An Annotated Chronology of RESEARCH HIGHLIGHTS

at the Agricultural Research Center—Hays 100TH ANNIVERSARY

Kansas State University
Agricultural Experiment Station and
Cooperative Extension Service

AN ANNOTATED CHRONOLOGY OF RESEARCH HIGHLIGHTS

Agricultural Research Center–Hays

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SUMMARY

This chronology was compiled by the current scientists at the Agricultural Research Center–Hays and includes highlights of eight areas of research: beef cattle, entomology, plant pathology, range management, soil, sorghum, weed management, and wheat. Investigations on these subjects have been conducted for various periods of time from 50 years to nearly 100 years. Considerable research also was done on forage crops from 1913 to 1969 mainly by Harold Hackerott and on alternative crops from 1971 to 1998 by William Stegmeier. Information about those areas, more details on research programs discussed here, and a lengthy list of publications can be found in A History of the Agricultural Research Center–Hays, The First 100 Years (Bulletin 663 of the Kansas Agricultural Experiment Station).

Compiling this chronology revealed several common threads through the years.

- An emphasis on topics that benefit producers in the region served by the station.
- A focus on addressing the problem and getting practical answers to the topic or question at hand.
- A concern for quality research with sound experimental design and execution and appropriate analysis and synthesis.
- Conducting truly novel research; virtually all of the effort at Hays has been original and independent.

1914. The first Roundup program was held. Tests reported were a comparison of cottonseed cake and linseed meal for cows and use of rations with wheat straw for growing out calves.

The second annual Roundup was held April 1, 1915. In most years the program was held in April. As indicated by the fire, everyone quickly learned to dress for cold weather on Roundup day.

1920. C.W. McCampbell from the Animal Sciences Department in Manhattan took charge of beef cattle research at Hays. This added discipline to the tests. He continued in this capacity for 25 years until 1945.

1920s. Emphasis was on roughages grown in western Kansas, especially fodders and stovers of sorghums: kafir, cane, and sudan. Extensive research on chopping and grinding roughages showed no advantage to chopping but a response to grinding when forages contained seed such as kafir fodder. Research also showed that protein needs could be met with alfalfa hay instead of purchased supplements.

1931. The first wheat feeding trial was conducted. Wheat feeding became a major topic and continued to be so through the 1960s.

1932. The first comparisons were made of different sorghums: milo versus kafir grains and sorgo versus kafir silages. (Before the advent of hybrids, sorghums were identified by species, and old feed analysis tables contain separate entries for kafir and milo.)

1933. A trial showed no response to a phosphorus supplement, indicating that feeds grown in the Hays area have adequate levels. (Based on that study, we have never added phosphorus to the feedlot rations. Retrospectively, we realize that this has been an immense contribution to the environment.)

1934. All studies during the year involved Russian thistle, because that was the only plant that grew in the drought.

View of research feedlot in 1937. The upright silos were torn down soon after this, and the sheds in the pens were removed in the 1960s.

One of the early livestock judging contests held in the 1930s. The judging contests traditionally were held the day after Roundup (Saturday), and 4-H and FFA judging teams from counties and schools west of highway 81 were invited. This event provided most rural youth an introducton to the research center that they remembered all their lives.

1930. The first beef cattle study using a replicated design was conducted. Good science requires replication. Most cattle research facilities have large numbers of small pens to allow such replication. However, the procedure at Hays usually has been to replicate over time with different cattle and environments. That provides a more critical assessment of treatment effects.

1930s. Intensive research showed little difference among protein supplements. That was an important finding, because present knowledge of rumen function explains why no difference would have been expected.

1943. The first "systems" study was conducted in which the carryover effects of different levels of wintering were followed through summer grazing and growth in the second winter. Because the cattle project includes all stages of the production cycle, this approach can be executed easily here–unlike many other locations.

1945. A.D. Webber briefly took charge of the beef cattle research but was replaced by Frank Kessler in 1947. The first cattle finishing trial in western Kansas was conducted. Previously, that side of the state had been regarded as suitable only for growing stocker cattle and shipping feeders east. This trial heralded the cattle feeding industry of western Kansas. This trial also involved the first attempt to document the feeding value of the combine grain sorghums (e.g., Midland milo).

1949. The first breeding study to determine the effect of sire on feed efficiency was conducted. Up to this time, the Station had focused on improving the genetics of the cow herd to demonstrate the importance of careful selection in building up the quality of commercial herds in the region. But the cow herd had not been directly involved in research.

1950s. More research was conducted at Hays on feeding wheat to cattle than at any other location. The major topics included relative value of wheat to other grains, differences among wheat types, and management of wheat in finishing rations.

1953. The first trial with feed additives considered the antibiotics bacitracin and aureomycin. Many trials with additives were conducted until the 1980's, but then diminished because private facilities had been developed to take on the role of product testing.

1953. An intensive study of creep feeding started. This was a popular topic at that time but did not withstand critical research. It was not an efficient or economical practice, and many of the contentions of its advocates were proven untrue.

1955. The first trial with stilbestrol was conducted. This was the first of the growth-promoting hormones so pervasively used in cattle production. Stilbestrol eventually was removed from use because of human health concerns.

1955. A project was initiated to measure the heritability of feedlot gain by comparing the performance of half-sib bulls with that of their progeny. This study validated performance testing of sire candidates that is used widely to this day.

1957. John Brethour took over the beef cattle research program and conducted the first of many silage studies. The station had four experimental silos, and two more were added in that year. Many of the details of silage management and also selection of best sorghum cultivars for silage were established by the studies conducted at this location.

1958. Studies began to follow cattle to the packing plant and collect individual carcass data. Because treatment effects on carcass quality may be as important as performance responses, this practice has been used consistently through the ensuing years.

1959. Ultrasound was used for the first time at this location to evaluate cattle. Dr. Jim Stouffer from Cornell University brought his prototype instrument to measure cattle that were committed to an extensive cutout study. The same cattle (Hereford steers) were evaluated by Charles Murphy of the USDA, and the data were used to construct the yield grade equation that is still in use.

1959. A toxic reaction was observed after systemic insecticide treatment for cattle grubs. This led to a revision in labeling of those pesticides, warning against use of the product after the grub has matured because its destruction resulted in production of toxins that got into the animal's system.

1959. The first experiment using wheat in a finishing ration was conducted. Results indicated the advantage of using 50% wheat and 50% rolled milo, which later was identified as being due to the associative effect of combining rapidly and slowly digested grains.

1959. The first of many studies was conducted with growth-promoting implants (stilbestrol).

1961. A high-concentrate finishing ration was studied for the first time. Until then, rations that were more concentrated than one part silage to one part grain were suspect. Results showed substantial advantages for the high-grain rations, and this response later was explained by the negative associative effect that depresses roughage digestibility when grain exceeds about 20% of the ration.

1961. Studies began on the use of ensiled high-moisture grain in feed.

1962. Studies showed that a simple finishing ration of rolled milo, sorghum silage, and alfalfa hay resulted in very satisfactory performance.

1963. All-concentrate finishing rations were investigated. These worked very well in small experimental groups but proved disastrous when attempted in a commercial feedlot environment with large numbers of cattle per pen. This emphasized the importance of considering evaluations of new ideas in field situations.

1963. We had our first access to a mainframe computer (an IBM 1401 on the Fort Hays State University campus). We developed a general linear model (GLM) statistical program that preceded the one now provided by the SAS Institute by 13 years. The program allowed improved statistical precision in the cattle research and enhanced the scientific quality of the experiments. That computer had only 16K memory but could invert a 50 X 50 matrix if intermediate calculations were exported onto punch cards and reloaded for the next phase. That task took about 50 minutes.

1965. Research showed an advantage to feeding waxy endosperm sorghum grain. This was an important indication that endosperm might affect feeding value of different types of sorghum.

1966. Don Ely took over the research program for two years; John Brethour resumed in 1968. Investigations started on the use of high levels of urea to replace natural protein in cattle rations. Use of ammonium chloride to suppress urinary calculi and provide non-protein nitrogen also was investigated.

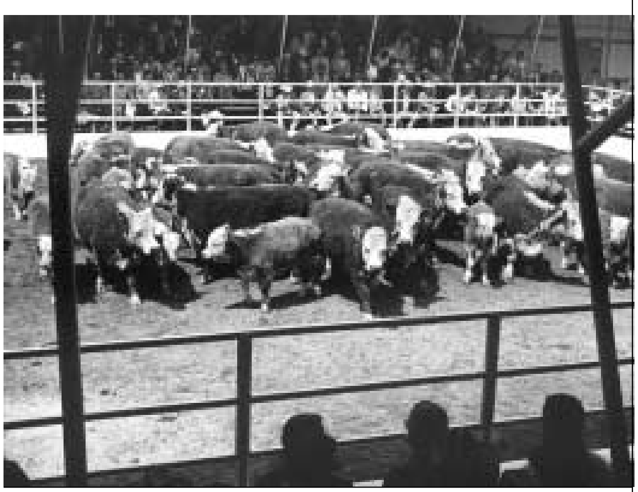
1970. The first study was done with ultrasound on live cattle to predict future carcass merit.

1971. Intensive evaluation of different wheat types showed that hard red winter wheat was equal or superior in cattle rations and thwarted interest in developing a specific feed wheat.

1971. One of the "Holy Grails" in cattle production would be a method to induce marbling and artificially increase carcass grade. Preliminary investigations suggested that dexamethasone might effect such a response.

1972. We published the first report (from any location) that implants depress carcass grade. This observation was largely ignored until producers started selling on a grade and yield basis.

1972. Additions of thiamin and sodium bicarbonate enabled use of 100% wheat in a finishing ration. Those additives appeared to circumvent the acidosis commonly encountered with high wheat levels. (Later studies showed that ionophores were equally effective in addressing this problem). Several trials were conducted with added thiamin in stress situations and provoked much interest.



View of part of the station cowherd and the arena at the 1974 Roundup. The arena gradually evolved from portable open bleachers into a comfortable roofed area. Only Hereford cattle were maintained at the Hays Center until the time of this picture. Then out-crossing with other breeds began.

Another view of the 1974 crowd at Roundup. In those years, before most producers also were encumbered by off-farm jobs, several hundred producers attended field days.

1973. We reported the first observation of a response to reimplanting cattle during the finishing phase. It took another 10 years before this became a common feedlot practice.

1974. A preliminary trial was conducted comparing different breeds crossed on Hereford cows, including Simmental, Limousin, Charolais, and Holstein. The Continental breeds from Europe had just arrived in this country. This effort was not continued because the USDA Meat Animal Research Center opened in Nebraska with more appropriate resources to conduct breed evaluations. But, in later years, the Hays project evaluated breeds not included in the MARC protocols, including Longhorn, White Park, Braford, and Wagyu.

