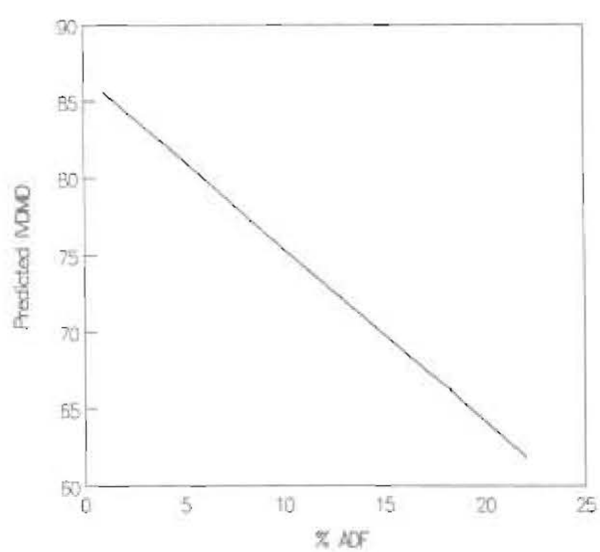


Figure 2. Predicted IVDMD for grain.

dried overnight and then weighed and calculated the following morning. Repeat runs require an additional day and the analysis can be made on any day of the week. This technique reduces the lab turnaround time from two weeks to two days—one day for drying the sample and one day for running minerals and ADF with an additional day to repeat questionable samples.

Two routes can be taken in using these equations: the lab will use the appropriate equation or a subscriber can request ADF and use the equation. It is very important that the equations be used exactly as presented, with every number used after the decimal. Dropping a number, especially with the higher-order coefficients, will produce erroneous results. The following example illustrates how to use the equation and what happens if the formulas are misused.

The equation to predict IVDMD from hay is:

$$IVDMD = b_0 + (b_1 \cdot ADF) + (b_2 \cdot ADF^2) + (b_3 \cdot ADF^3) + (b_4 \cdot ADF^4)$$

where:

$b_0 = -0.37$
$b_1 = 11.426$
$b_2 = -0.5642$
$b_3 = 0.010835$
$b_4 = -0.0000755$

If the equation is used correctly, a hay with an ADF value of 32.9 percent gives the following results:

$$IVDMD = -0.37 + (11.426 \cdot 32.9) - (0.5642 \cdot 32.9^2) + (0.010835 \cdot 32.9^3) - (0.0000755 \cdot 32.9^4) = 62.2$$

The equations must be used exactly as presented. Examples of common errors in using these equations and the erroneous results that follow are:

1) If only two numbers after the decimal are used for all the coefficients the IVDMD value changes dramatically.

$$IVDMD = -0.37 + (11.43 \cdot 32.9) - (0.56 \cdot 32.9^2) + (0.01 \cdot 32.9^3) - (.00 \cdot 32.9^4) = 125.6$$

2) If only the b_4 term is altered the results are still very different. Rounding up the fourth term:

$$IVDMD = -0.37 + (11.426 \cdot 32.9) - (0.5642 \cdot 32.9^2) + (0.010835 \cdot 32.9^3) - (.0001 \cdot 32.9^4) = 33.3$$

3) Dropping the last digit of the fourth term:

$$IVDMD = -0.37 + (11.426 \cdot 32.9) - (0.5642 \cdot 32.9^2) + (0.010835 \cdot 32.9^3) - (.000075 \cdot 32.9^4) = 74.6$$

When used correctly, these equations yield satisfactory and workable energy values for feeds so that animal rations can be properly balanced to achieve producer goals. They also permit more rapid lab turnaround of feed samples by elimination of the time-consuming IVDMD procedure. □

References

Anderson, M.J., G.F. Fries, D.V. Kopland, and D.R. Waldo. 1973. Effects of cutting dates on digestibility and intake of irrigated first-crop alfalfa. *Agron. J. 65*:357-60.

Anderson, M.J., and D.R. Waldo. 1975. Nutritional values of three varieties of alfalfa hay from two harvest system. Utah Agr. Exp. Sta. Rpt. 24.

A.O.A.C. 1980. Official Methods of Analysis (13th Edition). Association of Official Analytical Chemists. Washington, DC.

Bath, D.L., F.N. Dickinson, H.A. Tucker, and R.D. Appleman. 1978. *Dairy Cattle: Principles, Practices, Problems, Profits* (2nd Edition). Lea and Febiger. Philadelphia.

Coleman, S.W. 1986. Use of near infrared reflectance spectroscopy to predict animal response from forages. Arkansas Agr. Exp. Sta. Special Rpt. 124.

Coppock, C.E. 1975. Forage testing and feeding programs. *J. Dairy Sci. 59*:175-81.

Fonnesbeck, P.V., R.E. Lamborn, and M.J. Anderson. 1980. How does your hay stack up? A chemical analysis for haygrading. *Utah Science 1980*:1-6.

Tilley, J.M.A., and R.A. Terry. 1963. A two-stage technique for the *in vitro* digestion of forage crops. *J. Brit. Grassl. Soc. 18*:104-11.

Van Soest, P.J. 1963. The use of detergents in the analysis of fibrous feeds. II. A rapid method for the determination of fiber and lignin. *Assoc Off. Analytical Chem. J. 46*:829-35.

Effect of Six Gypsum Rates on Bromegrass Yield and Chemical Composition

By

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

In 1980, bromegrass grown by Bob Havemeister, a dairyman in the Matanuska Valley, provided very low yields even though 500 pounds per acre of 20-10-10 fertilizer, containing 3.5 percent sulfur (S), had been applied in the spring. In this area of southcentral Alaska this amount of fertilizer ordinarily produces bountiful yields. Since the grass had a yellowish color and an adequate amount of N had been applied, we suspected an S deficiency. On October 2, 1980, a fairly uniform area of low-producing bromegrass on Knik silt loam (an important soil in the Matanuska Valley) was chosen as an experimental site. The following May 5 a field experiment with six gypsum rates supplying 0, 10, 15, 20, 25, and 30 pounds S per acre was established. All treatments received 120 pounds per acre nitrogen (N) as ammonium nitrate, 31 pounds per acre phosphorus (P) (70 pounds per acre P_2O_5) as treblesuperphosphate, and 83 pounds per acre potassium (K) (100 pounds per acre K_2O) per acre as muriate of potash. The fertilizer treatments were broadcast annually on the appropriate plot by hand the first week of May. Another 120 pounds per acre N as ammonium nitrate was added immediately after the first-cutting each year.

Two clippings were made each of the four seasons with a small sickle-bar mower the third week of June and in the middle of August. The harvested area consisted of a strip 30 inches wide and 12 feet long cut from the center of each 6- by 15-foot plot. Green and dry weights were recorded from each harvest. Representative samples from each plot were ground to pass a 20-mesh stainless steel laboratory mill screen. Chemical determinations were made as follows on the plant tissue: nitrate N with the nitrate electrode (Smith 1975); total N and P colorimetrically with the Technicon autoanalyzer (TIS 1976); K, calcium (Ca), and magnesium (Mg) using an atomic absorption spectrophotometer following a sulfuric-selenious acid digestion and using lanthanum to control interferences (Perkin-Elmer 1973); and total S using an automatic S analyzer (Smith 1980). The soil pH, SO_4-S (Mehlich and Bowling 1976), and total S concentration (Smith 1980) in the soil were also measured.

