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South Dakota Farm and Home Research

Agricultural Experiment Station, South Dakota State University

W. L. Singleton

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Farm & Home Research

OAHE IRRIGATION
(See Research Series Pages 2-17)

AGRICULTURAL EXPERIMENT STATION □ SOUTH DAKOTA STATE UNIVERSITY, BROOKINGS

Duane Acker

From the Dean and Director

Irrigation Research and Education

SOUTH Dakota, now at the threshold of extended irrigation, has in South Dakota State University a functioning center for irrigation research and education, two of the most important elements needed to support the new era in which lack of water will become less of a limiting factor in the state's agriculture.

Directly involved right now in irrigation research at SDSU are departments of agricultural and civil engineering, agronomy, economics, horticulture-forestry and plant pathology plus the Water Resources Institute, which is headquartered on the SDSU campus.

Of prime importance to get research and other information about irrigation directly to the people who want and need it is the Cooperative Extension Service, an arm of SDSU which has had more than 50 years of statewide experience in educational activities.

While the Agricultural Experiment Station, the Engineering Experiment Station and the Extension Service are most directly associated with irrigation, the full resources of talent, facilities and experience at SDSU are available when needed. Included might be, for example, those dealing with livestock development and animal disease control, plant disease control, zoning and community development, pollution.

20 Irrigation Research Projects

Currently more than 20 research projects are concerned with irrigation. Articles elsewhere in this issue of South Dakota FARM & HOME RESEARCH tell about some of them at Redfield, near the area to be included in the Oahe Irrigation Unit. Other research has been or is being done in the western and southeastern parts of the state.

Thirty-five courses which deal directly or are closely related to irrigation are taught in the departments of agronomy, agricultural engineering, economics and horticulture-forestry to some of the 1,285 undergraduate and graduate students in the College of Agriculture and Biological Sciences. In the 1967-68 school year 217 students from the College of Engineering were enrolled in courses concerning irrigation.

More than 30 SDSU staff members and graduate assistants currently working in irrigation research seek new information and how to apply other knowledge to varying South Dakota conditions. The Cooperative Extension Service has 3½ full-time positions devoted to irrigation and water resources in addition to 10 other state staff specialists and 67 county agents who have been working on a part-time basis in irrigation educational programs.

Publications on Irrigation

Almost 100 publications or articles on irrigation and related subjects have been prepared by SDSU personnel during the past several years. Some 25,000 copies of popu-

South Dakota State University

SERVING THE PEOPLE OF SOUTH DAKOTA THROUGH TEACHING, RESEARCH, EXTENSION

SOUTH DAKOTA FARM & HOME RESEARCH

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A Quarterly Report of Progress

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Frank J. Shideler, Editor. (Editorial Office, South Dakota State University Brookings, S. Dak. 57006)

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To simplify terminology, trade names of products or equipment are sometimes used. No endorsement of specific products named is intended, nor is criticism implied of products not mentioned.

lar-type publications on irrigation have been printed within the past 2 years.

Scientists and specialists working in irrigation at SDSU keep in touch with latest developments through attendance at professsional meetings each year. These meetings provide an opportunity for contacts with scientists from USDA, other states and regions for interchange of information or cooperative planning activities.

An example of how far-reaching SDSU's impact extends is the fact that agricultural engineers alone working with irrigation the past 2 years have taken part in 18 off-campus workshops, 46 off-campus meetings, 31 tours, given in-service training for seven specialists, and made 230 visits to individual irrigated farms or farms where irrigation systems are being planned.

The annual visitors' field day at Redfield Irrigation Research Substation in cooperation with the Bureau of Reclamation is an event in which several departments at SDSU demonstrate and discuss new developments.

Expenditures for 1957 from all sources for irrigation and irrigation related research in agriculture totaled more than $275,000.

Activities of Extension

Extension has made a survey of irrigation practices carried out in South Dakota last year, set up demonstration farms in Campbell and Brown counties, assisted water user groups to organize in Hyde, Hand, Faulk, Sully and Hughes counties. Just finished is a series of six workshops attended by more than 320 persons at Mobridge, Aberdeen, Redfield, Mitchell and Wagner for new and prospective irrigators.

The Agricultural Experiment Station, since its establishment 80 years ago has been concerned with water —or the lack of it. Irrigation systems, one started by the federal government in the early 1900s, have afforded opportunities for study by SDSU personnel over a considerable period of time. An upsurge in Agricultural Experiment Station research, especially in the Redfield-Huron area, occurred in the late 1940s when the Oahe Irrigation Unit development first became a possibility. Information gained during this period of less than 10 years is useful now although research must be continuous to solve new problems, to keep up with changing times, and to be ready for the future. Generally, irrigation research must be planned and executed at least 3 to 5 years ahead of the time it is estimated the user will need it.

Irrigation is going to bring new problems along with its advantages. For example, plant pathologists say crop diseases become much more damaging under irrigated conditions than under dryland conditions. Suitable controls for South Dakota conditions must be found. Breeding disease-resistant crops is one, although time-consuming, possibility requiring the support of the many scientific branches represented in SDSU agricultural research.

Some Involved Indirectly

The Veterinary Science Department at SDSU with its new research and diagnostic laboratory scheduled for mid-1968 opening, has little direct contact with irrigation research or education. However, as the head of that department points out, when feed production increases in new irrigation areas so do the numbers of livestock, particularly feeder cattle and hogs. This, in turn, leads to concentrations of large numbers of animals in small areas for feeding. This results in increased health problems common to large concentrations of animals. In addition, such concentrations bring pollution problems. This type of pollution is something that bacteriologists at SDSU have been working on for years.

Several new studies concerning irrigation are now in the planning stage. One will compare methods of distribution of water in terms of labor and power costs, water efficiency and ease of applying it. Another will be directed toward developing automated irrigation systems.

Expanded irrigation is not going to be "easy" for South Dakotans. Unless research leads the way in keeping abreast of new developments and educational programs make this information available in such a way that the man on the farm can use it, irrigation and hopes of many South Dakotans will suffer a serious setback. SDSU, right now, has the Agricultural and Engineering Experiment Stations doing research, while resident instruction teaches irrigation agriculture and engineering to hundreds of students, and the Cooperative Extension Service conducts informational and educational programs statewide. □

contents . . .

IRRIGATION:
There's Still a Lot To Learn

By the time the first drop of Oahe Irrigation Unit water goes into the first crop some years hence, South Dakota should be in the midst of one of its most far-reaching, statewide educational efforts.

In fact, the educational effort has been going on for years. But now with thousands of acres (from Oahe and elsewhere) added to the potential irrigation picture, more people, a larger area, and millions of additional dollars are involved.

South Dakotans—on the farm, in urban areas and in the cities—will have the opportunity to better compete with other regions when a major segment of the state's basic agricultural industry gets the stabilizing influence of water . . . water available when, where and in amounts needed. Remember, South Dakota is part of regional, national and even international agriculture, subject to the forces of change that take place in any of those areas.

Learning to use water properly plus taking advantage of all the "multiplier" effects is where a vast educational effort will be needed.

Irrigation, of course, isn't the only thing involved at Oahe. Fishing and other forms of water sports are plus-benefits of the Dam. (Corps of Engineers photo.)

Wise Use a Basic Factor

However, all the possible ramifications of expanded irrigation for a quickening, thriving South Dakota economy have little meaning unless a basic requirement is met: wise use of water by the irrigation farmer.

Meeting this basic need is where South Dakota State University comes in with its Agricultural Experiment Station and Cooperative Extension Service. Knowledge accumulated over years of research is available. But to keep abreast of all possibilities, the need continues for new knowledge, especially as it applies to varying South Dakota conditions.

Importance of this agricultural research is recognized and stressed by many South Dakotans.

After an extensive study, the South Dakota Legislative Research Council's committee on agriculture and conservation reported, in part, about irrigation:

"The concensus of the committee was that the services (at SDSU) are already making a valuable contribution to irrigation but that technical and other assistance should be intensified with the state's rapid movement toward irrigation . . .

"Immediate priority be given to research concerning the methodology and technology applicable in irrigation in all forms . . ."

New Research

You'll be hearing a lot more about irrigation research as the Oahe Irrigation Unit develops.

Who does this research?

How is it done?

What has been learned so far?

What may be expected in the future?

A considerable amount of irrigation research is being done, with more slated in the future, by South Dakota State University through its Agricultural Experiment Station. Virtually every station department is, or will be, involved—from agronomy and agricultural engineering to rural sociology and wildlife management.

Some research is on a cooperative basis with other organizations such as the federal Bureau of Reclamation and the state Water Resources Institute.

South Dakota FARM & HOME RESEARCH in this and future issues will attempt to explain and discuss some of the current and future AES research.

County Water Resources Committees

County Water Resources Committees in conservancy sub-districts with rural-urban membership representing 81% of the people of the state, in a recent report suggest in part:

"Further development of research information and ideas . . .

"Research should be leading the way, not trying to prove ideas farmers have developed . . .

"Included in research could be: crops adapted for this area, methods of irrigation (this should include new and 'dream' ideas if necessary to find the best methods . . .); cultural and irrigation methods for best use of water; storage and handling of crops raised for cash or for feed; types of livestock and best methods to handle them; equipment to be used—types farmers could and would use in the future . . .

"Let's keep it realistic . . . distribution systems to save water . . . demonstration and research must be greatly expanded . . .

"Irrigation water will alleviate water shortages on irrigated lands,

but dryland areas should also receive attention . . . "

Where Information Needed

Here's a briefed list of recommendations on where more information is needed, according to the various county Water Resources Committees:

- Suitability of soils for irrigation.
- Type of irrigation—gravity or sprinkler.
- Cost of water, cost of pumping.
- Crops most profitable under irrigation.
- Water quality.
- Pollution.
- Recreation, wildlife.
- Planning and zoning.
- Community development.
- City, village and industrial water.
- Drainage and runoff.
- More educational and demonstration work to present factual information on irrigation.
- Demonstration farms on a local basis to show results of research.

Even from this abbreviated list you can see a lot of work remains to be done: by the researcher in obtaining and developing new information, and by the farmer in learning how to apply this knowledge to his fields with the necessary skill.

Information Need Is Continuous

And the need for learning and more information will not start or end when that first stream of Oahe irrigation water goes down the ditches. It must be continuous. (For example, irrigation may bring a whole new set of insect and plant disease problems).

While Oahe irrigation water in the farmer's fields is yet years away, the period between now and then is going to give us just that much more time to get ready for the most efficient and beneficial use of this water, Agricultural Experiment Station personnel point out.