1975. Intensive work began on feeding out young bulls. One item driving this research was the possibility that growth-promoting implants might be banned, so exploiting the natural hormones in intact males would have merit.

1976. A study showed that an implanting protocol over the lifetime of an animal could increase total gain by more than 100 pounds per animal.

1976. Research showed the advantage of finely rolled milo over coarsely rolled milo. Citing this work and arguing that earlier values had been obtained with improper processing, i.e., coarse rolling, convinced the National Research Council to substantially increase the energy value of milo in feed analysis tables.

1977. We discovered that a novel combination of a methane inhibitor and an ionophore had a synergistic effect in improving performance and feed efficiency. Repeated trials with two different methane inhibitors confirmed this response, but we were unable to persuade the companies to get the methane inhibitors cleared for use.

1977. We built an interactive program for a minicomputer that calculated balanced rations for cattle and then proceeded to select the least-cost formulation. This was farmed out for use by several feed companies and probably was the first of its kind.

1979. We attempted to develop a ration to study the effect of ionophores plus a methane inhibitor to combat nitrate toxicity. The strange result was that rations with 5,000 to 20,000 ppm nitrate performed better, apparently because rumen microorganisms were using nitrate as a nonprotein nitrogen source.

1982. A summary of eight trials indicated that finely rolled milo had 94% the energy value of rolled corn.

1982. We reported what may be the only trials ever conducted on feeding pearl millet to cattle.

1983. The first trials in the Western Hemisphere with Revalor and the first in the United States with Finaplix (growth implants containing trenbolone) were conducted. These are among the most widely used implants today.

1984. At this time, considerable interest existed in treating wheat straw with ammonia to increase digestibility and crude protein. Sorghum hay was treated with ammonia, and concrete evidence of toxicity was obtained. Putatively, ammonia reacted with plant sugars to form an imidazole compound that was absorbed by the cow and passed directly to the milk, which was especially lethal to calves. These results were circulated widely and resulted in recommendations against ammoniating roughages that might still contain sugar (e.g., sorghums, grass, and immature cereals).

1984. The first cattle trials in the country with zinc methionine (Zinpro) were conducted. This caused nutritionists to suspect that organic sources of minerals might be more available than inorganic sources.

1985. Developed the one calf heifer system, in which a female is bred and allowed to have one calf, which is weaned early, while the 2-year-old cow is fed for harvest. This may be the most efficient of all beef cattle programs but is labor and management intensive. This research was conducted during one of the "farm crises" and was promoted as a program to enable maximum profitability for operations with limited resources.

1987. Research began on applying ultrasound technology to beef cattle production. The first effort was to exploit serial insonation and develop a model for the increase in backfat thickness during the finishing phase.

1988. We discovered that an artifact called ultrasonic speckle is an indicator of marbling (intramuscular fat).

1989. Research showed that cattle management in a growing-grazing system needs to be attuned to cattle type.

1989. The first studies were conducted that indicated improved feedlot profit from sorting cattle into outcome groups appropriate to the carcass and performance potential of each animal.

1990. Research showed that light test weight milo (48 lb / bu) had 96% the feed value of normal milo. We seem to receive more producer inquiries about the feed value of discounted grains than any other topic.

1991. Several experiments during this period with the breeding herd addressed improved methods of synchronization and timed breeding (artificial insemination).

1992. We perfected computer measurement of ultrasound images to estimate backfat thickness and marbling score. That involved pattern recognition techniques and neural network technology. Three comparisons sponsored by the Beef Improvement Federation showed that the KSU system for estimating marbling was more accurate than other systems.

1993. A project studied refeeding cull cows. They represent an important component in the cash flow of a cow / calf operation. This effort showed that income could be enhanced if marketing systems could be devised to reward producers for their extra effort.

1994. We developed a profitability model that represented an expert system to synthesize ultrasound estimates with other parameters to predict days-on-feed for maximum feedlot profitability.

1995. We established the model for the rate of marbling increase in feedlot steers.

1997. Research showed adverse effect of supplementing low quality roughages with high starch feed ingredients (rolled milo).

1998. The first research was completed showing success in estimating potential carcass quality grade from ultrasound estimates made on calves at weaning.

1999. Six steer carcasses managed and selected with ultrasound technology placed first in the Denver Stock show carcass contest. All six graded USDA Prime and were acclaimed to be the best carcasses ever observed. They were from a set of Wagyu X Charolais steers that were fed to validate models of marbling increase. U.S. Patent 5,960,105 was granted for an ultrasound procedure to measure intramuscular fat in cattle.

John Brethour with a pair of ultrasound instruments. ARCH became a leader in the development of ultrasound applications for beef cattle in the last decade of the century.

Entomology Research, Tom L. Harvey, Entomologist

Woodrow Franklin was hired in 1948 as the first full-time entomologist and studied alfalfa insects. He was replaced in 1954 by Tom Harvey.

The studies mentioned here involved the cooperative efforts of many scientists, and results have been published in refereed journals.

BEEF CATTLE

1960s. Research showed that feeding cattle Bacillus thuringensis spore powder prevented development of house fly larvae in the manure. We also discovered that short-nosed cattle louse infestations were more severe on cattle that were fed urea compared with cottonseed meal.

1970s. We originated the idea for insecticide ear tags to control horn flies and face flies and published the first results. The adverse effect of horn flies on weight gains of yearling steers was recorded, and we identified their effect on cattle behavior that accounted for reduced productivity. We also discovered that whole-herd control of horn flies could be obtained by partial-herd treatment with insecticides.

First insecticide ear tag used to control flies on cattle.

1980s. Horn flies were effectively controlled with backrubbers made from insecticide ear tags attached to tire chains or sand-filled dust bags. We found that insecticide ear tags applied to nursing calves controlled horn flies on the both cows and calves. Horn flies also were controlled

Insecticide ear tags on chain backrubber used to control flies.

by insecticide in marking fluid applied to cows by bulls equipped with chin-balls or bull point-markers. They also could be controlled with pellets containing insecticide fired from a CO_2-operated pellet pistol. Brahman x Hereford heifers had 70% fewer horn flies than Angus x Hereford heifers, so using insecticide ear tags on 50% Brahman-cross yearlings provided no economic advantage. Livestock insect research was discontinued in 1989.

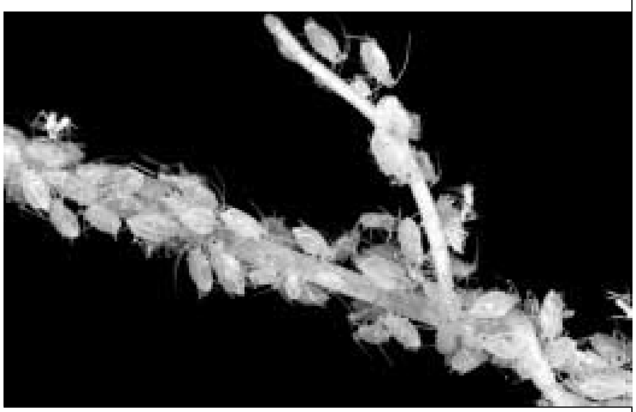
ALFALFA

1950s. We published the first detailed study of insects affecting alfalfa seed production in Kansas. Cody alfalfa, the first Kansas variety resistant to spotted alfalfa aphids, was developed and released.

1960s. Kanza alfalfa, the first variety with resistance to both the spotted alfalfa aphid and the pea aphid, was developed and released. A field rating system was designed to evaluate alfalfa for resistance to pea aphids based on the presence of parasitized aphids. Research proved that plant products responsible for resistance to spotted alfalfa aphid did not pass through graft unions of reciprocally grafted resistant and susceptible alfalfa clones.

MISCELLANEOUS

1960s. Research provided the first example of an insect becoming resistant to a microbial insecticide containing Bacillus thuringensis, which is now used widely in transgenic corn. We made the first detailed study of aphids, dodder, and dodder-host plant interrelations using 30 species of aphids and 16 host plants.

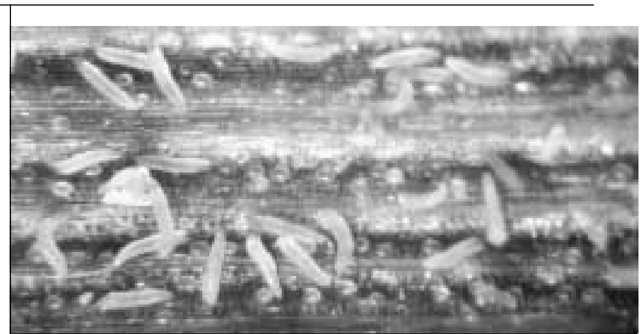


Green peach aphids infesting dodder, a parasitic plant.

1970s. Studies found that insecticides applied at recommended rates for 5 years on a 20-acre field did not contaminate groundwater. We studied leafhopper populations on upland seeded pastures at Hays and identified 57 species in 34 genera.

1980s. A technique was developed to uniformly infest plants with aphids using a mechanical insect dispenser. Also, a method was devised to estimate wheat curl mite populations in wheat spikes using sticky tape.

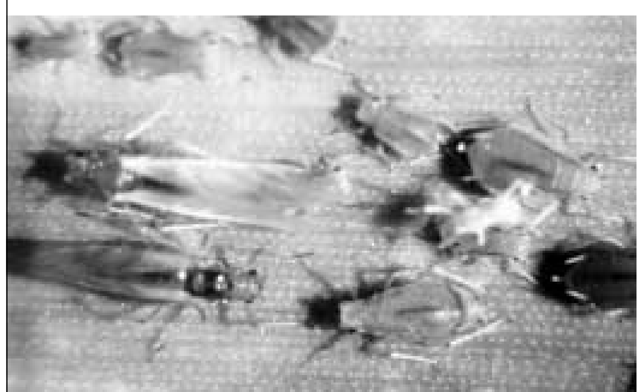
1990s. We determined the effect of sunflower planting date on infestation and damage by the sunflower moth. Research on the effects of differential grasshoppers on 15 corn hybrids showed leaf loss ranged from 8 to 47%, indicating that some hybrids have genetic resistance.



Wheat curl mite adults and eggs on wheat leaf.