These data were subjected to a split-plot type of analysis for a repeated measures experiment. The main plots of the experiment were the six gypsum treatments with six blocks. Each experimental plot was measured over four years for yield, NO_3-N, N, P, K, S, Ca, and Mg for all factors. In the analysis of variance the whole plot effects were the gypsum or S treatments. The subplot on repeated measures effects were 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 auto correlation among years were utilized. Since the year effects contribute no useful information, averages of all four years are presented to show the trends even when treatment × year interactions occurred.

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

Results and Discussion

Soil tests

Table 1 presents the soil pH, SO_4-S, and total S in the soil before applying fertilizer in 1981 and after the final harvest in 1984. Gypsum (calcium sulfate) application had no significant effect on the soil pH which appears to have been depressed by four years of heavy N applications. Both the sulfate S and total S tended to increase with increasing S rates. If one were to evaluate S response from the

***Research Soil Scientist (retired), Agricultural Research Service, USDA, Palmer, Alaska.**

****Laboratory Technician, Agricultural and Forestry Experiment Station, University of Alaska.**

*****Biological Technician, Agricultural Research Service, USDA, Palmer, Alaska.**

Table 1. Effect of six sulfur rates on the soil pH, SO_4-S, and total S on Knik silt loam (means of 6 measurements).

Date	S	pH[2]	SO_4-S	Total S
	(lb/A)		(lb/A)	(%)
5/5/81	[1]	5.02	9.2	.021
8/13/84	0	4.78a	12.4d	.019
	10	4.78a	19.0cd	.018c
	15	4.86a	19.4c	.021b
	20	4.88a	27.8b	.022b
	25	4.95a	27.6b	.021b
	30	4.86a	43.5a	.024a

[1]Prior to fertilizer application.
[2]One part soil to two parts water.

Table 3. Effect of six sulfur rates on yearly uptake by bromegrass of N, P, K, S, Ca, and Mg and on the N to S ratio for two cuttings on Knik silt loam, 1981-84 (means of 24 measurements).

S	N	P	K	S	Ca	Mg	N/S 1st	N/S 2nd
(lb/A)	(lb/A)							
0	80c	10.0c	80c	3.9d	9.1b	3.32c	19.5a	21.8a
10	129b	15.4b	140b	7.8c	14.5b	4.76bc	15.5b	17.8b
15	161a	19.5a	178a	10.3b	20.2a	6.86ab	15.3bc	16.0bc
20	174a	20.1a	193a	12.0ab	22.1a	7.57a	14.6bcd	15.0cd
25	180a	21.2a	201a	12.6a	24.0a	8.14a	14.2cd	15.0cd
30	175a	20.6a	191a	12.7a	23.0a	7.67a	13.8d	14.3d

soil test values for SO_4 or total S, only those values receiving 30 pounds S per acre per year are sufficiently higher than the no-S treatment to indicate an adequate amount of soil S. Yet no significant yield increases from S were secured above the 15 pounds per acre application (table 2), and no significant increase in S concentration occurred above 20 to 25 pounds S applications (table 2).

Yield

First-cutting bromegrass yield was increased by S application (table 2). Second-cutting and total season yield showed a S × year interaction[1] even though the results of each year were relatively consistent. These yields were increased by S rates exceeding 15 pound per acre. This increase with S application indicates the 1980 poor growth probably resulted from a S deficiency.

Nitrate N and total N concentration and uptake

Applications of S increased first-cutting NO_3-N and N concentrations and had no significant influence on the second-cutting NO_3-N concentration. The N concentration in the second cutting was erratic as related to S application (table 2). The N uptake was increased the first three years by S rates exceeding 10 pounds per acre and in 1984 by rates exceeding 15 pounds per acre. The averages for all four years are presented in Table 3.

[1]The sulfur x year interaction means the response to S was different in some years than in others. Throughout this study the trend each year was always the same; sometimes the increase between increasing S rates was greater some years than others.

P concentration and uptake

Increasing S rates through 20 pounds per acre tended to decrease second-cutting P concentration, while that of the first cutting was not influenced significantly by S (table 2). The first-cutting decrease probably results from dilution with increased yields. The P uptake was increased by each increasing S rate through 10 pounds per acre in 1981 and 1982, and 15 pounds in 1983 and 1984 with a further increase in 1984 with 25 pounds S per acre. The averages for all four yields are presented in Table 3.

K concentration and uptake

Sulfur application increased the first-cutting K concentration and had no significant effect on that in the second cutting (table 2). Although the S × year interaction was significant, each increasing S rate through 15 pounds per acre tended to increase the K uptake (table 3).

S concentration and uptake

Increasing S rates increased the S concentration in both cuttings with no significant increase above 20 pounds S per acre in the first cutting and above 25 pounds in the second cutting (table 2). The total S uptake was increased by each increasing S rate through 20 pounds the first three years and through 25 pounds S per acre in 1984. The four-year averages are presented in Table 3.

Table 2. Effect of six sulfur rates on bromegrass yield and NO_3-N, N, P, K, S, Ca, and Mg concentrations for two cuttings on Knik silt loam, 1981-84 (means of 24 measurements).

	Yield			NO_3-N		N		P		K		S		Ca		Mg	
S	1st	2nd	Total	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
(lb/A)	(T/A)			(%)													
0	0.70c	0.84c	1.54c	.090b	.144a	2.52b	2.70a	.303a	.343a	2.34b	2.65a	.131d	.127e	.255c	.313cd	.090a	.110bc
10	0.96bc	1.54b	2.50b	.412ab	.161a	2.71ab	2.54ab	.294a	.319b	2.76a	2.82a	.177c	.145d	.278bc	.298d	.082a	.101c
15	1.28ab	1.89a	3.17ab	.138a	.171a	2.79a	2.49bc	.305a	.320b	2.93a	2.79a	.184bc	.156cd	.300ab	.327cd	.092a	117abc
20	1.41a	2.03a	3.44a	.131a	.174a	2.77a	2.44c	.292a	.299c	2.97a	2.75a	.191abc	.164bc	.310ab	.336bc	.088a	.126ab
25	1.35ab	2.17a	3.52a	.109ab	.159a	2.74a	2.54ab	.300a	.310c	2.97a	2.82a	.194ab	.171ab	.318a	.362a	.091a	.132a
30	1.37a	2.04a	3.41a	.132a	.166a	2.78a	2.51bc	.300a	.307c	2.98a	2.73a	.203a	.178a	.316a	.352b	.085a	.131a

Ca and Mg concentration and uptake

Table 2 shows an increase in first-cutting Ca and in second-cutting Mg concentrations with increasing S through 15 pounds per acre and in second-cutting Ca concentrations through 25 pounds S per acre; first-cutting Mg concentration was not significantly influenced by S application. Sulfur rates through 15 pounds per acre increased the Ca uptake in 1981 and through 20 pounds S in 1982, 1983, and 1984. Table 3 presents the averages for all four years. The Mg uptake for all four years tended to be increased by increasing S through 15 pounds per acre.

N to S ratio

The N to S ratio in both cuttings tended to decrease with increasing gypsum rates. Every year the most significant decrease occurred with the application of the first increment of S (table 3).

Summary

The N to S ratio is regarded by many as a valuable key to the presence of a S deficiency. Responses to S were obtained by Byers and Bolton (1979) with wheat grain, Eppendorfer (1977) with Italian ryegrass, and Westermann (1975) with alfalfa when the N to S ratio exceeded 15, 20, and 17, respectively. These values correspond to those ranging from 17 to 22 in forage receiving no S in this study.