"At least a generation is required for irrigation to become established in an area," says Duane Acker, dean of the SDSU College of Agriculture and Biological Sciences and director of the Agricultural Experiment Station. "I admire South Dakota leaders who are spending time promoting irrigation, knowing that they, themselves, will never realize a dime from it. Their 'payment'—if that's the way to describe it—undoubtedly comes from knowing they are helping make South Dakota an even better place for the next generation." □

Getting Water AWAY From Irrigated Areas

With Walter D. Lembke, agricultural engineer

MUCH OF THE Oahe Irrigation Unit effort and interest are concerned with getting Missouri River water **INTO** the lake plains areas of Spink and Brown counties in northeastern South Dakota.

But, ironically, another major effort consists of getting other, unwanted water **AWAY** from the area.

And it isn't like digging a new hole to dispose of some excess dirt.

Much of this lake plains area already has considerable water. But partly because of location of this water (from just below to several feet under the soil surface) and mainly because of its poor quality (high in salts) it is not suitable for irrigation.

Suitable drainage of water which occurs in the root zone of crops is an essential part of a successful, permanent irrigation system. If water does not penetrate through the root zone, the result will be accumulation of salts and consequent loss of production.

Small Drop in Gradient

The pool-table-like flatness of the lake plains area in Spink and Brown counties is the source of part of the drainage problem. The drop in gradient (north to south) is only 10 feet in 50 miles over some of it. (Such a gradient applied to a distance of , say, the length of a football field would mean the north end of the playing area is less than a quarter of an inch higher than the south end).

The "lake plain" area was once—thousands of years ago—Lake Dakota, formed by the retreat of a glacier. The old lake drained slowly, leaving deposits ranging to 50 feet in depth. The best soils formed on this surface are now classified as Beotia silt loam—a good soil. Other soils are less desirable for various reasons. But below the soil is loose lake-bed sediment down to about 10 to 20 feet where a heavy glacial till was deposited prior to lake-bed development. This glacial till is highly impervious. Water percolates downward through it very slowly—if at all. This layer acts as a horizontal dam or as the bottom of a pan and is a big factor in high water table and drainage problems.

Draining or controlling the low-quality water from the zone of soil material just above the impervious layer is one aspect of the problem. A method of doing so without creating a pollution problem elsewhere (downstream, for example) is another aspect being developed by engineers. They are encouraged that it might be done more economically as a result of some recent research at the Agricultural Experiment Station of SDSU.

Possible Savings

Considering the economics of it, if what agricultural engineers are now investigating turns out all right, they might save something like an estimated $10 million in drainage tile and installation costs alone for just the first 190,000-acre part of the Oahe unit. This is just one phase of research now underway, or planned, by the Agricultural Experiment Station. Involved is possible control over about a 12-inch difference in water table level.

This saving could be realized, agricultural engineers explain, by using less drainage tile—plus cost to transport and install it—per irrigated acre. Yet it would be possible to maintain conditions favorable to crop growth without destroying favorable soil conditions.

Under present plans for irrigated

fields, drainage tile lines will be placed about 150 feet apart and 8 feet deep. This is calculated to prevent the water table from rising to within less than 4 feet of the surface when irrigation is underway. But if the water table can be controlled to rise to only 3 feet from the surface (and cause no damage) it means the tile drainage lines can be spaced wider than 150 feet apart. Incidentally, agronomists studying irrigation in the Redfield area say that nearly 90% of the moisture used by crops is from the top 3 feet of the soil profile, about 75% from the first 2 feet, and over half from the top foot. Only a small percentage of the water used by crops is taken from below 3 feet, they add.

Need Data for Individual Fields

The distances between drainage tile lines will vary, depending upon the soil. And that brings up still another question needing an answer: Just how far apart on *my* land? The answer involves several things, one of the main ones being permeability of the soil. Researchers have found that auger holes, properly tested, give a fairly reliable indication of permeability which in turn is used in estimating drainage line spacing.

About the possibility of salt pollution from drainage water? A combination of calculations and research leads engineers to believe this problem, too, will be licked. In the first place they point out, sufficient water is to be assigned from Oahe to greatly dilute any initial build-up of salt pollution. Salts which have been accumulating for thousands of years with not enough rain water to flush them through the soil to lower drainage levels will be present initially. However, to meet water standards set by state authority it will be necessary to prevent poor quality water from entering streams or other places where it could become a pollution hazard. Dilution with the high quality water from Oahe is one way of doing this.

As irrigation progresses, the salts in the soil will be flushed out—or leached—and gradually the quality of the drainage water will go up.□

Drainage Designed for YOUR Field

With Walter D. Lembke, agricultural engineer

RESEARCHERS tackling irrigation drainage problems on Spink and Brown county lake plains soils are looking for new information to help farmers in designing a system for their specific farm.

And in doing so they hope to find out how it can be done properly at the lowest cost.

For some of you planning to go into irrigation, what the South Dakota State University Agricultural Experiment Station learns might amount to an average estimated saving of $50 an acre in drainage tile costs.

In an experiment at Redfield, agricultural engineers are learning more about the actual outflow rate through drainage tile lines spaced at different widths. They are also determining how field test data can be used to predict the amount of drainage flow.

This helps in drainage system design even down to specific fields. It means that soil conditions on *your* farm may permit wider spacing of, and consequently less, underground drainage tile.

Engineers have found that actual drainage flow from an experimental plot was more than that predicted from calculations based on auger holes or core samples.

Getting Data Down to the Farm

One practical application of this aspect of the research is that soil tests from a relatively small area can establish certain factors (including permeability) used in determining about how much drainage is needed. For *your* farm, for instance, if soil tests indicate drainage tile lines 150 feet apart are adequate to maintain the water table lower than the 4-foot level, then they can be placed farther apart with the resultant savings. If other research now underway shows that water table levels up to within 3 feet of the surface do not cause crop damage, it is possible that drainage lines even farther apart will be sufficient.

Along with this drainage study, researchers are investigating how well corn grows over a high water table. This is done by holding the water table at a predetermined level for a specific length of time—possible under controlled, experimental conditions. In 1967, the first year, water table was held within a foot of the surface for a week during the time corn was setting ears. For this particular point in the growth period of corn, no ill effects were noted. It is quite probable, however, agricultural engineers say, that such a high water table at an-

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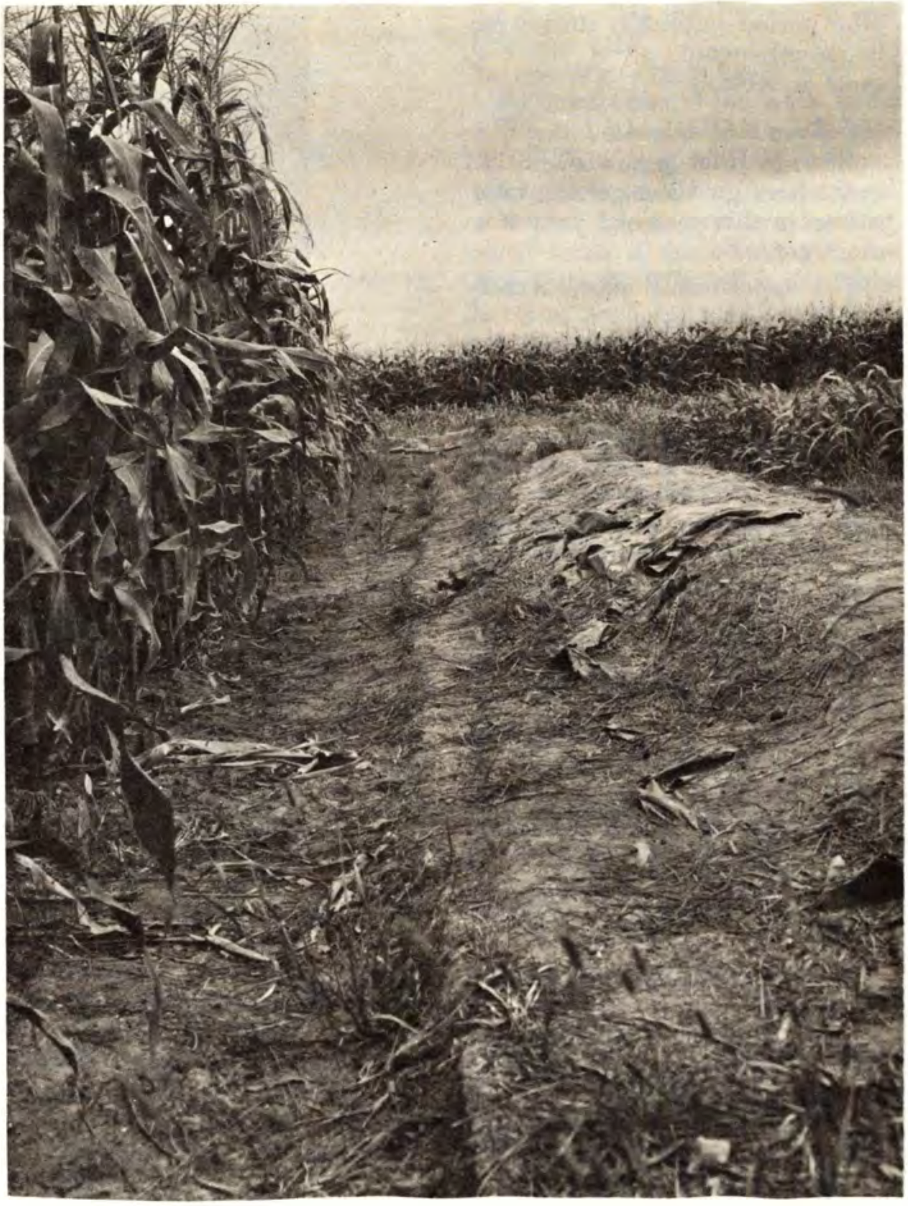
The mound of fill (right) separates the experimental plot from a 20-foot border which can be flooded or drained independently to control water level in the plot. Sheets of plastic just below the fill "enclose" the experimental plot to a depth of 8½ feet to prevent unwanted lateral movement of water. Sumps in the border area enable researchers to measure water table level to make adjustments to prevent lateral movement of water between the bottom of the plastic membrane at the 8½-foot depth and the impervious glacial till at a depth of about 13 feet.