WHEAT

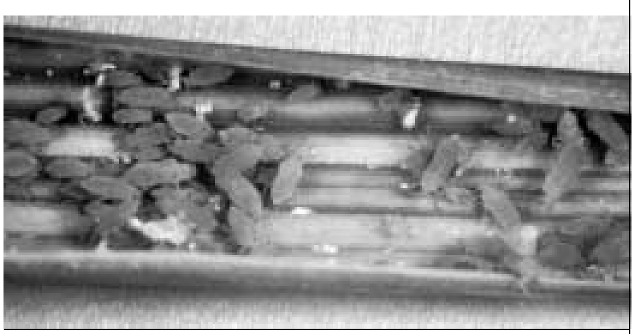
1980s. Resistance to the wheat curl mite was found in wheat-rye addition lines, and a germplasm source of resistance was released. The incidence of wheat streak mosaic in the field was reduced by 74% in a wheat curl mite resistant line (KS80H4200). Control of wheat curl mites and a reduction of wheat streak mosaic infection were achieved by a planting-time application of carbofuran. We discovered that pubescent wheat provided a more favorable landing site for airborne wheat curl mites than glabrous wheat, was more heavily infested with mites, and thus had a higher incidence of wheat streak mosaic. A 10-year study of greenbug



Greenbugs, a major pest of both wheat and sorghum.

flight patterns indicated that both early planted wheat and sorghum are more likely to be infested. We released a germplasm source of resistance to greenbug derived from Triticum tauschii (goatgrass). Wheat strawworms were found infesting over 53% of culms in six fields in Ellis County, resulting in a 5-10% yield loss per culm. Laboratory tests showed that the Russian wheat aphid was more cold tolerant than the greenbug and verified that it survived the 1986-87 winter at Hays under conditions that were fatal to the greenbug.

1990s. Common wheats resistant to Russian wheat aphids were identified by screening over 5000 plant introductions. Resistant germplasms were released in 1995, and the first Russian wheat aphid-resistant variety from Kansas (Stanton) was released in 1999. New sources of resistance to greenbugs derived from Triticum tauschii also were released. We identified the first sources of resistance to wheat curl mites in common wheat and released wheat curl mite-resistant germplasm. Studies showed that wheat curl mites in western Kansas had become virulent to the resistant variety TAM 107, and that wheat curl mites from different states varied greatly in their response to TAM 107 and other resistant wheats. Results from both field and greenhouse tests proved that wheat curl mites cause yield losses to wheat in addition to that caused by the viruses they transmit.



Russian wheat aphids, a relatively new pest in Kansas.

SORGHUM

From1968, when we first recognized the greenbug as a pest of sorghum, through 2001 we concentrated on plant resistance. We identified three of the four greenbug biotypes that have been or are pests of sorghum (biotypes C in 1969, I in 1990, and K in 1995) and released the first source of resistance (KS30) that was used to produce the first greenbug resistant hybrid in 1975. More information on our continuing efforts to develop sorghums with resistance to greenbugs is reported in the "SORGHUM RESEARCH" section of this publication.

1980s. Greenbug flight patterns indicated that seedling sorghum is most vulnerable to infestation during the last week of May and the first week of June. We found that greenbug numbers were lower on plants grown in thick stands than in thin stands, indicating that greenbugs would not exceed economic injury levels on resistant hybrids grown in thick stands. Increased levels of maize dwarf mosaic virus were found in carbofuran-treated sorghum in the field. The insecticide appears to induce increased movement of aphids from plant to plant, causing more plants to become infected.

1990s. Studies in both the field and greenhouse proved that wheat streak mosaic virus can be transmitted to sorghum by the wheat curl mite. Some exotic sorghums are susceptible to Russian wheat aphids, but commercial hybrids appear to be resistant, so sorghum probably will not serve as an important oversummering host. Imidacloprid seed treatment reduced the spread of sugar cane mosaic virus when aphid infestations were light but not when populations were high. A greenbug-resistant hybrid (DK-39Y) was found to be highly resistant to natural infection.

Plant Pathology Research, Dallas L. Seifers, Plant Pathologist

The plant pathology research program was established in 1974. T. Joe Martin served as the first pathologist until 1979, when he transferred to the wheat breeding program. Kurt Bender held the position for one year, and then Dallas Seifers took over in 1982.

Dr. Dallas L. Seifers, Research Plant Pathologist, works in lab with immobilized pH gradients in an isoelectric focusing apparatus used to separate proteins.

1974. Johnsongrass mosaic virus (JGMV) was isolated from sorghum.

1975. A large-scale field inoculation procedure was established to screen for resistance to wheat streak mosaic virus.

1976. A large-scale field inoculation procedure was established to screen for resistance to maize dwarf mosaic virus (MDMV) and sugarcane mosaic virus strain B (SCMV-MDB).

1976. Sources of resistance to wheat streak mosaic virus and Aceri tulipae were identified.

1978. Procedures were established for evaluating resistance to wheat streak mosaic virus.

1982. A technique was found to determine the reaction of sorghum to maize dwarf mosaic virus using seedlings in a greenhouse.

1983. A large-scale program was established to screen for JGMV in addition to MDMV and SCMV-MDB.

1984. Optimum conditions were developed for conducting studies of MDMV and SCMV-MDB.

1985. Phenotype responses of sorghum hybrids to infection by MDMV were determined in the field.

1987. Phenotpye responses of sorghum hybrids to infection by SCMV-MDB were determined in the field.

1987. Virus titers were correlated to yield loss in sorghums differing in resistance.

1988. An immunological technique was developed to correlate virus titer with tolerance in sorghum infected by SCMV-MDB.

1988. An immunological technique was developed to correlate virus titer with tolerance in wheat infected by wheat streak mosaic virus.

1989. Studies identified a phenomenon of increased virus infection by aphids treated with insecticide.

1992. Natural infection of wheat by Agropyron mosaic virus was identified.

1993. Eastern gamagrass was identified as a perennial overwintering host for SCMV-MDB in Kansas.

1993. The reaction of sorghum hybrids to infection by SCMV-MDB in the field was determined.

1995. The reaction of sorghum hybrids to infection by MDMV in the field was determined.

Jeff Ackerman, research assistant, plant pathology project. Putting cages over wheat plants to prevent infestation by wheat curl mites and other unwanted insects.

1995. Natural infection of wheat by American wheat striate mosaic virus was found in Kansas.

1995. Temperature sensitivity was identified in wheat with high levels of resistance to wheat streak mosaic virus.

1996. Natural infections of sorghum and pearl millet (crops previously immune) by wheat streak mosaic virus were identified.

1996. The High Plains virus of wheat was identified in Kansas.

1996. High levels of resistance in sorghum to MDMV, SCMV-MDB, and JGMV were identified.

1997. The wheat curl mite was identified as the vector of the High Plains virus.

1997. A new sorghum-infecting virus coded as B-ID was identified.

1997. A virus-like pathogen was isolated from wheat with yellow head disease.

1998. The host range of the High Plains virus was determined.

1998. A new sorghum-infecting virus coded as "Ni" was identified.

1998. Several new sources of temperature-sensitive resistance in wheat to wheat streak mosaic virus were identified.

1999. Natural infection of sorghum by foxtail mosaic virus was found in Kansas.

1999. Additional sources of resistance to wheat streak mosaic virus were identified in wheat.

2000. Zea mosaic virus, a new-sorghum infecting virus, was identified and characterized.

2000. A broad-scale program was established to screen sorghum for resistance to the MDMV, SCMV-MDB, JGMV, sorghum mosaic virus, ZeMV, and Ni and B-ID viruses.

1982-2000. The plant pathology project has established a world-class collection of wheat and sorghum virus isolates and appropriate polyclonal antisera for use in resistance screening work and research. The program has identified many new viruses and currently is characterizing others recently isolated from wheat and sorghum. The program has adapted new technologies and identified high-level resistance in wheat to wheat streak mosaic virus and high-level resistance in sorghum to several viruses. Many national and international collaborative projects have been initiated dealing with all phases of the program.

Dr. Raffi Salomon, Virologist, ARO, Bet Dagan, Israel. Dr. Salomon worked with wheat and sorghum viruses while on sabbatical leave at KSU-ARCH.

Range Management Research, Keith Harmoney, Range and Forage Scientist

Research on native rangelands and associated grasslands began with the intent of increasing production while at the same time maintaining the integrity of the land and conserving the natural resources of vegetation, water, soils, microbes, and animals involved.

1946. Not long after the Great Depression and the blowing Dust Bowl, Kansas State University established a range scientist position at the Branch Experiment Station in Hays. Frank Kessler was hired to fill that position and also to conduct research on animal feeding. The early emphasis of this position was to develop recommended stocking rates for native rangelands on the mixed and short-grass prairies. Years of drought and heavy use of cattle on grazing lands had deteriorated native pastures. The condition of native range following these events prompted the need for research on their effects in western Kansas.

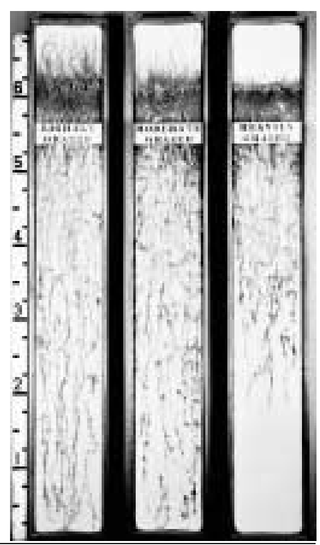
1949. Pastures of native warm-season buffalograss, native cool-season western wheatgrass, and introduced cool-season intermediate wheatgrass were established. Annual grazing comparisons of these pastures followed for several years. The cool-season wheatgrasses produced more forage than the low-growing buffalograss.

Native grasses, such as western wheatgrass and buffalograss, and grass species introduced from Europe and Asia, were seeded to compare which would have greater growth and yields for grazing animal production.

1951. Kessler summarized his findings concerning different rates and densities of stocking and their effects on rangeland plant populations. He discovered that continuous season-long stocking at light and medium rates was not detrimental to short-grass rangeland vegetation. However, greater animal production was achieved on the same acreage with medium stocking rates. Even greater animal production was achieved with the high stocking rates, but after 5 years, pastures showed signs of overgrazing and loss of desired plant species. Forage quality in terms of protein also was compared between pastures during this early study.

1955. John Launchbaugh was hired to lead the range management program and remained for 30 years. He continued to focus on stocking density and stocking rate research on short-grass rangelands.

1957. Studies continued on both animal performance and plant responses to the different densities of stocking during a season. Animal production was reduced greatly on a per head basis with heavy stocking because of the loss of desirable grasses and



Root excavations from light, moderate, and heavy stocking rate studies on native rangelands showed that heavy grazing eventually decreased native shortgrass root depth and dry-matter production.

forbs. Profile excavations of grasses from each stocking intensity showed that above- and below-ground plant growth was greatest with light stocking and somewhat less with moderate stocking. Compacted soils in the heavily stocked pastures also reduced soil moisture. Moderate to light stocking was recommended for cattle production on shortgrass prairie.