Although the soil increased in both sulfate and total S, the values from plots receiving S were not sufficiently higher than those plots receiving no S to make any reliable predications on a possible S deficiency.

Since we received no significant S response above the 15 to 20 pounds per acre applications, we feel the 1980 fertilizer applied either did not supply the 17.5 pound S per acre or the S applied was in a form the grass was unable to utilize. The two applications of N made in 1980 and on these plots each year are sufficiently high to bring out any existing S deficiency (Eppendorfer 1977). The increasing S concentrations in the forage with increasing S rates further verify that an S deficiency existed and that the gypsum is a source of S that is readily available to plants.

Although the soil increased in both sulfate and total S, the values from plots receiving S were not sufficiently higher than those plots receiving no S to make any reliable predictions of a possible S deficiency.

Even though S × year interactions occurred with second-cutting yield and with total uptake measurements, certain general statements can be made. Application of S increased the bromegrass yield and NO_3-N, N, and K concentrations in the first cutting and decreased the N to S ratio in both cuttings. Increasing S rates up to 10 to 15 pounds per acre increased the Ca concentration in both cuttings, second-cutting Mg concentration, and the N, P, K, Ca, and Mg uptake. The S concentration in both cuttings and the S uptake were increased or tended to increase and the N to S ratio was decreased by S rates of 20 to 25 pounds per acre. □

Literature Cited

Byers, M., and J. Bolton. 1979. Effects of nitrogen and sulfur fertilizers on the yield, N and S content and amino acid composition of the grain of spring wheat. *J. Sci. Food Agric.* *30*:251-26.

Eppendorfer, W.H. 1977. Effects of varying amounts of sulfur and nitrogen on yield, N/S ratio and amino acid composition of successive cuts of Italian ryegrass. K. Vet-Landbohojak Arsskr. 1977:42-57. (*Biolg. Abst.* *64*:24202).

Mehlich, A., and S.S. Bowling. 1976. Determination of sulfate sulfur by buffered ammonium chloride (pH 7.0) extraction. Mimeo 5. Agron. Div., N. Car. Dept. Agric., Raleigh, N. Car.

Perkin-Elmer Corp., Norwalk, Conn. 1973. Analysis of plant tissue-digestion procedure. Analytical methods for atomic absorption spectrophotometry. Perkin-Elmer Corp., Norwalk, Conn.

Smith, G.R. 1975. Rapid determination of nitrate-nitrogen in soils and plants with the nitrate electrode. *Anal. Lett.* *8*:503-508.

Smith. G.R. 1980. Rapid determination of total sulfur in plants and soils by combustion sulfur analysis. *Anal. Lett.* *13*:465-471.

Technicon Industrial Systems. 1976. Technicon industrial methods 369-75 A/A and 334-74 A/A. Technicon Ind. Syst., Tarrytown, N.Y.

Westermann, D.T. 1975. Indexes of sulfur deficiency in alfalfa. II. Plant analyses. *Agron. J.* *67*:265-268.

Inoculation of Alfalfa in Alaska

By

Stephen D. Sparrow*

The family Leguminosae is a highly diverse plant family which is distributed worldwide and which is comprised of almost 500 genera and thousands of species. Legumes are important agriculturally as animal and human food and as green manures. Some species are valued as livestock forages primarily because of their high protein concentrations. Legumes are unique among crop plants because they have the ability, in association with bacteria called rhizobia, to fix atmospheric nitrogen (N) into forms which are usable for plants. Thus, they can usually be grown without the addition of N fertilizer.

Rhizobia are free-living bacteria in the soil, which, upon contact with roots of the appropriate legume species, infect the root and stimulate the plant to produce small tubercles called root nodules. Inside these nodules the bacteria convert atmospheric N into forms which plants can use. Unless the appropriate bacteria are present in the soil in sufficient numbers to produce adequate nodulation, N fixation will be limited. In the absence of adequate soil N or N-fixing bacteria, plant protein content and yield will be low. In order to insure adequate numbers of root-nodule bacteria in the soil, farmers usually inoculate seeds with cultures of the appropriate rhizobia at planting time.

One of the limiting factors in the development of economical animal agriculture in Alaska is the availability of a high-yielding, high-protein forage legume. Numerous native legume species grow in Alaska, but they have agronomic deficiencies which make them generally unsuited for forage crops (Klebesadel 1971a). Numerous perennial forage legumes from temperate regions have been tested in Alaska, but generally they have been found to be insufficiently winter-hardy for Alaskan conditions, they produce very low forage yields, or they have other characteristics which make them poorly suited for crop use in Alaska.

*Assistant Professor of Agronomy, Agricultural and Forestry Experiment Station, Fairbanks.

Because of its potential for producing high yields of palatable, high-quality forage, alfalfa is the most widely grown forage legume in the United States and Canada, and it is sometimes referred to as the queen of forages. Alfalfa is generally not winter-hardy enough for Alaska except in protected areas. However, progress has been made in developing strains which are sufficiently winter-hardy to survive extreme subarctic winters (Klebesadel 1971b, Klebesadel and Taylor 1973). Also, some of the recently developed cultivars of annual alfalfa may have potential use for Alaska.

Many agricultural soils in Alaska are acidic. Alfalfa and, especially, its associated rhizobia are poorly adapted to soil acidity (Rice et al. 1977, Keyser and Munns 1979, Smith 1981). Some attempts to select strains of alfalfa rhizobia adapted to acid conditions have been partially successful (Rice 1982, Lowendorf and Alexander 1983). Inoculant strains selected for acid-tolerance in Canada are now produced commercially for use there. The study reported here, however, is the first study of such strains for Alaska.

Both farmers and researchers in Alaska have noted that newly established stands of alfalfa are often poorly nodulated after being inoculated at planting with inoculants developed for and adapted to temperate latitudes. These stands usually exhibit N deficiency symptoms and poor growth unless fertilized with N. In contrast, native legumes in Alaska generally are well nodulated. Also, old stands of introduced legumes are sometimes well nodulated. It is clear, therefore, that rhizobia well adapted to subarctic conditions occur in Alaskan soils. There is little information, however, on the adaptability of temperate rhizobia to subarctic conditions.

Low temperatures in the root environment are known to reduce nodulation and N fixation by legumes (Roughley and Dart 1970, Gibson 1971). Ek-Jander and Fahraeus (1971) and Hardarson and Jones (1977) found that clover rhizobia strains from high latitude regions perform better at low temperatures than strains from more southerly regions. This indicates that rhizobia can adapt to low temperatures.

I was curious as to whether rhizobia isolated from old stands of alfalfa growing in Alaska would perform better under Alaskan field conditions than inoculants from other regions and whether rhizobia strains selected for acid tolerance were effective in producing nodules and fixing N in Alaska. Therefore, this study was designed to determine the effect of inoculation with alfalfa inoculants from different regions on nodulation, plant growth, and plant protein content of alfalfa grown on acid and neutral soils in Alaska.