Experimental plot (left) and border (right) are flooded to establish a saturated condition—or to raise the water table level—for tile-flow measurements. Observation wells measure occurrence and movement of ground water. Stage recorders (the two box-like devices on legs) provide relative evaporation and seepage rates for the plot and border. Tile outflow is shut off when stage recorders are in use. They indicate very little deep or vertical seepage in the plot with no tile outflow.

This 75x150-foot plot at Redfield is used in irrigation drainage studies. The 4-foot, 6-inch bell and spigot drainage pipe of the type used is shown in foreground. It is placed 8 feet below the surface. Corn growing in the plot enables SDSU researchers to investigate effects of high water table level on growth of crops.

other period—especially during early growth—would affect the crop quite noticeably.

How Data Is Obtained

Here, in brief, is how the SDSU researchers go about getting information in this particular project on drainage:

The experimental plot, actually a form of what is known as a lysimeter, is an enclosed "device" that provides for controlled supply and drainage of water plus automatic instrumentation for measurement. In some ways it is similar to other lysimeters used in research at Redfield. The plot is 75x150 feet in size (a little more than a fourth of an acre) and contains soil representative of the area. Drainage tile is on a 150-foot pattern at a depth of 8 feet. A border 20 feet wide surrounds the plot.

The plot is separated from the border by a double thickness of 6-mil polyethylene to a depth of 8½ feet in order to prevent movement of water laterally. This plastic forms the "enclosure" for the plot. Although the polyethylene does not extend below the 8½-foot level (to the impermeable glacial till at about the 13-foot level), lateral movement of drainage water from the plot at this point is prevented by saturating a zone around the border (outside the plastic membrane and down to the glacial till).

Drainage Water Measured

The drainage system includes a plot drain of open- or loose-jointed pipe only in the plot area and which empties into a calibrated tipping bucket in the 12-foot-deep outlet sump situated outside the experimental plot. Tipping rate is electrically recorded in an above-ground shelter. The border has a separate drain, closed as it passes through the test plot. All tile drains are 4-foot lengths of 6-inch bell and spigot pipe, loose connected and embedded in a gravel filter so that at least 6 inches of gravel separate the drains from the surrounding soil.

The plot and border are flooded with water for 10 days prior to taking measurements. During this period no water is removed from the sump. □

Looking down the 12-foot-deep by 3-foot diameter sump which contains outlets for the experimental plot tile drains, the tipping bucket for automatic measurement of amount of drainage water, float control for the pump, and the suction line.

Data from the sump are recorded electrically at this above-ground station. Data obtained here includes tile flow rate of water and volume of water.

Control of WATER TABLE LEVEL

With Walter D. Lembke, agricultural engineer

LYSIMETRY, a research method at least 2½ centuries old but updated with modern, more complicated equipment, is used in Agricultural Experiment Station irrigation research by South Dakota State University scientists at Redfield.

Lysimeters themselves are not imposing devices and you probably wouldn't notice one unless you knew what you were looking for. They come in widely varying sizes, shapes, costs, materials used, and details of construction.

This is true at Redfield where agricultural engineers use a non-weighing type specifically suited to the need. Within a few hundred yards is another type which rests on delicate weighing devices to obtain certain data wanted by agronomists. An experimental plot used by both agricultural engineers and agronomists at Redfield might be described as even a third type of lysimeter in that plastic barriers help prevent movement of water to or from soil in the plot area.

Percolation and Drainage Studied

Agricultural engineers in one project at Redfield use eight of the non-weighing type lysimeters to obtain precise information about percolation and drainage of water through soils, removal of soluable constituents (salts, for example) and water table levels. Essentially, the devices consist of a tank of soil in the ground with controllable water intake and outlet all connected to recording instruments. From information obtained, engineers determine some of the field design data needed for establishing irrigation systems.

Each of the eight lysimeters of this project consists of a 12-gauge sheet steel tank, 3x3½ feet at the soil surface and extending to a depth of 7 feet. In making the hole for each tank, soil was carefully removed in layers so that it could be replaced inside the 3x3½ x 7-foot "container" with a minimum of profile change. It is a near duplication of the surrounding soil enclosed by the steel sides and bottom of the lysimeter tank.

Control Water Table Level

Engineers control the water table at 3 feet below the surface in four of the lysimeters and in the four others the water table is maintained at 4 feet. Researchers are learning about some of the conditions present with the different water table levels as well as variations in salt accumulation in the soil. For one thing, more salt accumulation is found on the surface of the 3-foot water table lysimeters.

The lysimeters at Redfield provide information of use for a wide area because data obtained is from the same soil type and under the same climatic conditions.

These studies have been underway 3 years. Beginning in 1968 and continuing for 3 years, row crops will be planted in the lysimeters. This will introduce a new set of conditions for which information is needed. For instance, what effects 3- and 4-foot water tables might have on a growing crop. Dimensions of the lysimeters will permit variations in row spacing and plant populations. □

(See Also Photos Page 10)

Water supply (six of eight steel barrels on racks, at right) maintains 3- and 4-foot water tables in lysimeters (left, ground level). The small tubing along the left side of lysimeters is a vacuum line connected to a pump (not shown).

One of four lysimeters in which water table is maintained at 3 feet. The 3x3½-foot ground level dimension is indicated by damp (darker) soil although sheet steel sides of lysimeter are covered. The small tube and bottle extending from left of vacuum line (diagonal at lower right) enables researchers to extract water from the soil to measure salt content. The two pipes at left are used to maintain water table at desired level below the surface. The larger standpipe equipped with automatic controls supplies water. The smaller pipe next to it houses a valve that drains water from the lysimeter if water table level raises above desired height.

One of four lysimeters with water table maintained at 4 feet. The pipe in the center is an access tube in which a neutron moisture meter is lowered to measure the amount of water in the soil. Researchers have found that soil at the surface in lysimeters with water table maintained at 3 feet is wetter than for those in which water table is at 4 feet. This is especially noticeable on cloudy days (compare drier soil at surface in this photo with photo of 3-foot-water-table lysimeter). More salt accumulation was also found on the surface of the 3-foot water table lysimeters.

Precise Information for Irrigation Planning

With Maurice L. Horton, agronomist

WHEN THE day comes — and it could be sooner than you think —that a South Dakota irrigation farmer can schedule his irrigation for the next few days from a report coming in with the weather news over his radio or TV . . .

. . . when that day of easier, more precise irrigation comes, it is quite likely the farmer will owe at least part of his thanks to four,

This trailer in the middle of an experimental sorghum plot at Redfield is chock-full of recording instruments and other devices used in evaporation and transpiration studies by Agricultural Experiment Station agronomists. The crop conceals most nearby field measuring instruments.

earth-filled plywood boxes and a trailer full of recording instruments.

These are not just ordinary boxes. They are quite special. About 39 inches square and deep, each contains about 1¾ tons of soil; they are invisible, being buried in the ground over a delicate weighing mechanism; and they are connected into a network of recording devices that provide data only a computer could relish.

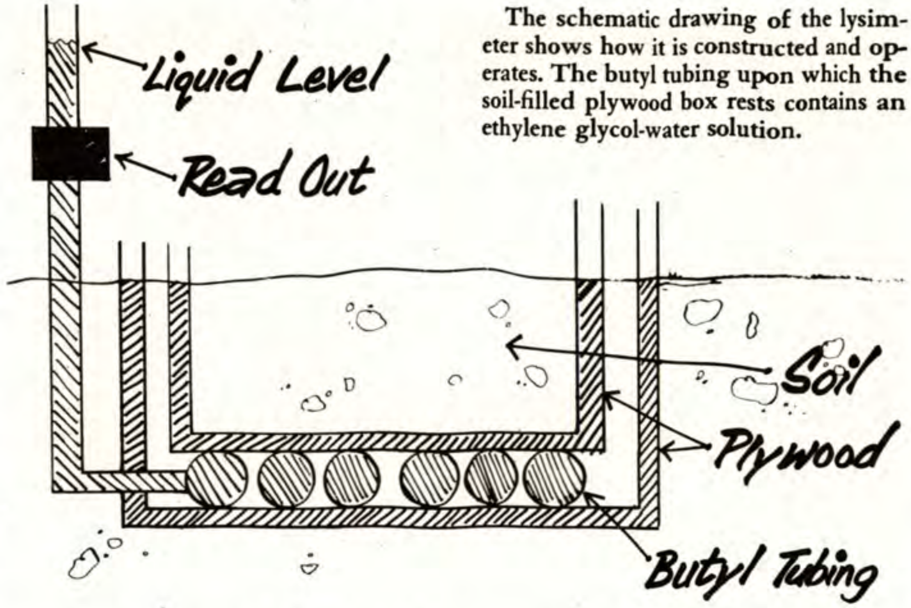
Actually, they are weighing type lysimeters, used as an irrigation research tool by Agricultural Experiment Station agronomists of South Dakota State University. Use of lysimeters is not new. Some are constructed at a cost of tens of thousands of dollars. Those in use in South Dakota cost SDSU designers only a few hundred dollars to build.

Research Near Oahe Unit Site

The lysimeters are on the Irrigation Research Substation at Redfield near the southern end of what someday will be a major part of the Oahe Irrigation Unit. Purpose of the research is to get precise information about water loss through evaporation and transpiration from cropped land plus its relation to soil and climatic conditions. Using this data, scientists hope to be able to predict water loss from measurements of climatic conditions and amount of sunshine. The lysimeters are used in measuring (by weighing) the small amounts of water or moisture involved in the complicated process of evapotranspiration—*evaporation* from the soil, *transpiration* through plants.

It is part of research by agronomists in central eastern South Dakota where several SDSU departments have conducted irrigation experiments over a period of nearly 20 years.

The evapotranspiration installation at Redfield includes, besides the lysimeters, instruments for continuous, 24-hour recording of radiation (solar and net), wind, humidity, soil heat flux, soil temperature and air temperature. In addition, the content and availability of soil water is recorded several times a week. The volume of data is enormous, so much so that unless it is computerized, months of work would be required to reduce it to practical use for irrigation.



The schematic drawing of the lysimeter shows how it is constructed and operates. The butyl tubing upon which the soil-filled plywood box rests contains an ethylene glycol-water solution.

Hope to Predict Needs

As researchers obtain the data and analyze it, they hope to be able to relate findings to field and weather conditions in such a way that predictions can be made on how much irrigation water is needed and when.