1963. Launchbaugh started to study other areas of interest in the late 1950s and early 1960s. He began investigations on methods to reseed cropland back into native or introduced forages. A study with Kling Anderson in Manhattan concluded that spring and early summer plantings of warm-season grasses were most reliable and that late winter to early summer plantings of native cool-season grasses also were successful. They concluded that amount and type of residue for ground cover during seeding was less important than seeding date. Further, to conserve soil and prevent erosion, Launchbaugh studied seeding western wheatgrass with perennial ryegrass or smooth bromegrass into drainages that carried water runoff.

1966. Launchbaugh contributed Kansas results to a report of the Great Plains Council, a group of state and federal institutions that studied establishment of native grasses through different methods on rangelands. Building on his earlier seeding studies, his new findings showed that grass establishment was first dependent on precipitation or soil moisture. If adequate moisture was present, grass could be established during most periods of the year and by most tillage and seeding methods.

1967. Research on stocking density continued into the 1960s. Vegetation changes were studied from several consecutive years of light, moderate, and heavy stocking. Western wheatgrass, a highly desirable cool-season native grass, basically was eliminated from pastures by heavy grazing. Lightly stocked pastures maintained the greatest western wheatgrass population. Blue grama decreased more during drought in heavily stocked pastures than in moderate or lightly stocked pastures. Buffalograss became the dominant grass in heavily stocked pastures. This work in Hays on native rangeland pastures was the foundation for moderate stocking rates still recommended for mixed- and short-grass prairies. These same pastures are still in use for grazing research today.

1969. Knowledge of natural phenomena also may provide solutions to future problems. Abnormal heading of blue grama, a warm-season native grass, was observed in April, two months prior to the normal date. Launchbaugh found that this was due to seedheads initiated in the fall that resumed growth during unseasonably favorable weather in the early spring. Recurrence of wintry conditions caused the deformed seedhead structures. Research showed that blue grama produces seedheads in the following season from fall-initiated tillers that overwinter, and that viable seeds are produced by these tillers if conditions are favorable. This allows cross pollination of naturally occurring variable blue grama plant types within a pasture population.

1970. A study in collaboration with Clenton Owensby from the Department of Agronomy showed the best seeding rates to establish six

Many experiments were conducted that analyzed the most productive times and methods to seed cropland back into native grasses, such as this experimental grass planting into stalk stubble.

different native grasses on soils of the short-grass prairie. Increasing seeding rates increased the number of plants established in the first year but decreased the percentage of seed that eventually formed established plants. They also found that grass species established independently of each other and could be seeded according to individual rates of pure live seed required to attain the desired composition of grass mixtures.

1971. Pure stands of seeded forages also were studied for animal production. Fertilization of switchgrass and Caucasion bluestem monocultures produced greater dry matter, gains per animal, and beef per acre compared to native warm-season grass or western wheatgrass pastures. Overall, switchgrass provided the greatest and most reliable animal production from seeded pastures.

1973. Launchbaugh contributed to a collaborative study after blue grama in a fence row in Nebraska was discovered to have stolons, vegetative stems that spread laterally across the ground and form roots to establish new plants. Blue grama previously was not known to have this capability. Results at Hays showed that blue grama from local populations and North Dakota populations, as well as the blue grama from Nebraska, were capable of producing stolons under manipulation of short day lengths and low light intensities in the greenhouse. Blue grama that could produce stolons under natural conditions could enhance vegetative spread of new seedings and establish ground cover more quickly.

1974. A study began in which Launchbaugh applied nitrogen fertilizer to native rangelands. Fertilization increased the carrying capacity of pastures, so stocking rates could increase by 50%. Greater forage production mostly came from increases in invading Japanese brome and native western wheatgrass. Individual animal weight gains were the same in fertilized and nonfertilized pastures. The variable economics of fertilizing native rangelands were based on fluctuations in precipitation, nitrogen fertilizer prices, and animal market prices.

1976. Native grass plantings usually require at least two growing seasons to reach productivity levels capable of sustainable animal production. Animals traditionally were not placed on newly seeded stands for fear of seedling mortality. Grazing newly seeded grass stands to reduce weed pressure was found to have no effect on survival of new grass seedlings. Research results indicated that spring grass plantings could be grazed until August to utilize weed forage to reduce competition for moisture and nutrients and to allow adequate seedling growth for winter survival.

1977. Three years of milo grain supplementation for steers grazing short-grass prairie resulted in no significant individual gains during the last half of the summer grazing season. Animals gained only one pound per 10 pounds of fed supplemental grain, a poor feed conversion ratio. Launchbaugh and Owensby concluded a study on prescribed spring burning of short-grass prairie. Forage production was equal for burned and unburned areas during the first season. Vegetative composition showed that western wheatgrass production increased and Japanese brome and threeawn production decreased on burned areas. Production of warm-season short-grasses was reduced greatly from annual burning. They concluded that spring burning could help to improve grazing distribution and reduce mulch and dead litter in the first season, but repeated burning may not be beneficial. Burning periodically could increase production and remove weedy species.

1982. Patches of native rangelands had been observed previously to be bare of new spring growth, and spotted cutworms were the possible cause. Rangelands are capable of recovering from normal infestations, so insects typically are noticed only when abnormally high populations reduce production in localized areas. Study results showed that range vegetation required two growing seasons to attain normal production following the heavy insect damage. Complementary forages, those used to fill nutritional and production gaps left by native rangelands during dormant or low quality periods, also were investigated by Launchbaugh to improve year-round grazing potential. His results showed that individual animal gains from grazing small-cereal grain forage during the fall and early spring, along with summer annual forages in late summer, were nearly equal to gains from grazing native rangelands only. The use of complementary forages allowed for higher stocking rates, an increase in herd size, and greater returns to management and labor on a per acre basis.

1983. Launchbaugh and three collaborators summarized intensive-early stocking trials in Hays and Manhattan. Intensive-early stocking entails increasing the number of animals on pasture during the first half of the growing season and then removing all animals during the last half of the season. At Hays, double stocking, triple stocking, and triple stocking plus grain supplement early in the season were compared. Animals double-stocked during the first half of the season at Hays had similar gains as animals stocked continuously. Because more animals were present, total beef production per acre was increased. Animals triple-stocked had lower gains during the first half of the season. However, animals triple-stocked with daily grain supplement gained nearly as well as the animals stocked season-long. Triple stocking, even with grain supplement, was considered too great a risk with highly variable market prices.

1986. Kenneth Olson, the newly appointed range scientist following Launchbaugh's retirement, continued the research on intensive-early stocking programs for western Kansas.

1989. In a summary of eight years of study on intensive-early stocking, Olson reported that total beef production per acre was similar between continuous and early double stocking, and vegetative composition of pastures remained similar over the course of the study. He concluded that early triple stocking produced more beef per acre than the other two stocking methods for only the first few years. Triple stocking caused rapid declines in beef production and desired vegetative composition over time and was not a sustainable practice.

1991. Supplemental feeding for reproductive animals received greater research interest. Gradual energy supplementation increases and steady energy supplementation were compared for effects on reproductive performance of replacement heifers. Both supplementation strategies prior to breeding were adequate to achieve acceptable heifer reproductive performance.

1992. Mature cows were given a high grain ration following calving to study subsequent cow condition prior to breeding and conception rates. Cows receiving high grain rations (four pounds per day) in addition to hay had greater body condition and weights than cows receiving a hay-only diet. However, conception rates and calving interval to the next calf crop were not different between the two groups.

1993. Eric Vanzant, who replaced Olson as the station range scientist, continued his work on modifying intensive-early grazing systems. The modified systems entailed double stocking early in the season and then removing only half of the animals during the latter half of the season. Vanzant found no improvement in beef production with this modified system. Double stocking early actually caused a reduction in weight gains of animals that stayed on pasture season-long.

1995. Earlier studies had shown that Old World bluestem could be as productive as native vegetation in western Kansas, so two varieties,

Some of the more recent grazing studies that investigated beef animal supplementation, intake, and selection included timing devices that detected when animals lowered their heads to graze. Records were kept of the amount of time and what periods of the day animals spent grazing.

WW-Spar and WW-Ironmaster, were compared for adaptation and production potential. No difference was found between them in terms of beef produced per acre or individual animal gains. Both varieties were initially low in crude protein, which declined greatly as the growing season progressed.

1996. Antibiotic feed additives had been used previously to increase gains of feedlot animals, but little prior research had considered animals fed those same additives while grazing short-grass rangelands. A study found a slight increase in daily performance for animals receiving the additives compared to animals not receiving them.

1997. Several studies were underway in which different supplementation types and amounts were used to investigate effects on digestibility and energy of low quality, forage sorghum hays. Increasing grain supplements did not improve fiber digestion and substituting other supplements for grain increased fiber digestion but did not result in greater energy consumption. Vanzant concluded that the best way to increase energy consumption for cows with greater energy requirements was to feed higher quality forages.

1998. Daily supplementation of steers on native rangeland with three pounds of a sorghum grain / soybean meal mixture produced greater gains compared to steers supplemented daily with three pounds of sorghum grain or one and a half pounds of soybean meal. Protein supplementation during the last half of the growing season proved to be beneficial because of the low quality forage available during that time period.

1999. Keith Harmoney replaced Vanzant as the station range scientist. Refinement of stocking rates on modified intensive-early stocking systems continued.

2000. Investigations began on the evaluation of different annual and perennial cool-season grasses as complementary forages. A study evaluating the control and utilization of Japanese brome by early grazing and prescribed spring burning was initiated. Another grazing study was initiated that eventually will evaluate the economics and effects on animal performance of using annual winter wheat or annual winter wheat with sudangrass as complementary forages for cow / calf production on native rangelands.

Soil Research, Carlyle A. Thompson, Soil Scientist

This list of highlights in soil research includes many long-term studies. The first soil scientist, L.E. Hazen, stayed less than 2 years and was replaced in 1909 by A.L. Halstead, who remained until 1945. Andrew Erhart held the job from 1946 to 1948, followed by Paul Brown from 1949 to 1956 and Ralph Luebs from 1956 to 1959. Carlyle Thompson was hired in 1964.

Fall plowing with a 3-bottom plow with comfort seat and umbrella.

1907-1954. Fall tillage increased milo yields over spring tillage.

1908-1958. Ongoing studies determined that wheat and grain sorghum were the major crops adapted to this geographical area.

Preparing land during the fallow period by discing with mulepower.

1908-1958. Fallow in the cropping rotation increased soil storage of precipitation, resulting in significant increases in wheat yields.

1908-1958. Shallow cultivation with a one-way disk plow or subsurface tillage equipment was as satisfactory for wheat production as deeper tillage with a moldboard plow or lister. However, subsurface tillage equipment left more crop residue on the soil surface that provided protection against soil and wind erosion.