Experimental Procedure

Seven alfalfa inoculants were field tested at Fairbanks, Delta Junction, and Palmer. The soil was near neutral (pH 7.3) at Fairbanks and acid at Delta Junction and Palmer (pH 5.7 and 5.9, respectively). Two of the inoculants, AK 81-1 and AK 81-4, were isolated from old alfalfa stands in Alaska; three of the inoculants, NRG 43-4, NSRG 185, and BALSAC, were selected for acid tolerance in Canada; and the other two, Nitragin A and Pelinoc A, were commercial inoculants produced for use in temperate parts of the USA. The latter two were similar except the Pelinoc A contained an adhesive to facilitate better adherence of the inoculant to the seeds. 'A-syn-B', an experimental alfalfa cultivar developed in Alaska, was used in all of the trials. Data on nodulation, plant growth, and plant protein concentration were collected and compared among inoculants. Unfortunately, bison grazed the plots at Delta Junction before harvest, thus no plant yield or protein concentration data were obtained for that site.

Results and Discussion

Although nodulation was improved by inoculation at all three sites (table 1), plant dry-matter yields and plant protein concentrations were improved only at Fairbanks (table 2). Overall nodulation scores were higher at Fairbanks than at the other two sites (table 1). There was little difference in nodulation scores among inoculants.

Table 1. Nodulation scores of alfalfa as affected by inoculant type at three sites in Alaska (scoring[1] based on Rice et al. 1977).

	Fairbanks		Delta Junction		Matanuska	
Inoculant	16 Jul	17 Sep	14 Jul	22 Sep	23 Jul	1 Sep
AK 81-1	6.0	8.6	6.1	8.1	4.7	7.6
AK 81-4	6.5	8.4	5.6	7.7	4.7	7.9
NRG 43-4	7.0	9.0	6.0	7.7	5.5	7.0
NSRG 185	7.1	8.5	6.2	7.1	4.3	7.5
BALSAC	7.1	8.9	5.8	8.2	3.1	7.5
Nitragin A	6.9	8.6	5.9	7.3	3.6	7.4
Pelinoc A	6.9	8.8	5.9	7.7	4.1	7.4
Mean	6.8	8.7	5.9	7.7	4.3	7.5
Uninoculated	2.3	6.6	1.4	1.3	0.6	2.7

[1]This scoring procedure takes into account number of nodules, internal pigmentation (pink or red color inside of nodules indicates N fixation), size, and position on the root. A score of 1 indicates very poor nodulation; a score of 10 indicates that all nodulation characteristics are good.

At Delta Junction average plant height in mid-July was only about 4 inches compared to about 8 inches at Fairbanks and Palmer, and all plants at Delta Junction showed N deficiency symptoms. There was no effect of inoculation on mid-July plant heights at any location. By September most plants at Palmer displayed moderate N deficiency symptoms with no apparent effect due to inoculation. At Fairbanks, some of the plants in the uninoculated plots showed moderate chlorosis by early September.

At Palmer, average plant dry-matter yield, plant protein concentration, and protein yield was 0.7 pounds per 10 feet of row, 11.5 percent, and 1.2 ounces per 10 feet of row, respectively, with no significant differences among inoculants or between inoculated and uninoculated plots. This compares to averages of 1.2 pounds per 10 feet of row, 14.9 percent, and 2.8 ounces per 10 feet of row at Fairbanks. (Note: yields were not converted to a per-acre basis because rows were spaced much wider than is normal for forage production. Yields are presented only for comparison among sites and among inoculants.) Plant dry matter and protein yields were, on average, increased by 85 percent and 106 percent, respectively, due to inoculation at Fairbanks. Although some inoculants resulted in somewhat better yields than others, no group of inoculants from any given geographical region performed better than those from another region.

Unfortunately, winter-kill at Delta Junction and Palmer was almost 100 percent and at Fairbanks a farm worker inadvertently applied a heavy dosage of N fertilizer to the plots early in the second growing season after seeding. Thus, data were available only for the seeding year. However, certain conclusions can be made. Results from Fairbanks indicate that inoculation with currently available commercial, temperate-region alfalfa inoculants can lead to substantial increases in forage yield and protein production on neutral soils in Alaska. The fact that some strains increased plant dry-matter production more than others at Fairbanks indicates that there may be potential for further improvement of N fixation and plant growth through con-

Table 2. Dry-matter yield, plant protein concentration, and protein yield of alfalfa herbage, as affected by inoculant type at Fairbanks.

Inoculant	Dry-matter yield	Crude protein concentration	Crude protein yield
	(lbs/10-ft row)	(%)	(oz/10-ft row)
AK 81-1	1.4	15.0	3.4
AK 81-4	1.2	14.7	2.7
NRG 43-4	1.5	14.2	3.6
NSRG 185	1.0	16.5	2.8
BALSAC	1.0	16.5	2.7
Nitragin A	1.3	15.1	2.2
Pelinoc A	1.4	14.1	3.1
Uninoculated	0.7	13.4	1.5

tinued selection for rhizobia strains possessing superior adaptation to subarctic conditions.

The fact that inoculation led to significant increases in nodulation at both Delta Junction and Palmer indicates that the rhizobia survived long enough, and in sufficient numbers, to initiate nodules; moreover, the good internal color of the nodules examined suggests that they were effective. On the other hand, the lack of plant response to inoculation may indicate that these nodules were either not abundant enough or not effective enough to supply the plants with the N they required.

Nitrogen fertilization of unnodulated alfalfa in acid soils in Alaska results in the rapid elimination of N deficiency symptoms and in good plant growth, showing that N is a major limiting nutrient for the satisfactory growth of the crop in these soils. Improved N fixation should therefore also result in better plant growth. The relatively poor apparent N fixation and plant growth at Delta Junction and Palmer was likely due to poor adaptation of the rhizobia or of the rhizobia/plant symbiosis to these acid subarctic soils.

Interestingly, the supposedly acid-tolerant strains did not perform any better in acid soils than other strains. Addition of lime has been shown to increase the growth of inoculated forage legumes on an acid soil in Alaska (F. Wooding, unpublished data[1]). However, no developed lime deposits exist in Alaska, and importing lime is prohibitively expensive. Recent work at Delta Junction by F. Wooding (unpublished) indicated that banding of small amounts of lime in the seed row has potential for improving growth of legumes at relatively small costs. Further research on liming effects and on inoculation of more acid-tolerant, subarctic-adapted legumes is needed.

Previously reported poor response to inoculation of alfalfa in acid soils in Alaska is not surprising; the poor response in neutral soils was probably due to use of nonviable inoculants or to too low an inoculation rate. In this study, a very high inoculation rate was used. Further research is needed to determine the optimum inoculation rate for legumes in Alaska.

[1] Professor of Agronomy, Agricultural and Forestry Experiment Station, University of Alaska Fairbanks, Fairbanks, Alaska 99775.

This work was recently published in less abridged form in *Crop Research* (Vol. 25, pp. 133-142). For more details of the study, please consult that article. Reprints are available from the author. □

References

Ek-Jander, J. and Fahraeus, G. 1971. Adaptation of *Rhizobium* to subarctic environment in Scandinavia. *Plant and Soil, Special Volume*, 129-137.

Gibson, A.H. 1971. Factors in the physical and biological environment affecting nodulation and nitrogen fixation by legumes. *Plant and Soil, Special Volume*, 139-152.

Hardarson, G. and D.G. Jones. 1977. The inoculation of white clover (*Trifolium repens L.*) with *Rhizobium trifolii* in Iceland. *Journal of Agricultural Research, Iceland* 9:29-46.

Keyser, H.H., and D.N. Munns. 1979. Tolerances of rhizobia to acidity, aluminum, and phosphate. *Soil Science Society of America Journal* 43:519-523.