Here is how it might all work out on a practical basis for the South Dakota farmer sometime in the future:

A weather reporting station in the area would take, for example, wind, radiation and possibly a few other measurements. These would be combined and broadcast as an "evaporation" report possibly each day along with the weather news. The farmer would use this report along with one or two easily-made

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This is one of the weighing type lysimeters at Redfield. It is about 39 inches square and deep and contains 3,500 pounds of soil. The soil was carefully excavated by natural horizons and then replaced in plywood boxes as near as possible to its original condition. The boxes were placed on weighing devices at the bottom of the excavation. Since evaporation and transpiration are measured by weight, the lysimeter must be free to move. The covering around the edges prevents clogging of the space between the lysimeter and the surrounding soil as well as preventing water flow onto it. One inch of water spread over the surface area of the lysimeter weighs 56 pounds and recording instruments can weigh to within 1½ pounds change in weight or approximately 0.03 of an inch of evapotranspiration.

Looking down on a corner of one of the lysimeters near the end of the crop growing season. The solid line approximates the soil surface outside the lysimeter and the broken line approximates the edge of soil surface inside. The lysimeter must have free, unobstructed vertical movement to assure correct weights when moisture is added or is lost by evapotranspiration. The soil and its condition inside the lysimeter must be the same as the surrounding soil.

A better idea of number and location of measuring instruments is obtained in this photo of the lysimeter site during installation of field instruments at the early growth stage of the crop. In addition to the trailer (background), the instruments shown include: (1) lysimeter readout tower; (2) wind direction indicator; (3) solar radiation sensor; (4) net radiation sensor; (5) the area in which four lysimeters are placed in a semi-circular pattern so all are the same distance from recording equipment in the readout tower; (6) recording rain gauge; (7) evaporation pan; (8) recording evaporimeter.

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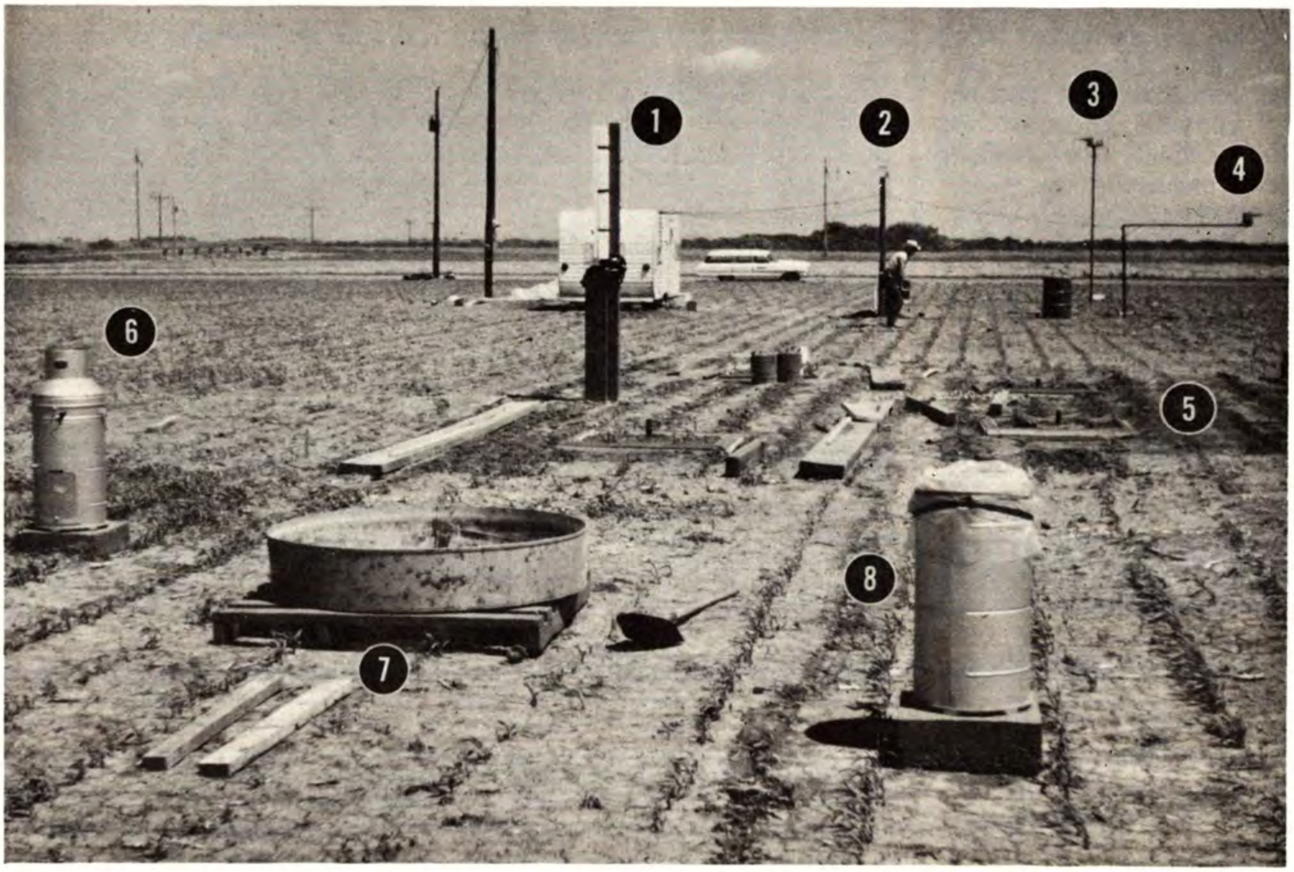
measurements from his field to determine if, when, and how much irrigation was necessary. For the skilled irrigation farmer it would be a bookkeeping process. He would consider moisture in the soil something as a bank account. Evaporation from soil and transpiration from plants would represent withdrawals, additions through precipitation (or irrigation) would represent deposits.

Data last summer show that on July 13 the sorghum crop on the experimental plots used 0.20 of an inch of water, on July 14 it used 0.10, and on July 22 it used 0.38.



Water Needed for Your Farm

Agronomists estimate that 6 inches of water stored in the upper 3 feet of the soil profile would last a month at the rate of crop use recorded last July 13, some 2 months at the rate on July 14, but only 15 days at the rate on July 22. By knowing amount of water stored in the soil, the amount used and transpired by plants, and the amount evaporated, a fairly good prediction could be made of the amount of water needed in the soil—that is, how much the irrigator would need to put on *his* field.

Even before the prediction technique is fully developed, agronomists will have useful information on some of the most important factors to consider in relating evaporation and transpiration to irrigation.

In addition to being able to predict irrigation needs, scientists may also be able to warn of possible adverse conditions. The farmer could use such warnings to avert excessive crop damage. Additional research concerning the microenvironment in which the plants grow, coupled with what is already known, undoubtedly will provide knowledge of great value to the farmer. Included in this could be fertilizer response—or lack of it — which is sometimes related to environmental conditions.

Reducing Water Losses

Also, when scientists know more about evaporation and transpiration perhaps methods can be developed to treat a crop or soil — chemically or physically — to cut down on unnecessary loss of water. They might be able to better pinpoint species and/or varieties of crops which use water more efficiently.

The type of research on evaporation and transpiration from cropped land at Redfield is not new. It has been done in other places under other conditions. In some cases broadcast reports are available for farmers to time irrigations properly or use irrigation (frequently sprinkler type) to avert frost damage.

(concluded page 14)

Delicate instruments record a wide variety of complicated data and take up most of the space inside this trailer. In this corner six instruments provide readings on a 24-hour-a-day basis.

The instrument being pointed out records small differences in weight during each 24 hours of two lysimeters some 50 feet away in the experimental plot as well as solar radiation or the energy available for evapotranspiration. Below this instrument, at left, is a spring-wound voltage recorder to show electric power changes or stoppages. Wind velocity is recorded on the instrument next to the voltage recorder. At upper right, relative humidity at two points near the crop surface is recorded. At upper left (only partially shown), soil heat flux is recorded. At the bottom of the photo (also only partially shown) is a portable scaler for recording soil water content. Other instrument equipment in the trailer includes a soil water content gauge, a voltage regulator, and temperature recorder. The trailer is necessary to secure instruments as well as protect them from temperature variations, wind, sun, dirt, rain.

Agronomists say the next step is to get an automatic data logger to partly replace these instruments plus providing data which could be processed directly by a computer.

Some results and techniques of previous research help South Dakota scientists. But researchers still must have more exact information for South Dakota climatic conditions, soils and crops. Even more exact data than this is being sought—down to the level where it can be applied directly to **YOUR** field and **YOUR** crop. □

Below is an example of the recorded data from the instrument described first in the photo of inside the special trailer. It is for August 19, 1967 from 12:00 noon (note figure 12 at bottom) until 3:30 p.m. (top of illustration here ends about midway between 3 and 4). The five vertical wavy lines show these readings (from left to right, starting at about the figure 100): total radiometer temperature, lysimeter No. 1, total radiometer, lysimeter No. 2, and Eppley (short wave) radiometer.

For this instrument the reading is recorded as a small number and a cross. These are later connected manually for convenience in processing the data.