1909-1934. Data from 26 years showed a close relation between the quantity of water in the soil or the depth to which the soil was wet at seeding time and wheat yield. The water quantity and depth of wet soil at seeding time were also useful in predicting failures and in determining the relative importance of the crop's dependence of precipitation during the growing season.

Determining the quantity of soil water using a core sampler that was pounded into the soil, then jacked out; a very time consuming process.

1912-1957. Yields of grain sorghum after fallow were nearly twice those of continuous grain sorghum.

1914-1957. Feedlot manure failed to significantly increase wheat yields on the Harney silt loam soil at Hays.

1916-1946. Nitrogen (N) losses from cultivated soils were most rapid immediately after breaking the native sod. Losses gradually decreased with continued cultivation. Row crop production caused the largest losses of N, whereas small grain production caused the smallest losses. Under small grains, N losses had ceased by 1938. Elsewhere, losses continued through 1946. Earlier and more intensive tillage caused greater losses of soil N than later and less intensive cultivation.

1918-1945. Green manure crops did not benefit winter wheat production. Their use of soil water overshadowed any value they might have had.

1945-1954. Removal of crop residues by burning reduced water infiltration, increased wind erosion hazard, and failed to increase average wheat yields.

Rain water is held with furrow diking using a bain lister.

1948-1957. Tillage on the contour significantly increased wheat and sorghum yields more than non-contour tillage.

1950-1958. With continuous cropping or on eroded soils, when surface and subsoil water levels were adequate, profitable increases in wheat yields were obtained when 30 lb N / a was banded with the seed at planting.

1958-1960. The Zingg conservation bench-terrace system utilized two-thirds of a field for a watershed area and the remaining one-third for a level bench terrace. Because more runoff water is impounded on the bench, crops could be grown there yearly, while a conventional rotation, like wheat-sorghum-fallow, was employed on the slope.

1964-1977. Sorghum fertilized with eight plant-nutrient elements had the greatest yield response to applied N. Measuring nitrate-N in the top 12 inches of soil showed that sorghum on 100% of the sites responded to applied N when nitrate-N was less than 4 ppm, 66% of all sites responded when nitrate-N was 4-8 ppm, and 43% had higher yields when nitrate-N levels were greater than 8 ppm. Nitrogen fertilizer increased wheat yields on 58% of all sites, added phosphorus (P) increased wheat yields on 33% of all sites, and all other plant-nutrient elements (potassium, sulfur, zinc, iron, manganese, and copper) increased wheat yields by 17% or less.

1964-1978. The level of soil nitrate-N had an effect on yield response to added N. Yield increases were highest when soil nitrate-N levels were less than 7 ppm. Yield increases were less with increasing amounts of soil nitrate-N.

1965-1977. Sorghum yield increases were not significantly different with fall, spring, or planting N applications. However, significant yield decreases resulted from early and late side-dress N applications.

1965-1977. Ammonium nitrate, urea, liquid N (UAN), anhydrous ammonia, and ammonium sulfate fertilizers had no effects on sorghum yield. Results showed that all N-containing materials should be injected into the soil or incorporated with tillage tools. The advantage of using anhydrous ammonia was that it could be applied with various tillage tools, thus weed control, seedbed preparation, and fertilizer application could be accomplished in one field operation. Liquid N could be applied with certain herbicides and in a single spray application. With a 2-inch buffer zone between the seed and fertilizer, the total N needs could be applied using liquid or dry N fertilizers.

1965-1977. Sorghum on only 33% of sites testing low in available P responded to added P, and sorghum on 17% of sites showed a significant yield decrease. With increasing soil P levels, yield increases were mixed, whereas yield decreases were significantly greater. The highest yield increase resulted when soil P and added P levels were low.

1965-1978. Wheat grain protein decreased with increasing yield levels. However, increasing levels of applied N significantly increased grain protein. Differences in protein among application times and N carriers were small. Spring-applied N often increased grain protein regardless of yield.

1965-1978. Depth of moist soil had less of an effect on wheat yields than grain sorghum yields. With application of an N+P combination to the wheat crop, 60% of the sites had yield increases when depth of moist soil was less than 36 inches, whereas 76% of the sites had yield increases when depth of moist soil was greater than 36 inches. When only N was applied, yield increases ranged from 46% to 64% with increasing depth of moist soil. When N carriers were either incorporated or injected into the soil, only modest wheat yield differences occurred. Wheat yields with all N carriers were significantly higher than the control. Because the long-term precipitation average was only 22.5 inches, leaching of applied N was usually not a problem at Hays. Wheat also responded to added P when available soil P levels tested 25 pounds or less. Banding P with the seed at planting resulted in significantly higher yield increases than broadcasting and incorporating. Nearly twice as much P was required with broadcast application to equal the yield response from P banded with the seed. Because wheat continued to show yield increases up to 46 lb P applied per acre, the economic return depended on the input cost and price of the commodity.

Wheat showing a visual response to commercial fertilizer.

1965-1996. In a wheat-sorghum-fallow rotation (W-S-F), crops were planted under clean-, reduced-, and no-till and fertilized with four N levels. They responded best to available soil water supplies when grown under reduced-till with 60 lb N / a. Yields of both crops correlated better with nitrate-N at the 6-inch depth than with ammonium-N or total N.

1965-1997. Soil samples taken in a W-S-F study with three tillage systems and four N levels resulted in some interesting findings. Instead of decreasing as expected, soil pH increased. Soil organic matter did not change significantly over the duration of this study. Available P was highest near the soil surface for no-till but at deeper depths for clean- and reduced-till.

1966-1977. When soil moisture in the seeding zone was adequate for seeds to germinate, N levels up to 30 lb / acre (using ammonium nitrate and liquid N) applied with the seed increased sorghum yields, even though plant population decreased significantly with increasing N rates. When soil moisture levels were marginal to low, significant yield decreases resulted from N applied with the seed.

Liquid side tanks on the tractor and anhydrous tank on the V-blade tillage tool allow a dual application of nitrogen and phosphorus fertilizer through tubes on the underneath side of each V-blade.

1966-1978. Forty lb N / acre applied to sorghum increased water use efficiency in terms of yield response over the control by 16% and net return per inch of water used by $1.07 when averaged on 90 sites located on- and off-station. Water-use efficiency on wheat from added N+P fertilizer increased with increasing depth of moist soil, as shown by the higher yield and greater dollar return per inch of water used.

1967-1976. Yield response to ammonium nitrate or liquid N applied with the wheat seed was significant up to 40 lb N / acre. However, a gradual decrease in plant population occurred with increasing N levels.

1967-1977. Depth of soil water had an effect on sorghum yields and water use efficiency. When the depth of soil water was 36 to 72 inches, response to added N increased significantly. When depth of soil water was less than 36 inches, modest to insignificant yield increases resulted. Water use efficiency increased as the depth of soil water increased.

Storing soil water for the upcoming summer crop starts with maintaining crop residue over the winter months to catch snow.

1969-1976. Yields of winter wheat were similar with N applications at preplanting, planting, in the fall (after emergence), and in the spring.

1969-1983. When starter fertilizer (N / P combination) was band applied with the seed to soils testing 25 lb or less available P per acre, significant wheat yield increases were consistent.

1970-1976. On soils testing 25 lbs or less of available P, several phosphate carriers resulted in significantly higher wheat yields than the control. However, no significant yield differences occurred among carriers.

1970-1977. When the soil flowed evenly over the V-blade during the application of anhydrous ammonia, little N loss occurred, probably because the ammonia attached itself to the water and clay in the soil. Unless considerable plant residue or large soil clods were present, applying anhydrous ammonia 2- to 4-inches deep had a positive effect on the performance of wheat and sorghum.

1970-2000. From 1970 to 1979, feedlot manure was applied on each crop in a W-S-F rotation. Thus, a total of six applications of manure were made for each phase of the rotation. Significant buildups of soil organic matter, available P, exchangeable potassium, nitrate-N, and exchangeable sodium occurred with increasing manure rates. Yields from the highest rates (40 and 80 tons / acre) exhibited a gradual decline in yield. Soil testing each year since manure additions ceased has shown a gradual downward trend of the chemical analysis. Wheat and sorghum yields since manure additions ceased are still depressed at the highest rates.

1971-2000. Continuous dryland grain sorghum consistently responded to fertilizer N at 20 to 40 lb / acre. The response to N depended on the depth of moist soil at planting. Deeper depths of moist soil resulted in greater yield response to higher N rates. Phosphorus additions did not increase yields on soil that tested medium in available P.

1972-2000. Yield responses to five N rates (20,40,60,80,100 lb N / acre) on continuous wheat under reduced-till generally were correlated to soil water amounts. The 20 and 40 lb N / acre rates usually resulted in the highest economic return.

1974-1977. Summer and fall applications of N using anhydrous ammonia increased yields more than spring applications before sorghum planting. Early N applications leached beyond the top foot or so of soil that normally dries out during the hot summer months and, thus, was available for plant use. Disulfoton 15% granules at 0.56 kg AI / ha produced a statistically significant increase in sorghum yields. The increase could not be attributed to insect, mite, or disease control. Possible explanations included: reduction in soil nematodes, nutritional ingredients in the insecticide, and an effect on some enzymes involved with plant metabolism.

1975-2000. Five crop rotations including wheat and sorghum under reduced- and no-till systems were compared. Continuous sorghum gave the highest average return per acre over the 25-year period. W-S-F was a close second, whereas W-W-W, W-F, and S-F were significantly lower in net return.

Wheat growing in no-till sorghum stalks.

1977-1981. Annual banded rates of concentrated superphosphate over a 5-year period resulted in higher wheat yields than an equivalent one-time broadcast rate. However, annual banded rates of 92 and 184 lb P / acre significantly depressed yields. Wheat yield did not differ with one-time preplant-banded applications of 230 lb P at 10- and 20-inch spacings over a 5-year period. Phosphorus applied 5 inches deep resulted in higher wheat yields than that applied 10 inches deep.

1977-1994. Planting sorghum 2 to 3 weeks later than normal (June 10 to June 25 versus May 20 to June 10), planting in 10-15-inch rows instead of 30-inch, seeding at about three times the normal seeding rate (90,000 instead of 30,000 seeds / acre), and using one maturity group earlier than normal resulted in rapid development of crop canopy over the soil, significant weed depression, even maturity, higher yields than conventional methods, and effective grazing. Planting date and seeding rate for this "Superthick" method were heavily dependent on depth of moist soil at planting. Producers are able to use their grain drills to accomplish this management procedure.