Klebesadel, L.J. 1971a. Native Alaskan legumes studied. *Agroborealis* 3:9-11.

Klebesadel, L.J. 1971b. Selective modification of alfalfa toward acclimatization in a subarctic area of severe winter stress. *Crop Science* 11:609-614.

Klebesadel, L.J., and R.L. Taylor. 1973. Research progress with alfalfa in Alaska. *Agroborealis* 5:18-20.

Lowendorf, H.S., and M. Alexander. 1983. Selecting *Rhizobium meliloti* for inoculation of alfalfa planted in acid soils. *Soil Science Society of America Journal* 47:935-938.

Rice, W.A. 1982. Performance of Rhizobium meliloti strains selected for low pH tolerance. *Canadian Journal of Plant Science* 62:941-948.

Rice, W.A., D.C. Penny, and M. Nyborg. 1977. Effects of soil acidity on rhizobia numbers, nodulation, and nitrogen fixation by alfalfa and red clover. *Canadian Journal of Soil Science* 57:197-203.

Roughley, R.J., and P.J. Dart. 1970. Root temperature and roothair infection of *Trifolium subterraneum* L. cv. 'Cranmore'. *Plant and Soil* 32:518-520.

Smith, D. 1981. *Forage Management in the North*. 4th edition. Kendall/Hunt Publishing Co., Dubuque, Iowa.

Continued from page 30

ference as President of the Natural Areas Association. Further travels will take Dr. Juday to Virginia, Ottawa, Ontario, New Jersey, and the New England states, in addition to locations in several southern states, California, Arizona, New Mexico, Oregon, and Washington. Dr. Juday will return to SALRM in April 1988 to complete his book which is to be published early in 1989.

Dr. Jenifer Huang McBeath, associate professor of plant pathology, has been awarded a grant from Alaska Department of Natural Resources, Division of Agriculture, to develop snow mold resistant, high yield, early maturing, cold hardy, and hard red winter wheat for Alaska. Her approach will be to select and manipulate winter wheat genetic materials for snow mold resistance by means of anther culture and other biotechniques. The anther culture technique—obtaining plantlets from pollens in the anthers of early maturing cold hardy, winter wheat—was developed by Dr. McBeath in collaboration with Dr. Gideon Schaeffer during her stay at the Plant Molecular Genetic Laboratory, USDA Beltsville Agricultural Research Center while Dr. McBeath was on sabbatical leave during the 1985-86 academic year.

Dr. McBeath has also received a grant from the USDA, Animal and Plant Health Inspection Service, Plant Protection and Quarantine Program to continue her work in plant pest survey and detection. The Alaska plant pest survey and detection project is a part of the National Cooperative Plant Pest Survey and Detection Program. This project's objective is to establish a national plant pest database with high quality information on both indigenous and exotic pests, collected by using established survey methods.

A Zeiss 109 transmission electron microscope and a Reichert ultramicrotome recently were added to the scanning electron microscope and other equipment in the Electron Microscope (EM) Laboratory at the UAF. The Zeiss 109 and Reichert were purchased with a grant from the Division of Biological Instrumentation, National Science Foundation. Dr. McBeath was a principal investigator. Coprincipal investigators of the project were Mr. Don Ritter (director of Northern Region Virology Laboratory) and Dr. Marilyn Griffith (former assistant professor of plant physiology, AFES). Dr. McBeath is currently in charge of the EM Laboratory.

Dr. McBeath has been elected chairperson of the Western Regional Hatch Project W-147, "Biological suppression of soil-borne plant pathogens." The objectives of this project are to identify organisms with the potential for suppression of specific soil-borne plant pathogens, to determine their mode of activity, and to establish field application procedures. This committee is comprised of many scientists highly regarded for their contributions to plant pathology. Work done by several committee members have led to technological innovations that have been patented (two approved, one pending). Currently, the discovery by Dr. McBeath and her associates of a low temperature tolerant fungus capable of controlling snow mold and many other economically important soil-borne plant pathogens has attracted great interest from committee members. Presently, preparation for patent application of this mycoparasite and its UV-induced biotype (fungicide-resistant mutant) are in progress at the University of Alaska Fairbanks.

Dr. Feridoon Mehdizadigan recently joined the Plant Pathology Laboratory as a post-doctoral research associate. Dr. Mehdizadigan has completed doctoral studies in both animal nutrition (University of Arkansas) and plant pathology (Oklahoma State University). He will be working with Dr. J.H. McBeath on the identification and characterization of extracellular enzymes of snow molds, as well as on the development of snow mold resistant, cold hardy, hard red winter wheat through biotechniques.

Dot Helm, research associate, Palmer Research Center, has received a $16,000 grant to summarize and synthesize existing data on potential grazing lands of the Matanuska Susitna Borough so that utilization of that grazing resource may begin.

Dr. Carla Kirts has received the Honorary American Farmer degree from the National FFA Association. This is the highest award the association can give to a nonmember. Dr. Kirts has also received a certificate of appreciation from the Alaska Department of Education Office of Adult and Vocational Education for serving on the Task Force for Developing the Renewable Natural Resources/Agriculture State Model Curriculum. This standard, yet flexible, model will improve current vocational agriculture programs and foster the development of new ones. Nontraditional agricultural enterprises and a broad spectrum of natural resources management disciplines are included. Additionally, Dr. Kirts has been elected Chair of the Fairbanks North Star Borough School District's Vocational Education Advisory Council for a second term. During the 1986-87 academic year, an assessment of the local vocational education programs was conducted via the advisory council. A final report was prepared and presented to the superintendent and school board.

Dr. Paul Windschitl joined the staff of AFES in November as assistant professor of dairy science. Working on his family's dairy farm in southcentral Minnesota, Dr. Windschitl gained practical experience with dairy cattle nutrition and management. The farm included forty head of dairy cows as well as a swine and poultry operation. Dr. Windschitl has just completed his Ph.D. at the University of Minnesota in protein and amino acid nutrition of high-producing dairy cows. His M.S. work at South Dakota State University involved the study of whey in dairy cattle rations and its effect on rumen bacterial metabolism.

Dr. Windschitl will be working with the dairy herd at the Matanuska Research Farm, near Palmer. His work will include the use of local protein and energy sources in dairy cattle diets and their effect on rumen fermentation. He also is interested in the use of feed additives to improve dairy performance.

Dr. William G. Workman, associate professor of economics, has rejoined SALRM in a full-time appointment. For the past few years, Dr. Workman divided his time between SALRM and UAF's School of Management.

Dr. Workman received a Mellon Foundation Travel Grant to attend the Regional Hatch Project W-133 meeting in Monterey, CA in January 1988.

Clyde Hornal, farm maintenance mechanic at the AFES Palmer Research Center, retired December 1987. Mr. Hornal came to Alaska in 1948 with the Army and remained here after his discharge until 1954. He returned to Alaska in 1969 and settled in Wasilla where he owned and operated his own repair service until 1970 when he began employment with AFES doing engineering maintenance. While with AFES Clyde attended classes at Matanuska-Susitna Community College and received an AAS degree in Refrigeration and Heating in 1977. He plans to spend some of his retirement years hunting, working with wood, and travelling back and forth between Tennessee and Alaska.