"Programming" Irrigation Drainage

With Walter D. Lembke, agricultural engineer

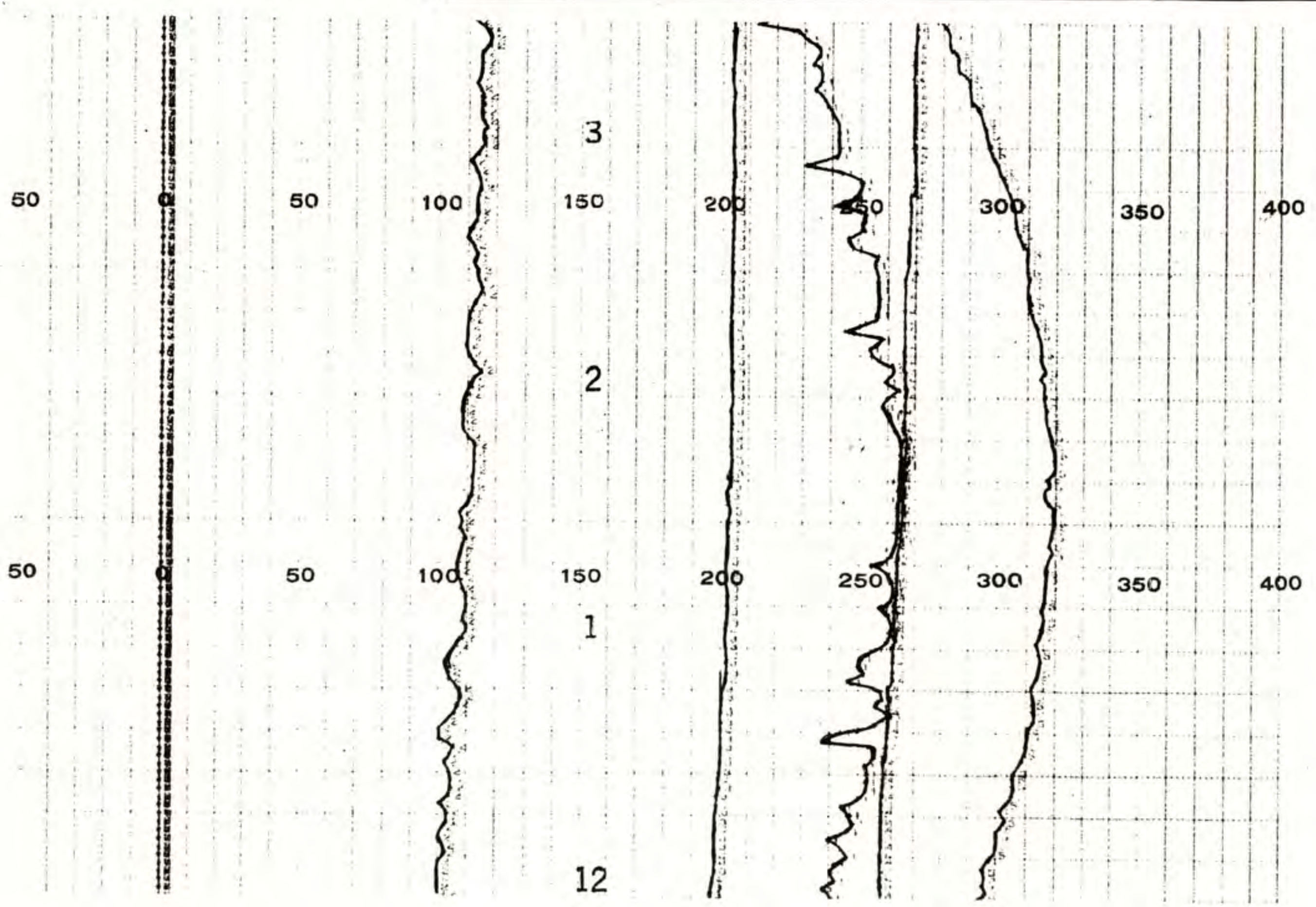
Because water and electricity have something in common, your irrigation drainage system may be designed with the help of a "computer" in Agricultural Experiment Station laboratories at South Dakota State University.

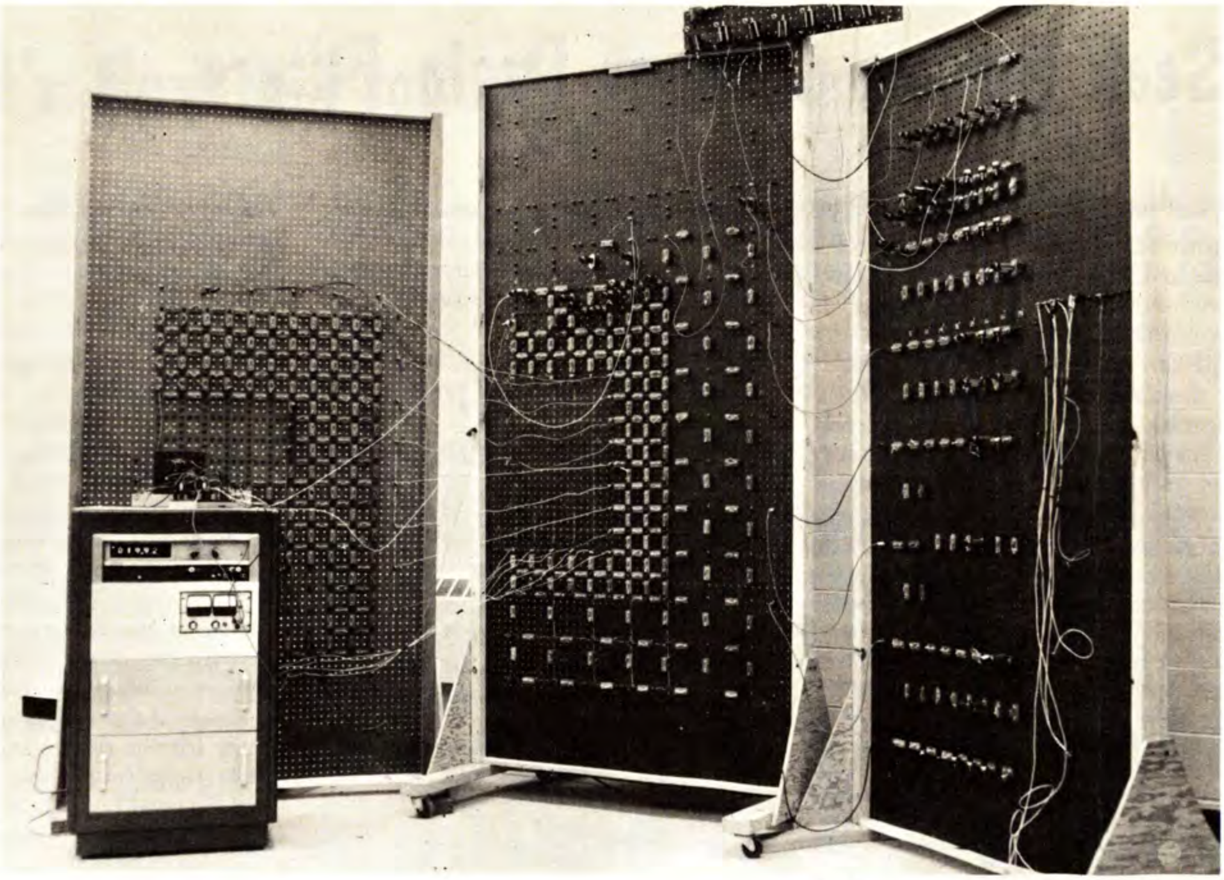
Agricultural engineers are working on design and calibration of a device—more technically known as a resistance *network*—based on flow of electricity through a resistance. The flow of electric current, they explain, can be measured and compared to water flowing through a soil—the same natural laws apply to both. For instance, if a soil has low permeability the flow or percolation of water through it is comparatively slow because of more resistance. Amount of electric current flow also depends upon resistance—the higher the resistance, the lower rate of flow.

It is this similarity—permeability of soil and amount of electrical resistance — that engineers use in working with the resistance network device which might be classed as a distant relative of a computer. This "computer" isn't like the popular concept of a machine with a console of buttons, flashing lights, spinning reels and eerie noises. It isn't quite so dramatic. It consists of panels of peg board (the same kind you'd buy at a lumber yard) with dozens of small resistors that can be plugged into the holes plus a current meter, a voltmeter and a power source.

Duplicates Soil Profile

Resistors, when the device is properly calibrated, will be placed on the peg board (either by quanti-





This resistance "network," built in SDSU agricultural engineering research laboratories, may some day help in design of irrigation water drainage systems covering thousands of acres in South Dakota. Small electrical resistors can be arranged on the 8-foot-high pegboard panels to duplicate the permeability (resistance) of a soil profile. Electric current simulates flow of water and is measured by the meter shown at lower left.

ty or degree of resistance) to match data from field measurements. It will be a laboratory duplicate of a soil profile including an underground drainage pipe. Flow of small amounts of electricity will represent percolation of water. The voltage measured at any given point on the board corresponds to the pressure of water at a similar point in the soil profile being represented.

From this information and from current flow, engineers will be able to determine about how far apart your underground drainage lines should be.

This "network" will provide accurate data much faster as well as eliminate a lot of field work, according to engineers. They are quick to point out, however, that "what comes out" of it will be no better than "what is fed into" it. Data from soil tests enable researchers to get the right resistance in the board to come up with information used in designing a drainage system for a particular field.

Need Field Data for Programming

Previous, current and future research in South Dakota and elsewhere will be used to gain knowledge about proper information for the "network." Experiments at Redfield in which actual underground drainage water outflow was related to permeability of soil and its depth are currently being evaluated on the device. As soon as these studies are finished, engineers hope to be able to program the "network" to give information for soil conditions at various depths and different permeabilities. When this stage is reached, agricultural engineers believe they will be able to use auger-hole measurements from a given field to design an adequate drainage system.

While the "network" itself would be a costly way of designing each individual drainage system, its main use will be to check the specific but different soil types. ☐

Two types of resistors are used on the "network" board. One (at right) can be adjusted to vary resistance by turning a knob at the end. The other has a set resistance. About 500 resistors are used.

Seek Better, Cheaper Drain Filters

With Walter D. Lembke, agricultural engineer

THOUSANDS of dollars—some of it could be yours—may be riding on results of irrigation research in South Dakota State University agricultural engineering laboratories.

Involved in these Agricultural Experiment Station studies is not only money in the form of possible savings, but technical knowledge which might give longer lasting, more efficient drainage systems for irrigated land.

Drainage to control ground water is a big aspect of the proposed Oahe Irrigation Unit, for instance. Concrete pipe drain lines under all the irrigable land in the project will make up a large part of this ground water control—about 14,000 miles of it according to estimates. A considerable portion of this drain pipe is to be installed by landowners themselves.

How Much Gravel for Filter?

If the Agricultural Experiment Station is able to come up with something to lessen costs by even a fraction of a cent a foot for these underground lines, it will represent a sizeable sum. And a fraction of a cent a foot may be conservative. Consider, for example, the gravel used around the tile as a filter to prevent entrance of soil that would clog the system. A vast amount of gravel —and its transport—is involved plus other possibilities such as depth of trenches for burying the tile.

According to current calculations, most of the drain pipe is slated to be installed 8 feet below the surface over most of the area. This depth, as well as distance between lines, probably will vary.

A thinner envelope around the drain pipe, however, would mean less gravel. This would reduce gravel transportation and handling costs.

Seek Better Filter

Another major purpose of the research is to develop a better filter to keep soil out of the drain.

It would be much better costwise, of course, if it wasn't necessary to put gravel around the tile. But would enough water penetrate through the walls of the concrete pipe and at the joints for proper drainage? "No—definitely," say agricultural research engineers. The "seepage" through the pipe walls is virtually nil in any good drain pipe. The water must enter the drain through the open joints. Without the filtering effect of the gravel the open joints soon become plugged with fine soil particles.