1977-1994. Winter wheat varieties differed slightly in their ability to utilize soil N to increase grain production and grain protein. This finding indicates that new variety releases may need to be screened for N-use efficiency.

1978. Grain protein of nine wheat varieties increased significantly with late May foliar applications of three N rates (5, 10, 15 lb N / acre). When the market pays the producer for protein, this procedure may become a sound management practice.

1981-2000. Downy brome and other weeds resulted in moisture loss in continuous no-till wheat. Without coulters, dragging of wheat straw was common. Yields were reduced, and numerous skips in stands were observed.

1983-1985. Seeding wheat and applying anhydrous ammonia at the same time on the same horizontal plane with a V-blade proved successful only when surface soil moisture was adequate and maximum pressure was applied to the packer wheels.

1984-1985. Growing resistant sorghum hybrids in thick stands (superthick sorghum) kept sorghum greenbug infestations below the economic injury level. Any practice resulting in decreased plant populations densities could intensify the greenbug problem on sorghum.

1984-1993. Sunflower planted in 12-inch rows at three to four times the conventional seeding rate produced similar yields to that planted in 30-inch rows at 15 to 20,000 seeds / acre. Apparently, sunflower has a great ability to adjust to row spacing and seeding rates. Sunflower heads were smaller where plant populations were high, but the number of heads per acre compensated.

1985-1992. Spring cereals (oats, barley, and wheat) exhibited higher yields when N / P combinations were used than when N or P was applied separately. Because of reduced tillering compared to cereals seeded in the fall, spring cereals exhibited higher yields when nearly twice the conventional seeding rate was used.

1985-1994. Narrow row spacing (6 inch) was superior to the conventional 12 inch only in years when surface soil moisture was slightly above average. Wheat seeded in both row spacings responded similarly to N fertilizer. High seeding rates had little effect on grain production, whereas the low seeding rate of 0.5 bu / acre reduced yields.

1985-1995. Although the yield differences of soybeans between row spacings were small, they were consistent enough to favor a 24-inch row spacing regardless of variety or seeding rate. Late maturity group II or maturity group III had consistently higher yields than maturity groups I and IV. Seeding rates tended to favor 140,000 to 150,000 seeds / acre.

1986-1992. Grain sorghum when mowed off at the late vegetative stage to simulate severe hail damage grew back and produced a crop slightly below to slightly above that from the unmowed plots. Although maturity was delayed by mowing, this study showed sorghum's great ability to produce a significant crop in spite of hail damage.

1986-2000. Seventeen fertilizer variables were incorporated into a W-S-F study under clean-, reduced-, and no-till systems. On a highly eroded soil, wheat and sorghum grown under no-till have performed well. This is noteworthy because on more level, higher fertility soils, wheat in reduced-till has performed the best. Band placement of N fertilizer on wheat and sorghum provided yields equal to or higher than those from twice the N rates surface broadcast.

1988-1990. Winter-associated changes in dry-soil aggregation as influenced by clean-, reduced-, and no-till systems were studied. Aggregates

In the foreground 20 lb N/a banded with the seed compared to the control immediately behind.

from plots with low residue cover decreased in stability more than aggregates from high-residue treatments. Differences in aggregation between tillage systems were maintained during a drier winter and minimized during a wetter winter. Studies also showed that insufficient residue production for wind erosion control in the no-till system could lead to more erodible conditions than in clean- or reduced-till systems.

1989-1991. Liquid starter fertilizer 10-34-0 banded with the seed increased wheat yields up to a rate of 15 lb N combined with 51 lb P_2O_5 / acre. Yields tended to level off thereafter. When anhydrous ammonia was applied at seeding time (about 2 inches below the seed), N rates over 30 lb / acre reduced wheat stands and yields.

1990-2000. For the first 5 years, shredded newspaper and grass clippings were spread via hand and a manure spreader at rates of 5, 15, and 45 tons / acre. Some combination treatments included both newspaper and grass. Cropping systems were dryland forage sorghum-fallow and irrigated, continuous forage sorghum (water was hauled to specific designated plots). Because newspaper is devoid of N and grass is high in N, the combination treatments have performed well. Since the first 5 years, the soil has been monitored for carbon (C) and N. Only in the last 2 years have we been unable to read the print on the newspaper, particularly at the high tonnages. The microorganisms are gradually decomposing the newspaper, but it will take several more years to reach a 12:1 C / N ratio.

Spreading 45 ton/a of shredded newspaper by hand on a 24' by 30' plot.

1991-1993. Wheat seeded within multiples of 4-second intervals after applying various N rates of anhydrous ammonia exhibited minor stand and yield depressions. At the 50 lb N / acre rate, yield increases were noted, especially at 12- and 16-second intervals. Apparently, anhydrous ammonia ties itself very quickly onto water or clay in the soil.

1992-2000. Strategies were developed for small grain forage (triticale, rye, and wheat) that provided profitable grazing, haying, and grain production. Rye had more grazing potential in the fall through the late winter months whereas triticale performed well in March, April, and May. Wheat had the poorest performance.

1994-1998. Pearl millet and grain sorghum were used in a study where row spacing, plant population, and seeding date were compared. In all comparisons, grain sorghum yielded more than pearl millet. The best pearl millet yields were from 12-inch rows at a high seeding rate. Date of planting had little effect on pearl millet yields, but the later planting did favor the grain sorghum yields when planted in narrow rows at a high seeding rate.

1996-2000. Use of cross-linked polyacrylamides in combination with banded fertilizer provided a synergistic effect on the grain yields of wheat and grain sorghum. High humidity and flow in the distribution tubes sometimes were problems with the granular polymers. Finely ground polymers when blended with liquid fertilizers did not gel in the tank but did significantly increase yields over fertilizer alone. This study at Hays was the first test of such blends with finely ground polymers.

1998-2000. When the same hybrid was used, Bt corn significantly outproduced non-Bt corn, regardless of plant population or row spacing.

Sorghum Research, Kenneth D. Kofoid, Sorghum Geneticist

Research dealing with sorghum started with the establishment of the Fort Hays Branch Experiment Station. Sorghum occupied 27 acres of land during the first year of research. Most of the work was carried out by employees of the USDA in cooperation with the state experiment stations, and research was established on a region-wide basis that included the entire sorghum belt.

1902-1920. Because sorghum was important as both a forage and grain, most of the research effort was directed towards adapting cultural practices to maximize both grain and forage yields. B.E. Rothgeb (grain) and R.E. Getty (forage) were two of the scientists stationed at Hays that participated in this work. Their research included experiments with different cultivars, dates of seeding, rates of seeding, weed control, row spacing, harvesting of forage and grain, and handling of seed. They were able to demonstrated that sorghum was extremely versatile and that plantings could be done from May to July, that row spacing could be varied from drilling to 80 inches between rows, and that within-row plant spacing could vary from 2 to 8 inches with little change in forage or grain yield. Varietal improvement was another component of the research, and during this time, Pink Kafir was released for grain production, and Red Amber was released for forage production. Pink Kafir remained an important cultivar for more than 20 years.

1921-1930. Hybridization of existing sorghum lines to develop new varieties was begun by Arthur F. Swanson. This effort resulted in the release of Modoc, Dwarf Freed, and Kalo grain sorghums and Early Sumac forage sorghum. He also determined that differences in germination among cultivars were related to the seed coat and its influence on water absorption. Studies confirmed the genetics of seed color.

1931-1940. Varietal improvement continued with emphasis placed on combine-height sorghums. New cultivars released included Club Kafir and Early Kalo. Studies determined the relationships of seed size and germination to plant stand. Because of the drought years, a condition known as “weak neck” developed. Studies were conducted to determine the genetic inheritance of smut resistance, stalk juiciness, and awns.

1941-1950. A new type of sorghum was developed and released in response to the war. Cody sorghum contained a waxy endosperm, and the starch was used as a replacement for cassava starch. This line also was the first to be grown under contract as an identity-preserved line that garnered a premium in price. Other grain cultivars released included Midland and Gurno and forage lines released were Norkan, Ellis, Kansas Sourless, and Kansas Collier.

W.M. Ross makes hand-emasculated crosses in greenhouse.

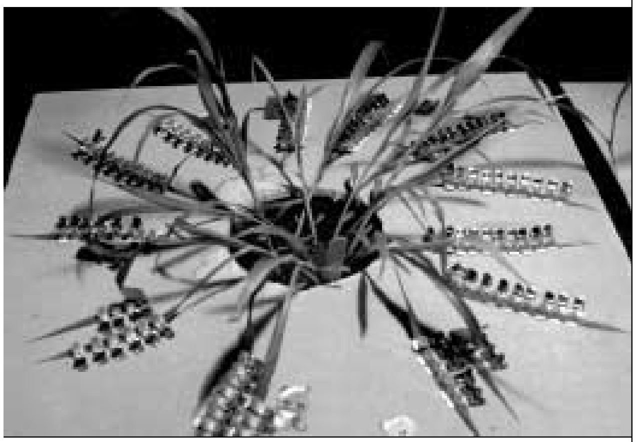
1951-1960. The decade saw major changes in sorghum research at Hays. William M. Ross took over the breeding effort, and hybrid sorghums replaced cultivars. Development of parental lines and testing of hybrids rather than cultivars became the objective. Cultivars that had been developed were converted to either cytoplasmic steriles or restorer lines. Research was conducted to study various aspects of hybrid seed production. Stigma receptivity in male steriles was studied to determine the length of time that females remained receptive to pollen. Intergeneric crosses were made, and triploids were recovered. These triploids then were used to identify genes. In an attempt to produce larger seeds, tetraploid grain sorghums were developed. Agronomic studies were conducted to determine effects of border rows on plot yields. These studies allowed sorghum breeders to work with smaller plots and still produce valid results.

H.L. Hackerott evaluates sorghums for resistance to milo disease.

1961-1970. The major research effort of this decade was the development of parental lines and the testing of hybrids. Releases included four restorer lines (KS 2, KS 4, KS 19, and KS 20); three cytoplasmic steriles (KS 4, KS 22, and KS 23); and four hybrids (KS 602, KS 603 KS 651, and KS 701). These lines were among the first to add the yellow endosperm trait to commercial sorghums. Several of these releases are still being used to add drought tolerance to present-day germplasm. Following the move of Ross to Nebraska in 1969, Harold L. Hackerott took over leadership of the sorghum project. That same year, the greenbug was identified as a major pest of sorghum. Screening of germplasm in the field resulted in the identification and release of the first germplasm line with resistance to greenbug biotype C (KS 30).