Marvlyn Burleson, administrative assistant at the AFES, Palmer Research Center, also retired in December. Ms. Burleson has been an Alaska resident since 1970, and she came to work for AFES in August 1970 as a clerk specialist. In February 1978 she was promoted to personal secretary, and in December 1981 she accepted the position of administrative assistant. Her retirement plans include relaxing, traveling, gardening, camping, and fishing. She will divide her time between Texas and Alaska.

Peter Rissi supervisor of field research in horticulture at the AFES Palmer Research Center, retired in December as well. A native of Switzerland, Mr. Rissi has called Alaska home for more than 25 years. Prior to joining AFES in 1981, Mr. Rissi was a commercial grower of potatoes, lettuce, and other vegetables. Expertise and skills acquired during his many years in business were of great value to the horticulture research program at the Palmer Research Center. His broad knowledge of vegetable crop production in Alaska and his skillful organization of field and laboratory work will be missed. Mr. Rissi's retirement plans call for equivalent amounts of gardening, fishing, and wood cutting; and possibly a little travelling.

Dr. Edmond C. Packee, assistant professor of forest management, presented an invited paper, "Larch in North America," at the Northern Forest Silviculture and Management Symposium held in Lapland, Finland, in August. The symposium was sponsored by the International Union of Forest Research Organizations (IUFRO) Working Party S1.05-12 which includes participants from countries which have northern forests. Dr. Packee is working party chairman and in that capacity will be participating in a similar symposium in Heilongjiang Province of the People's Republic of China in September 1988. The working party evolved from a series of annual workshops initiated in 1979 by the School of Agriculture and Land Resources Management of the University of Alaska Fairbanks. The symposium in Finland was the ninth annual meeting of the group. While in Scandinavia, Dr. Packee observed forestry practices and research projects in Sweden and southern Finland.

Publications List for 1987

Journal Articles

BRUCE, L.B. 1987. Beef cattle dietary and intake calculation for the net energy system by quartic equation. *J. An. Sci. 64*:1189-93.

CARLING, D.E., R.H. LEINER, AND K.M. KEBLER. 1987. Characterization of a new anastomosis group (AG-9) of Rhizoctonia solani. *Phytopathology 77*:1609-12.

ELLIOT, CHARLES L., JAY D. MCKENDRICK, AND D.J. HELM. 1987. Plant biomass, cover, and survival of species used for stripmine reclamation in southcentral Alaska, U.S.A. *Arctic and Alpine Res. 19*(4).

GALLAGHER, THOMAS J. 1987. The Colorado Joint Review Process: Its Success in Coordinating Permits for Major Development Projects. *Env. Manage. 11*(2):193-201.

GORDON, A.M., R.E. SCHLENTNER, AND K. VANCLEVE. 1987. Seasonal patterns of soil respiration and CO_2 evolution following harvesting in the white spruce forests of interior Alaska. *Can. J. For. Res. 17*:304-10.

GORDON, A.M., M. TALLAS, AND K. VANCLEVE. 1987. Soil incubations in polyethylene bags: effect of bag thickness and temperature on nitrogen transformations and CO_2 permeability. *Can. J. Soil Sci. 67*:65-75.

GORDON, A.M., AND K. VANCLEVE. 1987. Nitrogen concentrations in biomass components of white spruce seedlings in interior Alaska. *For. Sci. 33*:1075-80.

HELM, D.J., J.D. MCKENDRICK, AND W.B. COLLINS. 1987. Fertilizer effects on annual grass in wet sedge-grass vegetation site, Susitna Basin, Alaska, U.S.A. *Arctic and Alpine Res. 19*(1):29-34.

HOLLOWAY, P. 1987. Seed germination of Alaska Iris, *Iris setosa* ssp. *HortSci 22*(5):898-899.

JUDAY, G.P. 1987. Selecting natural areas for geological features: A rationale and examples from Alaska. *Natural Areas Journal.*

LEWIS, C.E., C.W. KNIGHT. 1987. Yield response of rapeseed to row spacing and rates of seeding and N-fertilization in interior Alaska. *Can. J. Plant Sci. 67*:53-57.

LEWIS, C.E., R.W. PEARSON, AND W.C. THOMAS. 1987. Agricultural development in Alaska. *Polar Record 23*(147):673-82.

MCKENDRICK, J.D. 1987. Plant succession on disturbed sites, North Slope, Alaska, U.S.A. *Arctic and Alpine Res. 19*(4)

MATULICH, S.C., W.G. WORKMAN, AND A. JUBENVILLE. 1987. "Recreation Economics: Taking Stock," *Land Economics 63*(3):310-16.

MICHAELSON, G.J., AND C.L. PING. 1987. Effects of P, K, and liming on soil pH, Al, Mn, K, and forage barley dry matter yield and quality for a newly cleared Cryothod. *Plant and Soil 104*:155-61.

MICHAELSON, G.J., C.L. PING, AND G.A. MITCHELL. 1987. Correlation of Mehlich 3, Bray 1, and ammonium acetate extractable P, K, Ca, and Mg for Alaska agricultural soils. *Commun. in Soil Sci. and Plant Analysis 18*(9):1003-15.

MITCHELL, W.W. 1987. Grasses indigenous to Alaska and Iceland compared with introduced grasses for forage quality. *Can. J. Plant. Sci. 67*:193-201.

PING, C.L. 1987. Soil temperature profiles of two Alaskan soils. *J. Soil Sci. Soc. Amer. 51*:1010-18.

SHARRATT, B.S., D.G. BAKER, AND C.C. SHEAFFER. 1987. Climatic effect on alfalfa dry matter production. Part II. Summer harvests. *Agric. and For. Meteor. 39*:121-9.

SPARROW, S.D., AND MASIAK, D.T. 1987. Errors in analyses for ammonium and nitrate caused by contamination from filter papers. *J. Soil Sci. Soc. Amer. J. 51*:107-10.

Bulletins and Technical Reports

FARRIS, M., AND J.S. CONN. 1987. Weed control in annual strawberries grown with plastic mulch: Efficacy, photoxicity, and soil persistence studies. Bulletin 75. AFES, SALRM, University of Alaska Fairbanks.

HUSBY, F.M. 1987. Annual report of cooperative regional project: W-166; Characteristics and feed value of barley and western protein supplements for swine. Regional Research Office, CSRS, Office of Western Director at Large, Ft. Collins, CO.

LAUGHLIN, W.M. G.R. SMITH, M.A. PETERS. 1987. Effects of nitrogen lime, and boron on Candle rape grown in the Trapper Creek and Pt. MacKenzie Areas in Southcentral Alaska. Bulletin 74. AFES, SALRM, University of Alaska Fairbanks.

LAUGHLIN, W.M., G.R. SMITH, M.A. PETERS. 1987. Influence of nitrogen rate, nitrogen source, and phosphorus rate on native bluejoint grass yield and composition on the lower Kenai Peninsula. Bulletin 76. AFES, SALRM, University of Alaska Fairbanks.

LEWIS, C.E., E.L. AROBIO, AND C.A. BIRKLID. 1987. The economics of barley production in the Delta Junction area of interior Alaska. Bulletin 77. AFES, SALRM, University of Alaska Fairbanks.

MITCHELL, W.W. 1987. Revegetation research on coal mine overburden materials in interior to southcentral Alaska. Bulletin 79. AFES, SALRM, University of Alaska Fairbanks.

SAMPSON, G.R., AND J.H. MCBEATH. 1987. Temperature changes in an initially frozen wood chip pile. Research Note PNW-RN-454. USDA-Forest Service. Pacific Northwest Research Station.