A start has been made, but research is not finished, on determining feasibility of using less-than-6-inch gravel filter or envelope on drainage tile under lake plain conditions. Part of this research is being done in the Agricultural Experiment Station laboratories of the agricultural engineering department at SDSU. In addition to determining that a gravel envelope is necessary for the drainage pipe, so far it has been found that fine gravel must be used because the soil particles themselves are fine. Engineers point out that gravel of this type is available throughout the area. □

Field irrigation problems are brought to the laboratory in this experiment designed to determine maximum thickness of gravel filter needed around underground drainage pipe. In this laboratory replica of a lake plains soil condition, Dale Bucks, Redfield, a graduate student in agricultural engineering, indicates a section of concrete tile under study. Soil in the glassed-in container is from the lake plains area. Different thicknesses of gravel are used for experimental filters that surround the section of drainage tile to prevent entrance of soil. Tubes extending through the glass at different levels of the soil profile measure pressures at these points. Water is introduced at the top and percolates through to the drainage tile. The amount of water through the tile is measured by an automatic tipping device and recorded on an event recorder (front, center).

Pressures from various points on the experimental soil profile are recorded on this panel of vertical glass tubes. From this data researchers determine the water pressure drop through any particular section of the experimental soil profile.

What's New in Products for Irrigation?

With Walter D. Lembke, agricultural engineer

WHAT ABOUT new products or new methods for installation of irrigation drainage systems in South Dakota?

The Agricultural Experiment Station is taking a look at some of these under both field conditions at Redfield and in the laboratory at South Dakota State University. As of now, these evaluations are only in the preliminary stages.

Thousands of miles of concrete tile pipe used in underground field drains will require vast amounts of materials for manufacturing, regardless of where they are made. The transportation bill will also be a major item.

Plastic pipe for underground drainage systems could greatly reduce transportation and certain installation costs. Some plastic pipe is now in the ground for evaluations at Redfield.

Current research is with 3-inch, round, plastic pipe which is corrugated for strength. Small perforations in the pipe permit entrance of water. This flexible pipe comes in rolls hundreds of feet long so that it could be unreeled directly into an excavation or trench. If necessary it could be placed in slight curves.

New methods of excavating for installation of drainage pipe are under consideration for future investigation in lake plain soils. Trenching machines are generally used. Engineers would like to know more about use of large plow-like machines to make a "furrow" with the drainage pipe placed right in behind it. Such implements are in operation elsewhere under conditions somewhat similar to those in much of the Oahe area soils.

How about materials other than gravel for the filter or envelope surrounding the underground pipe? A fiberglass mat, a half inch thick and a foot wide which comes in rolls, is being tested. The fiberglass mat is placed in the trench beneath the drainage pipe. Gravel is then placed over the pipe and mat. Engineers say this might reduce the amount of gravel needed as well as making it easier to keep a smooth, even grade for the system. □

Evaluations of new industrial products will help determine their suitability for underground irrigation drainage use in lake plains soils of the Oahe Irrigation Unit. Walls of this 3-inch plastic pipe are corrugated (for additional strength) and perforated (not visible here) for entrance of water. The pipe is shown as it might be installed on a ½x12-inch fiberglass mat at the bottom of trenches excavated for field drainage systems. Gravel would be packed over the mat and pipe to form a filter to keep soil from clogging the line.

If these products are suitable, agricultural engineers point out some advantages: plastic pipe weighs only a fraction as much as concrete drainage tile; initial cost of plastic pipe is less than concrete; its flexibility would permit slight curves in a drainage line; the fiberglass would give a smoother, even grade at the bottom of excavated trenches. Furthermore, plastic pipe and fiberglass mat may be manufactured in long rolls for easier handling.

Farming's Drop-Outs . . .

Displaced Person or Forgotten Man?

By **Arthur J. Matson,** associate professor, Economics Department

FARMS IN South Dakota today are fewer than when the state was admitted to the Union.

The 50,158 farms in 1889 compare to the 49,703 listed for 1964, the last year covered by the latest U. S. Census of Agriculture. The number in the intervening 75 years had risen to more than 83,000.

People have entered and departed from farming at different rates as numbers of operating farms have risen and fallen. A look at farm operators by age groups in two recent census years may indicate trends useful for planning to meet future needs of present-day farm people.

Land settlement and enlargement of farms are evidences of dramatic progress in agriculture witnessed by some living residents of South Dakota. Present forces may be fully as important in registering future changes as were forces in the past for causing changes seen today. This record has meaning for farm youth, established farmers, and for persons who leave farming for other work or through retirement.

Progress, in agriculture as well as in other industries, is usually an advantage to most people who are affected. But progress in agriculture has also been associated with losses in opportunities for youth to farm and displacement of farm operators who are required to find other employment.

Young persons are flexible in choosing careers. Some can become successful farm operators, and others can train for non-farm employment. Commercial farmers may be able to find capital to take advantage of modern technology. There are farmers, however, who by choice or necessity, leave farming after becoming established, but before retirement. These may be the forgotten few who are not represented in programs of public policy.

Land in South Dakota Agriculture

Since territorial days, South Dakota has become fully settled, and the land area in farms has increased four fold. Consequently, with about the same number of farms now as at the close of the territorial phase of our state's history, the average size of farms has doubled and doubled again.

Changes and trends in number of farms, land in farms, and average size of farms in terms of acres are shown graphically in figure 1. With South Dakota's variety in type of farming, statewide trends are only a broad indication of change. Land in farms has been generally stabilized, with a growth in average farm size each census report except in 1909 and 1924. Land as a factor of production in South Dakota can probably be measured more closely in terms of acres than in most other states.

For a time, growth in farm size came with the creation of larger farms and ranches from land in the central and western parts of the state. More recent growth has been recorded with the adoption of large scale machinery and farm consolidation.

The accompanying drop in farm operators has been so sharp that significant numbers of farmers leave in the middle of their working years. Whether in closing the frontier by settlement, or in reacting to present forces, people have made personal adjustments which have impacts on community life.

In 1964 South Dakota had 49,703 farms by Census count, as compared to 62,520 in 1954. Here we are concerned with the persons who had operated those 12,817 "disappearing" farms which represent a decline of 20.5% in 10 years.

Where Do They Go?

South Dakota lost nearly 13,000 farms in the 10-year period, 1954 to 1964.

What happened to the people? To the farm operators?

Many middle aged farmers dropped out because of reduced opportunities in farming or attraction of non-farm employment. About a fifth of them faced "mid-career displacement." They may have taken jobs other than those in which they had training or experience.

Many in the group now 8 to 18 years of age are or soon will make career choices. Some—but not all—will be able to farm if they wish. Those wanting to farm have a difficult decision—partly because they must decide upon a career which may not be there when they reach middle age.

Between now and the time in the future when size of farms and number of operators are more or less stabilized, there is a "built-in" group which will probably face "mid-career displacement." What can, and will, be done for them is a matter of state and national concern.

In this article, the author discusses what South Dakota age groups are dropping out of farming and some implications for personal and public decisions.

People in South Dakota Agriculture

Plans and aspirations of individuals are recognized partly by their membership in certain age classes. Table 1 shows age groups of South Dakota farm operators in 1954 and 1964 from the U. S. Census. The assumption is made for convenience in later analysis that no farm operator is under 15 or over 75 years of age. The Census reports categories at the end of the age scale as "under 25 years" and "65 years and over."

Also, there is a correction in the 1954 figures for farmers who did not report their age.

Number of farm operators in 1964 as a percent of 1954; as shown graphically in table 1, points to the decline in the 25 to 34 age group which accounts for over 43% of the total loss of operators.

The average age of South Dakota farm operators in 1964 was 48.6 years and 46.8 years in 1954.

South Dakota had 13,514 farm operators under 35 in 1954 and 7,-659 in that age group in 1964—less than 57% as many. For ages 35 and over there were nearly 86% as many in 1964 as 10 years before. Those relatively few young farmers, 38 and under at present, will not pull the average age of farmers down very fast. In 1964 there were more than twice as many operators 45 to 54 as 25 to 34. These younger operators will see a type of farming quite different than others not many years older.

Comparing Farm Operators of Same Age Group for Two Time Periods

Age groups are compared here in two ways. One is to compare the number in one age group in 1964 with the number in the same age group in 1954, as in table 2. None of the individuals are the same, as all persons are inescapably in the group 10 years older 10 years after they were first counted. This method offers a basis for comparison but it does not tell what happened to people listed as farm operators in 1954.

The graphed portions of table 2 point up: *(a)* The drop of nearly 50% in operators aged 25 to 34, an age when a young person typically takes over management of a farm. These figures may reflect the reduction in opportunities to become farm operators in the state, affecting even those who have recently started farming. And *(b)* The percentage drop in farms from 1954 to 1964 by age of operator. The sum is the percentage decrease of 20.5% for all ages. This approach is interesting and factual but it does not show the rate at which persons drop out as farm operators as they move from one age group to another.