1971-1980. In an attempt to broaden the cytoplasmic sterility base of sorghum hybrids, six new sources of cytoplasmic sterility were developed and released (KS 34-KS 39). In addition, five new male parent lines and one new female parent were released. In response to the yearly greenbug infestation, more than 10,000 accessions were screened for greenbug resistance. From this number, only 21 new sources of resistance were identified. Because of the appearance of viral epidemics, inoculation procedures were developed to screen for maize dwarf mosaic virus (MDMV) and sugarcane mosaic virus (SCMV). With the ability to determine resistance, we were able to develop and release lines with tolerance to MDMV and SCMV (KS 55-KS 56).

1981-1990. Johnsongrass mosaic virus was identified as a new pest of sorghum, and screening techniques were expanded to include this disease. A new immunological technique was developed to correlate virus titer with tolerance to SCMV. Other studies noted the correlation between yield loss and virus titer in hybrids infected with SCMV. Research showed that greenbugs were attracted to clean-tilled fields, thus furthering the use of conservation tillage procedures. After the untimely death of Hackerott, Kenneth D. Kofoid assumed leadership of the sorghum breeding project. With the presence of a new biotype of greenbug, more than 10,000 additional accessions of sorghum germplasms were screened for biotype E greenbug resistance, but only seven new sources of resistance were found. A new method to infest plants with greenbugs using a mechanical insect dispenser was developed. With these new screening techniques available, germplasm with resistance to greenbug biotype E (KS 85-KS 93) sometimes combined with tolerance to MDMV and JgMV (KS 85); tolerance to MDMV and SCMV (KS 90); and tolerance to MDMV, SCMV, and JgMV (KS 93) were developed and released.



Greenbug biotype determination.

1991-2000. Further changes in the greenbug were identified as biotypes I and K. Screening of available germplasm against biotype I greenbug showed that all but two germplasms were susceptible. In response to this, KS 96 with resistance to biotype I, was released. New germplasms with biotype E greenbug resistance (KS 99-KS 107) as well as with biotype I resistance (KS 108-KS 114) were released. Eastern gamagrass was identified as a perennial host for SCMV, thus showing how the disease could overwinter. Natural infections of sorghum by foxtail mosaic virus and wheat streak mosaic virus were recorded. Zea mosaic virus and three new viruses also were identified, and broad-scale screening techniques were developed to test for all sorghum-infecting viruses.

Weed Management Research, Phillip W. Stahlman, Weed Scientist

Weed research has focused on weed problems in dryland cropping systems in western Kansas. However, many findings proved applicable to major portions of the western United States and in similar environments internationally. This compilation reveals three major areas of emphasis that developed over the years.

- Research during the first half of the century emphasized control and management of field bindweed through use of intensive cultivation, competitive crops, salts, and persistent chemicals.
- Starting in 1945, the emphasis shifted to testing and developing selective herbicides for use in winter wheat, grain sorghum, and fallow. Dryland corn, sunflower, and soybean were added in the 1990s. Herbicide evaluation and development remain important areas of research.
- Evaluating alternatives to chemical herbicides, determining economic control thresholds, and developing integrated weed management systems were emphasized in the 1980s and 1990s.

1907. The Kansas Legislature appropriated $1000 for experiments to eliminate field bindweed. Results of experiments conducted for 2 years on privately owned land near Victoria showed that with winter plowing and proper use of smother crops such as sorghum or kafir, field bindweed could be destroyed or at least weakened. Also, field bindweed was destroyed with high quantities of salt or brine, but nothing grew on treated areas for several years.

1915-1930. Experiments using salt, intensive cultivation, and smother crops were initiated by R.E. Getty, leader of the cooperative Federal-State Project on Forage Crop Investigations. Field bindweed control research was continued as part of the Forage Crops project until about 1930. Applications of salt made in 1919 were still affecting crop production adversely into the 1960s.

1935. The U.S. Department of Agriculture started a field bindweed control project at Hays under the direction of F. Leonard Timmons. This cooperative federal-state project, one of several begun in the Great Plains, was the formal beginning of the Weed Investigations Project at Hays.

1935-1950. Extensive, highly detailed, cultural-control experiments using intensive cultivation

F.L. Timmons sprays field bindweed in 1936.

F.L. Timmons and assistant pick bindweed roots from soil in 1936.

and competitive cropping systems were conducted. The effects of cultivation depth and frequency on bindweed's root system and root food reserves were documented, and studies were initiated and continued by others showing that bindweed seeds can remain viable in the soil for more than 50 years.

1945. Timmons was one of the first civilians allowed to test 2,4-D, and he conducted numerous experiments investigating its use for control of bindweed and broadleaf weeds in winter wheat. His studies and subsequent work determined that 2,4-D would not eliminate field bindweed under most conditions, but it was highly effective especially when combined with intensive cultivation and competitive crops.

1948. William M. Phillips succeeded Timmons as project leader. He scaled back research on field bindweed control and broadened the scope of research to include control of annual weeds in winter wheat, grain sorghum, and fallow.

1950s. Several new preemergence herbicides were evaluated and developed for selective weed control in grain sorghum, including atrazine, norea, propachlor, and propazine.

1951. Recommended intervals between cultivations were reported to be 18 to 20 days for field bindweed, 4 weeks for johnsongrass, and at least 3 weeks for hemp dogbane and Russian knapweed. Studies showed no advantage for cultivating deeper than 3 to 4 inches.

1958. Culmination of severl years research resulted in recommended uses of 2,4-D in grain sorghum and identified associated risks. Amine formulations were less injurious than ester formulations. Excavations revealed that roots of kochia plants growing on an upland soil penetrated as deep as 10 ft, had a lateral spread of up to 8 ft, and depleted moisture to the permanent wilting point to a depth of 6 ft.

1961. A USDA bulletin was published summarizing 24 years of field bindweed control research at the Fort Hays Branch Experiment Station.

1964 & 1969. Phillips published pioneering research that enabled farmers to combine herbicides with minimum tillage for weed control during fallow after wheat harvest and prior to planting grain sorghum in a winter wheat-sorghum-fallow rotation. This system reduced the number of tillage operations needed, increased soil moisture storage, substantially increased grain sorghum yields, and reduced risks of soil erosion. Additional research refined and improved the system. Variations of the original concept were adopted widely and remain in use into the 21st century.

1967. Applying 2,4-D to winter wheat was found not to affect the milling quality of the grain or baking quality of the flour.

1972. Phillips began evaluating glyphosate (Roundup®) for use in reduced tillage and fallow systems.

1973. The U.S. Department of Agriculture ended support of the Weed Investigations Project at Hays. The state of Kansas assumed full support of the project, and Phillips left USDA to continue as project leader.

1974. A loss of herbicidal activity was observed in field experiments when glyphosate was tank mixed with atrazine and / or propachlor (Ramrod®) herbicides.

1975. Studies were initiated to determine the effects of water quality, spray volume, and tank mixing with other herbicides on glyphosate efficacy.

1976. Phillips was appointed Acting Superintendent of the Fort Hays Branch Experiment Station. Phillip W. Stahlman succeeded him as leader of the weed control program. The name was changed to the Weed Control Research Project.

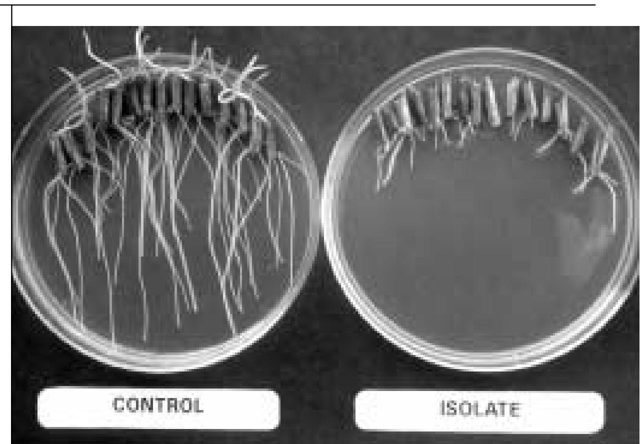
Former scientist and Branch Station head Bill Phillips inspects wheat stubble in reduced-till grain sorghum.

1977. Evaluations began of two experimental compounds, DPX-4189 and DPX-T6376, belonging to a new class of low use-rate herbicides for use in winter wheat. Eventually, they were registered as Glean® and Ally®, respectively, and represented the first of several sulfonylurea herbicides.

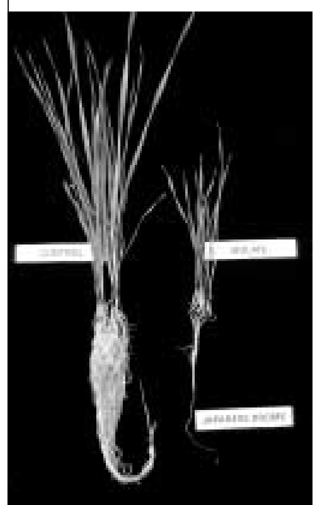
1979. Stahlman continued Phillips' work, and they coauthored two of the first peer-reviewed scientific papers on factors affecting glyphosate activity. These publications were cited frequently and led to changes in use recommendations that improved glyphosate performance.

1980s. Anticipating that weed problems in winter wheat would increase with adoption of conservation tillage and semidwarf wheat cultivars, Stahlman conducted numerous studies to determine economic control thresholds of downy brome in wheat. He also intensified testing of experimental herbicides for control of broadleaf and grass weeds in wheat.

1984. Stahlman took sabbatical leave and an unpaid leave of absence to work towards a Ph.D. in Weed Science at the University of Wyoming. He continued to direct research at Hays by communicating frequently with Research Technician Douglas A. Schneweis and by traveling to Hays periodically. He resumed full-time, onsite responsibilities in 1986 and completed his Ph.D. in 1989.



Inhibiting root development of jointed goatgrass with a bacterial isolate.



Inhibiting root and shoot growth of Japanese brome with a bacterial isolate.

1985. Studies showed that downy brome, cheat, and Japanese brome, commonly referred to collectively as cheat or cheatgrass, were not controlled equally by diclofop (Hoelon®) herbicide. Subsequent research demonstrated differential response to other herbicides as well.

1989. Stahlman began investigations on the use of indigenous soil bacteria for selective control of winter annual grass weeds in winter wheat. Competitive grant funding allowed the hiring of a soil microbiologist, Pamela A. Harris, to facilitate the research.

1990. Field experiments in Kansas and Wyoming showed that downy brome emerging within 14 days after winter wheat at densities of 20, 30, and 50 plants per square yard reduced wheat yields by 10, 15, and 20% respectively. Downy brome emerging 21 or more days after winter wheat did not reduce wheat yield.