SHARRATT, B.S., D.G. BAKER, AND C.C. SHEAFFER. 1987. Environmental guide to alfalfa growth, water use, and yield in Minnesota. Bulletin 581. Minnesota Agricultural Experiment Station.

Circulars and Extension Publications

AROBIO, E.L., D.M. QUARBERG, C.E. LEWIS, AND G.A. MITCHELL. 1987. Rapeseed production demonstration in interior Alaska. Circular 61. AFES, SALRM, University of Alaska Fairbanks. 12 pp.

CARLING, D.E., AND P. RISSI. 1987. Potato variety performance Alaska 1986. Circular 58. AFES, SALRM, University of Alaska Fairbanks.

EPPS, A.C. 1987. Applied reindeer research program. Circular 60. AFES, SALRM, University of Alaska Fairbanks.

GALLAGHER, T.J. 1987. Who's planning Alaska: The Alaska planning directory (2nd edition). CES, University of Alaska Fairbanks.

HUSBY, F.M., AND K. KRIEG. 1987. Alaska's feeds for Alaska's livestock. Circular 63. AFES, SALRM, University of Alaska Fairbanks.

HUSBY, F.M. 1987. Alaskan marine by-products: Production and utilization. Alaska Marine Resource Quarterly. Vol. II No. 2. CES, University of Alaska Fairbanks.

WAGNER, P., M. GRIFFITH, AND G. MATHEKE. 1987. Gardening with annual flowers in interior Alaska. Circular 59. AFES, SALRM, University of Alaska Fairbanks.

WOODING, F.J., R.M. VANVELDHUIZEN, J.T. HANSCOM. 1987. Performance of cereal crops in the Tanana River Valley of Alaska, 1986. AFES, SALRM, University of Alaska Fairbanks.

Agroborealis

BRUCE, L.B., E.L. AROBIO, M.L. HERLUGSON, AND W. SIMPSON. 1987. Performance, costs, and value of Holstein steers fed a corn diet or an Alaskan barley diet. *Agroborealis* *19*(1):27-30.

DAU, J., A. DIETERICH, W.C. THOMAS, AND L.T. DAVIS. 1987. Trip report: a visit to the Swedish reindeer industry, 1986. *Agroborealis* *19*(1):6-15.

HOLTY, G., K. KAWASAKI, AND T.E. OSTERKAMP. 1987. Observations of effects on agricultural soils of the artificial enhancement of snowmelt in interior Alaska. *Agroborealis* *19*(1):20-26.

KLINGENSMITH, K.M. 1987. Denitrification in floodplain successional soils of the Tanana River in interior Alaska. *Agroborealis* *19*(1):39-42.

LAUGHLIN, W.M., G.R. SMITH, AND M.A. PETERS. 1987. Effect of Basic-H on vegetable and agronomic crops and soil fertility at Pt. MacKenzie. *Agroborealis* *19*(1):31-33.

LAUGHLIN, W.M., G.R. SMITH, AND M.A. PETERS. 1987. Effect of lime and four phosphorus rates on yield of head lettuce, table beets, and carrots at Pt. MacKenzie. *Agroborealis* *19*(1):34-38.

MITCHELL, W.M. 1987. Notice of release of 'Kenai' polargrass. *Agroborealis* *19*(1):5.

SWANSON, R., AND M.P. PENFIELD. 1987. Whole-grain yeast bread production and consumer acceptability using hull-less barley grown in Alaska. *Agroborealis* *19*(1):16-19.

Books and Chapters in Books

GALLAGHER, T.J. 1987. *Problem Solving with People: The Cycle Process*. University Press of America: Landham, MD.

JUBENVILLE, A. 1987. *Outdoor Recreation Management: Theory and Application*. Venture Publishing Inc: State College, Pa. (and F.N. Spon. Ltd.: London).

LAURSEN, G.A., J.F. AMMIRATI, AND S.A. REDHEAD (EDS.). 1987. *Arctic and Alpine Mycology II*. Environmental Science Research Vol. 34. Plenum Press. N.Y.

LAURSEN, G.A., J.F. AMMIRATI, AND D.F. FARR. 1987. Hygraphoraceae from Arctic and Alpine Tundra in Alaska. IN: *Arctic and Alpine Mycology II*. Laursen, G.A., J.F. Ammirati, and S.A. Redhead (eds.). Environmental Science Research Vol. 34. Plenum Press. N.Y.

Proceedings

BROWN, A.L., AND J.D. MCKENDRICK. 1987. Joint industry/agency/university revegetation feasibility project. IN: *The Fifth Symposium on Coastal and Ocean Management, Proceedings*, May 26-29, 1987, Seattle, Washington.

GRAHAM, D., R.F. CULLUM, AND L.D. GAULTNEY. 1987. Tractor instrumentation for tillage research in remote areas. IN: *Proceedings of American Society of Agricultural Engineering*. No. 87-1024.

GRAHAM, D., R.F. CULLUM, AND L.D. GAULTNEY. 1987. Tillage energy requirements for interior Alaska. IN: *Proceedings of American Society of Agricultural Engineering*. No. 87-1003.

HOLLOWAY, P. 1987. Propagation of Alaska wild iris, *Iris setosa* ssp. *interior*. IN: *Proceedings, Sixth Alaska Greenhouse Conference*. Anchorage. pp 95-98

JARUSSI, R., AND P. HOLLOWAY. 1987. Propagation of highbush cranberry, *Viburnum edule* by stem cuttings. IN: *Proceedings, Sixth Alaska Greenhouse Conference*. Anchorage. pp. 92-94.

JUDAY, G.A. 1987. The emergence of the natural areas profession in the West. IN: *Proceedings of the 1986 Montana Natural Areas Conference*, October 14-16, 1986. University of Montana Press.

KOMARKOVA, V., AND J.D. MCKENDRICK. 1987. Vascular plant growth forms in arctic communities and environment at Atkasook, Alaska. IN: *Proceedings, International Symposium on Vegetational Structure*,. July 14-18, 1987, University of Utrecht, The Netherlands.

MITCHELL, W.M. 1987. Revegetation research on coal mine overburden materials in interior to southcentral Alaska. IN: *Proceedings, Focus on Alaska's Coal '86 Conference Anchorage, AK., October 27-30, 1987.*

MITCHELL, W.M. 1987. Turfgrass varities and their management. IN: *Proceedings, Sixth Annual Alaska Greenhouse and Nursery Conference, Anchorage, AK., February 11-12, 1987. Pp 43-51.*

PACKEE, E.C. 1987. Current utilization of alaska boreal forest resources. IN: *Management of Boreal Forest Proceedings*. Resource Development Council Education Foundation, Inc. Anchorage, AK. Pp. 11-23.

PACKEE, E.C. 1987. Forest management agreements: The Canadian experience applied to Alaska. Public Forum: Should the Private Sector Manage Forests for the State? Alaska State Society of American Foresters Cook Inlet Chapter, Anchorage, AK, April 27, 1987. 9 pp.

PRITCHARD, R.H., R. HANSEN, AND L.B. BRUCE. 1987. Effect of mixed or phase-feeding two ratios of corn and corn silage on performance of feedlot steers. IN: *Proceedings, South Dakota State University Cattle Feeders Day*. Brookings, SD.