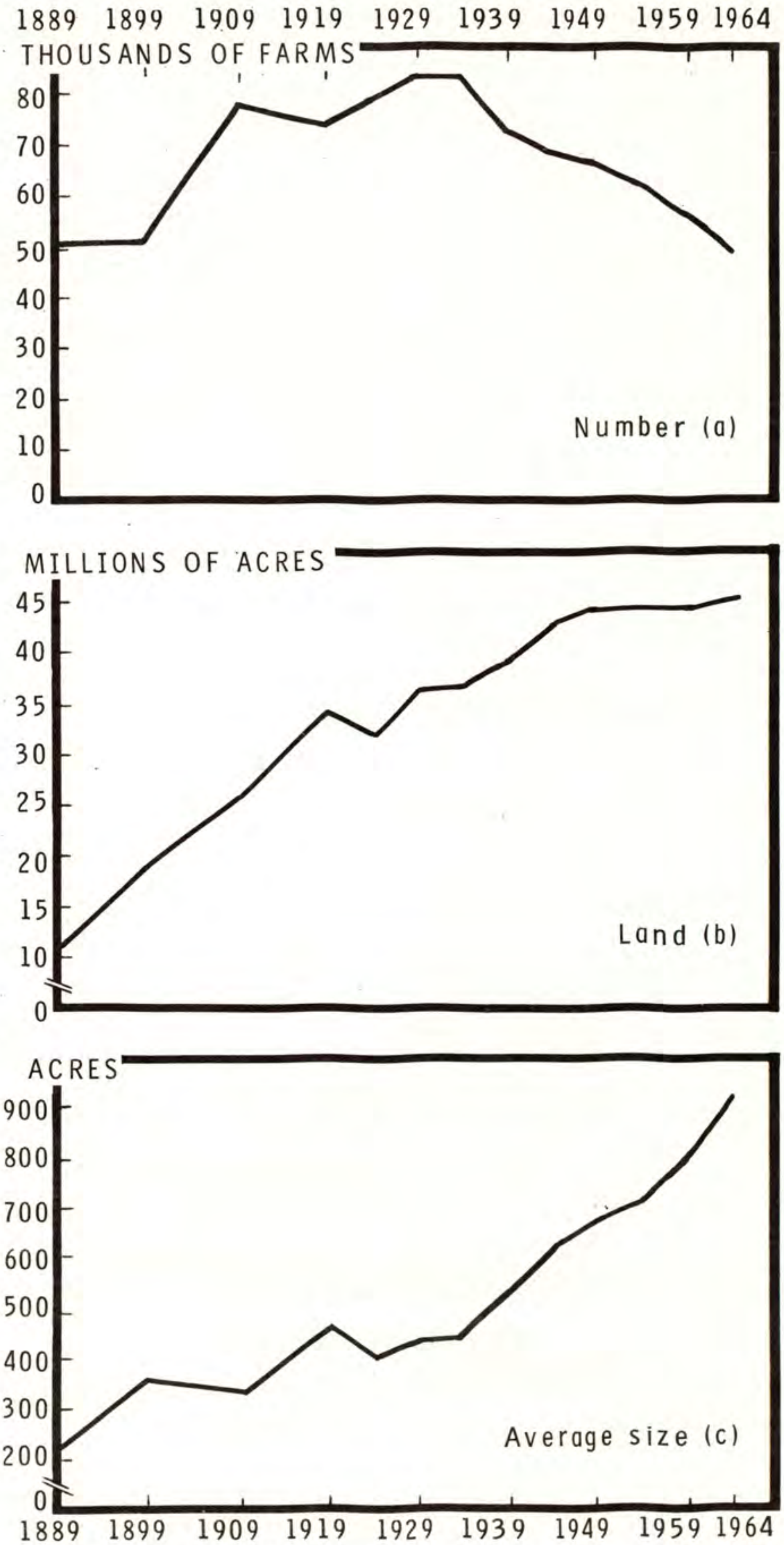


Figure 1. Farms in South Dakota in census years 1889 to 1964

Comparing Same Group of Farm Operators Over Two Time Periods

A second way of making a comparison is to consider the same people as time passes and places them in an older age bracket.

Table 3 exhibits the number of farm operators who were of one age group in 1954 and in the next older age group in 1964. Thus, it is assumed so that all operators can be accounted for, that all farmers have discontinued operation before becoming 75 years of age, even though some undoubtedly remain as farm operators. There were 7,234 who were 65 and over in 1954.

Persons operating farms from ages 65 to 74 in 1964 were from the ages of 55 to 64 in 1954. During the 10 years a net of 5,875 or 49.4% of them dropped out. This comprised 9.4% or nearly half of the over-all reduction of 20.5% of the 1954 base.

The decline is less with younger age classes. A 1% increase in the 35-44 (in 1964) group is scored over the number of farm operators 25-34 (in 1954). This means that 120 more of them began farming than left farming for whatever cause and were no longer represented as farm operators. The effect of this category was to raise the operator total slightly, 0.2%. The two younger categories also had net gains in numbers of farm operators from the base 10 years younger, 10 years before.

The left graphed portion of table 3 shows comparison of number of farm operators who were members of one age group in 1954 and number in the group 10 years older in 1964 in which they would hold

Table 1. Number of farm operators by age group in 1954 and in 1964 in South Dakota and number in 1964 as percent of number in 1954.

Age of Operator	1954	1964	1964 as percent of 1954
75 and over	0	0	
65 to 74	7,234	6,016	83.2
55 to 64	11,891	10,583	89.0
45 to 54	14,532	13,224	91.0
35 to 44	15,349	12,221	79.6
25 to 34	12,101	6,578	54.4
15 to 24	1,413	1,081	76.5
Under 15	0	0	
All ages	62,520*	49,703	79.5

*Operators not reporting age in 1954 were distributed among age groups in proportion to those who did report age.

Table 2. Number of farm operators by age group in 1954 and 1964 with change in number of operators from 1954 to 1964 as percentage of same age group and of all farm operators in 1954.

Age—Year	Number of farm operators	Comparison of farm operators in 1964 with farm operators in 1954: with operators in same age group — number change	with operators in same age group — percent change	with operators of all ages — percent change
75 and over—1964	0			
65 to 74—1954	7,234			
65 to 74—1964	6,016	—1,218	—16.8	—2.0
55 to 64—1954	11,891			
55 to 64—1964	10,583	—1,308	—11.0	—2.1
45 to 54—1954	14,532			
45 to 54—1964	13,224	—1,308	—9.0	—2.1
35 to 44—1954	15,349			
35 to 44—1964	12,221	—3,128	—20.2	—5.0
25 to 34—1954	12,101			
25 to 34—1964	6,578	—5,523	—45.6	—8.8
15 to 24—1954	1,413			
15 to 24—1964	1,081	—332	—23.5	—0.5
Under 15—1954	0			
All ages—1954	62,520			
All ages—1964	49,703	—12,817	—20.5	—20.5

Table 3. Number of farm operators by age group in 1964 and in age group 10 years younger in 1954 and change in the number of operators in 1964 compared to number in 1954 10 years younger as percent of 1954 operator group and of all operators in 1954

Age—Year	Number of farm operators	Comparison of farm operators in 1964 with farm operators in 1954: with operators of younger age group — number change	with operators of younger age group — percent change	with operators of all ages — percent change
75 and over—1964	0	—7,234		—11.6
65 to 74—1954	7,234			
65 to 74—1964	6,016	—5,875	—49.4	—9.4
55 to 64—1954	11,981			
55 to 64—1964	10,583	—3,949	—27.2	—6.3
45 to 54—1954	14,532			
45 to 54—1964	13,224	—2,125	—13.8	—3.4
35 to 44—1954	15,349			
35 to 44—1964	12,221	+120	+1.0	+0.2
25 to 34—1954	12,101			
25 to 34—1964	6,578	+5,165	+365.5	+8.3
15 to 24—1954	1,413			
15 to 24—1964	1,081	+1,081		+1.7
Under 15—1954	0			
All ages—1954	62,520			
All ages—1964	49,703	—12,817	—20.5	—20.5

Percent Decrease 0 Percent Increase

membership if they were still farm operators. The bar representing the 45-54 group in 1964 in the left graphed portion of table 2 is dropped down in table 3 to be compared with the group 35 to 44 in 1954 because the same individual would belong to both these groups if he were farming in both census years. However, 13.8% of the 35 to 44 group who were operators in 1954 did not fill those positions in 1964. The loss of 2,125 comprises 3.4% from the loss for all ages of 12,817 (or 20.5%).

The right graphed portion of table 3 shows distribution of the drop of 20.5% in farms back through the age brackets. Gains at the younger age scale failed to offset the dropouts in the older age categories.

Farm operators can be divided into three main groups. The "younger" group members were 34 and younger in 1954. Mainly because of persons beginning or taking over operation of a farm when they were between ages of 25 and 34, the younger group had the effect of adding 10.2% to the number of farm operators during the decade.

The "middle-age" group was 35 to 54 in 1954, but none of them in 1964 was yet 65, a traditional age of retirement. These were many of the persons, who, aside from death, disability, and retirement, shifted to other occupations; or if they remained in farming, changed from operator to another status. Of the 29,881 operators 35-54 years old in 1954, a net number of 6,074 were not represented in that capacity 10 years later. They accounted for 9.7% of the state total, and 20.3% of their age group. It is not apparent how many died, became disabled, or retired, but it is reasonable to assume that most of them found non-farm employment.

The "older" farmers who were 55 and over in 1954 all would have been 65 and over in 1964. About 13,000 of 19,000 (68½%) did not continue as farm operators. Neither were they replaced by others of the same age beginning as operators, which would have been very uncommon for an advanced age group.

In total, the drop of 12,817 in numbers of farms and farm operators was 20.5% of the 63,520 operating farms in 1954. These figures, while historic, are nevertheless part of a continued current trend. The number of persons living in the household of farm operators in 1964 was 190,169, which compared to the total state population of 690,514 in 1960, was 28%.

People in younger age groups have an interest in planning careers, and older groups have needs in retirement. In addition, the decline in farms probably took out of agriculture most of the departing 6,074 operators in the middle age group because of reduced numbers of opportunities for farm operators through farm consolidation and the attraction of non-farm employment compared to farm jobs. They were committed to farming by training, experience, and investment. The needs of this group have not been clearly recognized.

Implications for Personal and Public Decisions

In looking ahead, what about the plans of, or for, the 24,730 farm

(concluded next page)

boys and 23,540 girls between the ages of 5 and 15 living on South Dakota farms in 1964? They will be making career choices in the next 10 years. Decisions affecting youth are long-lasting and important, yet certain key decisions will be made, or have already been made, by themselves or by others. To acquire an education that equips them for opportunities is their prime objective. Some of this group, now from 8 to 18, will be able to farm if they wish, although there is no assurance that 90%-95% of the farm managers of tomorrow will come from today's youth on the farm, as was the case yesterday. The rest will have vocational interests similar to non-farm youth.

Some youth may have adequate opportunity for a career in farm production. Expanded world-wide food requirements are forecast for the future. Additional persons may be attracted into farming prematurely, however, at a time when new technology is bringing forth abundant supplies of farm commodities.

On the other hand, some studies show the number of farms in some areas to be stabilizing, and questions are asked about the source of the next generation of farmers. The drain of people off the farm appears ultimately limited as farm population falls. However, for the next decade or two the trend seen the last 10 years is likely to continue.

Another concern is whether one-fifth of the present farm operators under age 35 will experience mid-career displacement from agriculture, as occurred from 1954 to 1964, with a resulting waste of acquired skills and need for investment in retraining programs in order to give them new skills. The record for South Dakota appears to be one of reduced entry into farming by the youngest age classes with the possibility, as a result, for greater chances to stay on as farm operators.

Action to improve the off-farm skills of middle aged farmers presently moving to non-farm employment is likely to be too late to help them appreciably. Some of these farmers may leave farming because non-farm jobs have attractive retirement programs.

Education systems for farm youth and adults have made farmers more efficient producers. Government farm programs were designed largely to offset some of the impacts from increased productivity. Both have helped people engaged in farm production more than people leaving the farm. A public obligation toward the latter individuals to help them find gainful full-time, off-farm employment may be as real as the obligation to improve the lot of those who remain on the farm.