1992. Studies in collaboration with scientists in Colorado, Montana, and Wyoming concluded that mixtures of 2,4-D plus picloram (Tordon®) at 0.125 or 0.25 lb / acre provided better long-term field bindweed control than 2,4-D, glyphosate plus 2,4-D or dicamba premixtures (Landmaster® and Fallowmaster®, respectively) or dicamba plus 2,4-D. A 4-year collaborative experiment began with scientists in three other western states to determine feral rye interference and economic thresholds in winter wheat. Also, another 4-year collaborative experiment began with scientists in seven other western states to develop regional, predictive, bioeconomic management models for jointed goatgrass in winter wheat.

1992-1996. Feral rye was found to be more competitive with winter wheat than jointed goatgrass, which in turn was more competitive than downy brome. As few as 4 feral rye plants / yd^2 were enough to reduce wheat yield.

1993. Work at Hays helped identify the scope and threat of jointed goatgrass leading to establishment of a USDA Research Initiative and subsequent federal funding for a National Jointed Goatgrass Research Program.

1994. A 3-year collaborative experiment began with scientists in three other western states to determine the effects of wheat cultivar and seeding rate on jointed goatgrass interference in winter wheat. Stahlman was one of the first public scientist to evaluate MON 37500 for winter annual brome control in winter wheat. The herbicide was registered as Maverick™ in 1999. A U.S. patent was awarded for three bacterial isolates showing promise for selective biological control of downy brome, Japanese brome, and jointed goatgrass in winter wheat.

1995. The first statewide survey on the extent of winter annual grass weeds in winter wheat indicated that winter annual bromes infested 13.2% of the 1994 Kansas wheat acreage, and jointed goatgrass and volunteer cereal rye were present on 2.3 and 5.3% of the acreage, respectively. Application method affected the population and distribution of biocontrol strains in the soil and downy brome rhizosphere and influenced the efficacy of rhizobacteria for weed control. The first evaluation of a genetically modified crop at Hays involved Roundup-Ready® soybeans.

1996. Purified bacterial isolates began losing biocontrol effectiveness each time they were cultured, and attempts to restore original activity were not successful. Either the isolates mutated or lost the ability or need to produce growth-suppressive toxins when in purified culture. What initially appeared so promising ended in disappointment, and the project was terminated. Tests showed that Japanese brome was more susceptible to soil-applied Maverick™ than cheat or downy brome, and jointed goatgrass tolerated two to three times more Maverick™ than the bromes. A long-term integrated study was initiated to assess the interactive effects of crop rotation, wheat cultivar, and fallow weed-control method after wheat on jointed goatgrass management. The first field experiment was conducted demonstrating the potential of sulfentrazone for weed control in sunflower. The herbicide was registered as Spartan® for use in sunflower in 1999.

1997. Research indicated that foliar injury of up to 50% caused by applying urea-ammonium nitrate (UAN) alone or as a carrier for herbicides in spring did not reduce winter wheat yields. Adding nonionic surfactant (NIS) to the UAN solutions increased foliar injury, and diluting UAN 50% with water lessened foliar injury, especially in the presence of NIS. Foliar injury was related inversely to temperature following application. The first evaluation was conducted of genetically modified corn resistant to glyphosate. A field experiment was done to demonstrate the potential of imidazolinone herbicide-tolerant winter wheat for control of winter annual grasses. This represented the first known successful selective control of jointed goatgrass and feral rye in winter wheat. Studies showed that critical periods of longspine sandbur interference in dry corn and grain sorghum were 3 and 4 weeks, respectively.

1998. Maverick™ controlled downy brome best when applied preemergence or fall postemergence compared with spring postemergence application. A satellite weed science project was established at the Northwest Research-Extension Center in Colby, and the first weed control experiments were conducted in dryland corn. A long-term field experiment was initiated to monitor shifts in the weed spectrum and assess potential risks associated with the continuous growing of glyphosate-resistant crops.

2000. The first evaluation was done of genetically modified winter wheat resistant to glyphosate.

1901-1940. The wheat research program at the Hays Station began very early in its history. Most of the early research dealt with improving production practices and little with the genetic improvement of wheat. However, varieties of wheat that were available were tested. Eventually, reselections were made from existing varieties and evaluated. Numerous selections were made and tested from Turkey and Kharkof, the original hard red winter wheat introductions from Russia. A number of important studies were done over long periods of time to establish optimum planting dates and rates of planting and to evaluate long-term performance on continuously cropped land verses fallowed land.

Winter wheat varietal plots, 1937. Plots in background sown on fallowed land where subsoil moisture had reached a depth of 36 inches at seeding time. Plots in foreground seeded on cropped land where subsoil moisture had reached a depth of 12 inches at seeding time. The fallowed plots yielded from 23 to 28 bushels per acre. The cropped land plots failed to produce grain.

1926-1941. One of the most frequently cited research projects that was conducted by the wheat improvement project during these early years was on grazing winter wheat. Arthur F. Swanson conducted research at Hays to determine the effects of various cattle grazing protocols on wheat production. Those studies are cited in almost all of the scientific literature on wheat grazing because they formed the basis for recommendations on the Great Plains.

A.F. Swanson (third from right) in a grain sorghum field in 1945. Swanson selected the first two wheat varieties (Kiowa and Bison) released from the KSU Agricultural Research Center—Hays. Others shown are (from left to right): Dr. C.L. Shrewsbury, Kansas City; D.L. Jones, Lubbock; F.A. Horan, Kansas City; Frank Gaines, Lubbock; R.E. Karper, Lubbock; and O.J. Webster, Lincoln. Picture taken at Lubbock, Texas.

1940-1956. During the early 1940s, the process of intercrossing wheat varieties or lines to obtain offspring with improved performance levels was started at Hays and led to the wheat improvement program as we know it today. Lewis Rights, an agronomist at KSU-Manhattan, sent Swanson seed of a wheat population derived from a cross between an experimental line (Oro-Tenmarq) and Chiefkan. The intention was to allow Swanson to select lines from the cross that were best adapted to western Kansas growing conditions. Eventually, the varieties Kiowa and Bison were selected from that cross and were the first wheat varieties selected, increased, and released from the Hays Station. Kiowa was released to seed producers in 1950, and Bison was released in 1956. Bison was planted on more acres in Kansas than any other variety in 1960 and 1961. Until 1953, wheat and sorghum breeding research were both conducted under the leadership of A.F. Swanson. J.D. Miller was then hired to lead the wheat breeding project.

Dr. R.W. Livers stands in the first sage foundation seed production field at the KSU Agricultural Research Center—Hays in 1973.

1957-1965. James A. Wilson was the second full-time wheat breeder at Hays from 1957 to 1961. During his tenure, Wilson discovered the genetic resources needed to produce wheat hybrids. However, he was quickly hired by Dekalb to direct a hybrid wheat program, and Ronald W. Livers replaced him in 1962. After several years of research, Livers concluded that the potential of hybrid wheat in Kansas was relatively low because of the high cost of seed production and the low levels of hybrid vigor measured in his experiments. He then turned his full efforts towards the development of pure line varieties adapted to western Kansas.

1970. Foundation seed of Eagle was released to Kansas producers. Eagle was selected from the Nebraska-developed variety Scout. It was shorter and earlier than Scout and had improved bread baking quality. Eagle was the most popular variety grown in Kansas in 1978 and 1979.

1973. Sage and Kirwin were released to Kansas producers. Sage was a Scout type variety with leaf rust resistance. Kirwin was an improved Bison type with Hessian fly resistance derived from Parker.

1976. Larned was released, which added resistance to the Hessian fly to a Scout background. This was the only Scout-type wheat still grown on a significant acreage in western Kansas at the end of the 20th century.

1978. Cheney foundation seed was distributed, but seed production was stopped in the following year because of purity problems. Cheney was also a Scout-type wheat with resistance to soilborne mosaic virus added.

1979. Ronald W. Livers passed away, and T. Joe Martin was moved from the plant pathology project to the wheat breeding project.

1982. Arkan foundation seed was released to Kansas producers. This was the first variety in Kansas to combine resistance to multiple pests, including leaf rust, stem rust, soilborne mosaic virus, powdery mildew, Cephalosporium leaf stripe, and Hessian fly. It was also the first short wheat (semidwarf in height) equal to the standard height varieties in coleoptile length. Arkan replaced Newton as the most popular variety in Kansas in 1987 and 1988.

1985. Dodge and Norkan foundation seed were released to Kansas producers. These two varieties were the first released from Hays that were truly semidwarf in stature. They carried the same dwarfing source that was responsible for the Green Revolution in the 1970s.

1987. The decision was made to devote a large portion of the Kansas breeding resources to the development of hard white wheat varieties. By the late 1980s, enough research had been done on white wheat by KSU wheat breeder Elmer Heyne, plant physiologist Gary Paulsen, and grain scientist Arlin Ward to warrant a major effort towards the development of white wheat varieties for production in western Kansas. Their research indicated that white wheat could be produced there and that our world markets could be increased if white wheat were produced instead of red wheat. Over the next 12 years, most of the efforts of the Hays breeding program were focused on the development of hard white varieties.

1989. The experimental hard white wheat KS84HW196 was furnished to the American White Wheat Producers Association on an experimental basis to allow that organization to start developing white wheat markets.

1993. Foundation seed of the hard red winter wheat Ike was released to Kansas producers. This was a high-yielding variety for western Kansas. Ike became the second most popular variety in that area by 1997.

1999. The next important change in western Kansas wheat production is taking place as this history is being written, the conversion to hard white wheat. The Station released its first high-yielding hard white variety, Trego. Its performance record in western Kansas was superior to that of the available hard red wheats, which was of primary importance to producer acceptance of a new class of wheat. Trego also carried most of the important agronomic and pest resistance traits needed in a western Kansas wheat variety. It had the Scout level of winter hardiness, produced grain with outstanding test weights, was nonshattering, and had improved tolerance to preharvest sprouting. Its pest resistance package included effective levels of tolerance to wheat streak mosaic virus and Hessian fly and high levels of resistance to leaf rust, stem rust, and soilborne mosaic virus, all major pests of western Kansas wheat production.

2000. Lakin and Stanton were distributed to Kansas producers. Lakin is the first Kansas hard white wheat that combines the ability to produce good quality breads with the ability to produce good quality Asian noodles. The latter trait will be very important, if we are to compete in the expanding markets. Stanton is a hard red winter wheat primarily adapted to the western third of Kansas. Its most important attribute is its resistance to Russian wheat aphid.

The ultimate success of the breeding program in terms of converting to hard white wheat likely will not be known for years; however, there is no question that important contributions to wheat production in Kansas have been made. Estimates on the rate of wheat yield improvement in Kansas during this century from variety development have averaged from 0.25 to 0.5 bushels per acre per year. The prospects for the future continue to be promising, especially when you consider that biotechnology has not yet had an impact on Kansas wheat production by the end of the 20th century.

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