RICHMOND, A.P., AND P. HOLLOWAY. 1987. Effect of cell size and fertilization rate on seedling survival and growth. IN: *Proceedings, Sixth Alaska Greenhouse Conference*. Pp. 60-69.

Popular Publications

MILLER, R. 1987. Taking stock of Alaska's trees. *American Forests Magazine* 93(748):50-53.

WEEDEN, R.B. 1987. On wooden nickels, trojan horses, and lonely drummers. *Alaska Fish and Game*, May-June 1987, pp. 5, 16, 17.

Research Progress Reports

MITCHELL, W.W., G.A. MITCHELL, AND D. HELM. 1987. Perennial grass and soil responses to four phosphorus rates at Pt. MacKenzie. Research Progress Report. No. 2. AFES, SALRM, University of Alaska Fairbanks.

CARLING, D.E. 1987. The effect of nitrogen fertilization rates on head lettuce yields: A preliminary report. Research Progress Report No. 3. AFES, SALRM, University of Alaska Fairbanks.

LEWIS, C.E., C.W. KNIGHT, B.J. PIERSON, R.F. CULLUM. 1987. The effects of banding and broadcasting the complete nutrient requirement for barley. Research Progress Report No. 4. AFES, SALRM, University of Alaska Fairbanks.

Abstracts

BRUCE, L.B. 1987. Calculation of dietary intake for beef cattle by using Newton's method for approximating roots of equations. *J. An. Sci.* *65*(1):482.

ILLG, D.J., M.D. STERN, P.M. WINDSCHITL, D.M. WALTZ, AND F.J. BAS. 1987. Evaluation of diaminopimelic acid and purines as markers for estimating ruminal microbial activity. Nineteenth Conference on Rumen Function, November 18-19, Chicago, IL. Pg. 24

MCBEATH, J.H., AND M. ADELMAN. 1987. Cyanogenesis of a sclerotial low temperature basidiomycete. *Phytopathology 77*:1701.

MCBEATH, J.H., AND J. PLASKOWITZ. 1987. Sclerotial formation of snow mold causing low temperature basidiomycete. *Phytopathology 77*:1700.

MARION, G.M., K. VANCLEVE, C.T. DYRNESS, AND C.H. BLACK. 1987. The Soil Chemical Environment in Primary Successional Vegetation Types on the Tanana River Floodplain of Interior Alaska. *Agronomy Abstracts*. 79th Annual Meeting of the American Society of Agronomy. Atlanta, GA. P. 261.

SHARRATT, B., AND R.F. CULLUM. 1987. Albedo of crop surfaces in the subarctic. *Agronomy Abstracts*. 79th Annual Meeting of the American Society of Agronomy. Atlanta GA. P. 17.

SPARROW, E.B., COCHRAN, V.L., AND SPARROW, S.D. 1987. Phosphorus mineralization in forest and agricultural subarctic soils. *Agronomiy Abstracts*. 79th Annual Meeting of the American Society of Agronomy. Atlanta GA. P. 193.

SPARROW, S.D., AND SPARROW, E.B. 1987. Residual effects of crude oil spills on subarctic soil biological properties. *Agronomy Abstracts*. 79th Annual Meeting of the American Society of Agronomy. Atlanta GA. P. 193.

VAN CLEVE, K., R. SCHLENTNER, C.T. DYRNESS, AND L.A. VIERECK. 1987. The soil physical environment in primary successional vegetation types on the Tanana River floodplain of interior Alaska. *Agronomy Abstracts*. 79th Annual Meeting of the American Society of Agronomy. Atlanta GA. P. 267.

WINDSCHITL, P.M. AND M.D. STERN. 1987. Effects of urea supplementation of diets containing lignosulfonate treated soybean meal on ruminal bacterial fermentation in continuous culture. Annual meeting American Society of Animal Science, July 28-31. Logan, UT. P 468.

WINDSCHITL, P.M. AND M.D. STERN. 1987. In vivo evaluation of lignosulfonate-treated soybean meal as a source of rumen protein. 20th Annual meeting Midwestern Section American Society of Animal Science, March 23-25, Des Moines, IA. Pg. 165. Vol 65. Supp. 1.

Theses and Dissertations

CANDLER, R.C. II. 1987. Characteristics of metal-organic complexes in aspen and birch forest soils in interior Alaska. Ph.D. Thesis. University of Alaska Fairbanks. 108 pp.

COLLINS, G.V. 1987. An economic evaluation of stumpage appraisal methods used in the interior of Alaska, British Columbia and the Yukon Territory. M.S. Thesis. University of Alaska Fairbanks.

WILHELM, R.D., II. 1987. Land planning on a Pacific Island possession of the United States: The case of Saipan. M.S. Thesis.

Miscellaneous

KIRTS, C.A. 1987. Alaska FFA Rituals Contest. UAF: Agricultural Education Publication No. 4. 4pp.

MCKENDRICK, J.D. 1987. *Arctophila* feasibility study 1986 annual report. Standard Alaska Production Company, Anchorage, Alaska. 69 pp (+ appendices A through H, 352 pp.) Contract report.

MICHAELSON, G.J., C.L. PING, AND G.A. MITCHELL. 1987. Methods of Soils and Plant Analysis, Lab Manual. AFES, SALRM, University of Alaska Fairbanks. Misc. Pub. 87-2.

MURRAY, M. 1987. Annual Report 1987. AFES, SALRM, University of Alaska Fairbanks. Misc. Pub. 87-1.

Are you interested in the Environment? People? Problem Solving?

Have you considered:

- **A career in natural resources management?**
- **A profession promoting responsible stewardship of our natural resources?**

Specialize in any of the following areas:

- Forestry
- Outdoor Recreation
- Animal Science
- Water Resources
- Land Use Planning
- Agronomy
- Resource Economics
- Range Management
- Soil Conservation
- Horticulture
- Land Reclamation
- Environmental Education

After graduation, develop your own business or work for such agencies as:

- National Park Service
- Soil Conservation Service
- Bureau of Land Management
- Alaska Native Corporations
- Local Government Agencies
- Other state's resource agencies
- U.S. Fish and Wildlife Service
- Alaska Department of Natural Resources
- U.S. Forest Service
- Alaska Department of Fish and Game
- University of Alaska Lands Office
- U.S. Military Bases

Our undergraduate and graduate programs in Natural Resources Management offer:

- Diverse courses in management of renewable resources such as forestry, hydrology, soils, agronomy, range science, and outdoor recreation.
- Scientific orientation for understanding the natural environment with opportunity to evaluate Arctic and subarctic areas.
- Broad-based curriculum for understanding the social and human aspects of our cultural environment.
- Course selection, self-directed within guidelines established by faculty advisors.
- Comfortable class size for individual instructor attention and independent study.
- An active campus life with various recreational opportunities.

For more information, send this form to: School of Agriculture and Land Resources Management, Recruitment Coordinator, University of Alaska Fairbanks, AK 99775-0100 or call (907)474-5276.

Name ____________________

Address ____________________

____________________ Phone ____________________

Agricultural and Forestry Experiment Station
UNIVERSITY OF ALASKA FAIRBANKS
Fairbanks, Alaska 99775-0080

James V. Drew, Director
Publication

Address correction requested
Return postage guaranteed

Non Profit
Organization
U.S. Postage
PAID
Permit No. 2
Fairbanks, Alaska
99701

If you do not desire to continue receiving this publication, please check here ☐; cut off this label and return it to the above address. Your name will be removed from the mailing list.