The increase in non-farm employment in South Dakota in the past has not been enough to absorb people quitting farming. Hence, in order to find jobs, people leave the state. These persons can be retained in the state only by provision for employment, full-time or part-time, off the farm. Whether the shrink in farm jobs goes on or is stopped, state employment depends largely on the creation of new non-farm jobs.

The oldest group for whom planning is necessary, are those who retire from farm operation. Income protection, development of hobbies, and health care are among the concerns planners and social workers have for members of this group.

Adjustments associated with farm enterprises becoming larger and economically more efficient within a region of limited non-farm employment are costly, in dollars and in sacrifices of personal values and levels of living. There are also costs in planning for future needs of people. But the total cost can be reduced by anticipating changes and in preparing research plans, educational facilities, and government welfare programs to meet those needs. □

New Varieties of Small Grain

By **R. S. Albrechtsen,** associate professor of Agronomy; **J. J. Bonnemann,** assistant agronomist; **G. W. Buchenau,** associate professor of Plant Pathology; **D. G. Wells,** professor of Agronomy; and **L. S. Wood,** Extension plant pathologist

THE SMALL grains are many things.

To a botanist they are plants; to a plant breeder, a challenging organism to be studied and changed; to a pathologist, a disease problem. To the producer they mean income; to the processor, grist for the mill; to the freight handler, cargo; and to millions of people, life-giving food.

Improvement of small grains is slow, complex, but very rewarding. Annually in South Dakota *Farm & Home Research* newest varietal releases are described. Most of them originate in breeding programs in the North Central States. Description of a variety in this article, however, does not imply recommendation.

Complete *performance* data on all varieties and strains grown in the Standard Variety Nurseries throughout South Dakota in 1967 and the previous 4 years can be found in South Dakota Agricultural Experiment Station Circular 182, "1967 Small Grain Variety Trials."

Varieties of small grains and other crops *recommended* for 1968 are

given in the South Dakota Cooperative Extension Service Fact Sheet 382, "Field Crop Varieties Recommended for 1968." These publications are available at no charge from the Bulletin Room or the Agronomy Department, South Dakota State University, Brookings, or from your County Extension Agent.

SPRING WHEAT

Red River 68 is a hard red spring semi-dwarf widely publicized by a commercial group. The Agricultural Experiment Station has not had seed of this variety for testing so it cannot be recommended by the Station. It is said to be resistant to leaf and stem rust, high yielding and of high test weight. Tests of its milling and baking characteristics have been reported by the Crop Quality Council to reveal important shortcomings that make inadvisable the commercial production of this variety at this time, pending further testing or renewed breeding efforts to correct the faults in quality.

WINTER WHEAT

Scout 66 is a 1968 release of the University of Nebraska. It is similar to Scout but is more uniform in plant type. Thus it is resistant to stem rust and loose smut, susceptible to leaf rust, early maturing, and high yielding. Its winterhardiness is similar to that of Ottawa. While Scout 66 has not been yield-tested in South Dakota, it is recommended because of its similarity to Scout.

Parker, a new Kansas variety, is susceptible to stem rust, loose smut, and wheat streak mosaic but resistant to leaf rust. It is 4 days earlier than Ottawa and similar to Triumph in maturity. Parker is less winterhardy than Scout. It is of only fair quality. Parker's stem rust susceptibility, low level of hardiness, and extreme earliness make it unsuited for production in South Dakota.

Guide is a 1968 release of the University of Nebraska. Only a single year of testing has been made in South Dakota. It heads with Scout and is 1 to 3 inches shorter. Guide is less hardy than Scout. It is susceptible to leaf rust, loose smut, bunt and wheat streak mosaic and resistant to

Using a spray in the greenhouse for fall inoculation of wheat seedlings with wheat streak mosaic in plant disease research.

Oat Performance in South Dakota

	Yield, bushels per acre									Test weights, pounds per bushel		
Variety	Brookings* 66-67	Brookings* 65-67	Watertown* 66-67	Watertown* 65-67	Centerville* 66-67	Centerville* 65-67	Highmore† 66-67	Wall† 66-67	Bison† 1967	Brookings 66-67	Watertown 66-67	Centerville 66-67
Kelsey‡	115.3	110.0	69.6	87.7	69.0	73.4			59.1	33.6	33.8	30.8
Sioux	112.9	113.5	67.3	77.2	64.7	72.4	55.0	66.6	63.7	34.2	32.3	31.1
O'Brien	96.9	96.1	67.4	79.0	64.6	71.6	63.2	61.2	60.5	37.8	35.3	33.4
Holden	103.1	106.1	64.6	76.2	72.3	81.3	54.2	68.9	72.6	34.8	34.1	32.3
Portal	105.5	106.0	68.9	80.2	65.0	72.8	57.9	64.4	58.3	36.0	34.5	33.1
Jaycee	97.1	99.3	65.6	74.1	70.3	76.2	61.4	62.2	58.8	35.9	33.1	32.9
Dawn	99.4	96.4	56.8	69.8	66.7	70.8	58.7	57.4	59.1	36.1	33.5	31.8
Wyndmere	101.0		59.8		71.1		54.8	70.9	63.8	36.0	31.7	31.7
Orbit	112.1		68.4		67.6		69.2	78.6	72.6	33.4	30.9	29.6
Clintland 64	97.9	99.7	69.0	74.0	72.2	76.0	59.8	56.0	48.7	36.8	34.5	33.7
Andrew	99.4	96.6	67.0	76.2	70.3	77.4	75.1	63.1	72.9	35.4	34.4	32.2
Garry	102.3	104.8	61.7	71.8	58.3	60.5	53.1	56.7	67.9	35.1	33.1	29.2

*Averages from Uniform Midseason Oat Performance Nursery (UMOPN) data in 1965; Standard Variety Oat (SVO) data in 1967; UMOPN plus SVO in 1966.
†Averages from SVO data.
‡No SVO data for Kelsey in 1966.

stem rust. Not recommended without further testing.

Winter Wheat Performance at Highmore, 1967*

Variety	Protein %	Sedimentation cc	Lodging %	Test wt. lbs.	Yield bu.
Guide	13.7	64	0	62.3	39.4
Lancer	12.9	51	1	62.6	45.0
Hume	13.3	59	5	61.6	45.7
Minter	13.0	54	1	62.1	47.2

*Combined results of 2 tests each of 2 replicates in which Guide, Lancer and Hume appeared 3 times and Minter appeared once.

Winter Wheat Performance at Presho, 1967*

Variety	Protein %	Sedimentation cc	Lodging %	Test wt. lbs.	Yield bu.
Guide	14.2	60	0	62.2	37.4
Lancer	14.8	61	0	62.5	42.7
Minter	14.6	61	0	60.9	41.9

*A test of 4 replications.

OATS

Two new oat varieties, **Kelsey** and **Sioux** were released by the Canada Department of Agriculture in 1967. Seed of both varieties was increased by the South Dakota Foundation Seed Stock Division in 1967 for release to County Crop Improvement Associations in 1968. Both varieties are recommended in South Dakota for 1968.

Kelsey (C.I. 8171) is a high yielding, medium-late variety of medium height, test weight, and lodging resistance. It is similar to Garry in test weight, straw strength, stem rust, leaf rust and smut resistance. Kelsey has consistently yielded higher than Garry in South Dakota tests, has a higher groat percentage (kernel exclusive of the hull), slightly smaller kernels, is 1 to 2 inches shorter and 1 to 2 days earlier in heading and maturity.

Sioux (C.I. 8172) resembles Kelsey in its high yielding ability, maturity date, straw strength, groat percentage, stem rust and smut resistance. It possesses less leaf rust resistance than Kelsey, is 1 to 3 inches shorter and produces slightly larger kernels of lower test weight. Sioux has given consistently high yields in South Dakota and throughout the North Central Region and Canada. Both Sioux and Kelsey are best adapted under conditions of a long favorable growing season.

O'Brien is a new release from the Iowa Agricultural Experiment Station. It is tall, medium-early, has good straw strength and resistance to most races of stem rust, is susceptible to barley yellow dwarf (red leaf) and some of the newer races of leaf rust and is only moderately resistant to the Clintland race of loose smut. O'Brien produces large plump kernels of high test weight and groat percentage but has given only medium yields in South Dakota. It is not presently recommended but is being described here since seed will undoubtedly be for sale within the state.

Holden, **Portal**, **Jaycee**, **Dawn**, **Wyndmere** and **Orbit** were described in the Winter 1967 issue of *Farm & Home Research* but are included in the table of oat data since all are recent releases.

FLAX

Linott (C.I. 2522) is a new Canadian release. It has blue flowers, brown seeds, medium height, medium-early maturity, resistance to rust and wilt, moderate tolerance to pasmo. In a single year of testing in South Dakota it has produced high seed yields. The seed is high in oil content; oil is of good drying quality. Further testing in South Dakota is necessary before a decision can be made on recommendation.

Mac (C.I. 1910) was released by the Texas Agricultural Experiment Station to be grown as a winter variety in the northern flax-growing area of south Texas. It has outstanding frost tolerance after plants have progressed through the rosette stage of development characteristic of the winter types. Mac is short, early, resistant to rust but has only fair wilt resistance and pasmo tolerance. It has blue flowers and produces brown seeds which are good in oil content; oil is of average drying quality. Yields of Mac have been erratic in South Dakota but overall averages are lower than recommended varieties. Mac is not recommended for South Dakota.

Noralta was described in the Winter 1966 issue of *Farm & Home Research* but is included in the table of flax data since it is a recent release. □

Flax Performance in South Dakota

	Early Seeded*				Late Seeded†				Brookings+Watertown			
	Brookings		Watertown		Brookings		Watertown		Early	Late	Early	
Variety	1967	64-67	1967	64-67	1967	1965	1967	1965	1967	1967	1967	1967
	Bushels Per Acre										% Oil†	Iodine No.†
Linott	29.8		21.0		19.8		16.8		25.4	18.3	40.5	178
Mac‡	24.3	20.6	15.4	19.8		24.3		23.1	19.8			
Noralta	30.2	23.4	23.6	21.7	12.8	24.8	11.1	20.9	26.9	12.0	39.2	180
Redwood§	28.8	23.3	22.2	21.3	17.6	27.4	14.7	27.1	25.5	16.2	40.8	180
Summit§	29.0	23.4	23.4	22.7	20.0	27.0	18.3	24.2	26.2	19.2	39.8	180
Windom§	28.9	24.0	21.5	22.2	19.2	25.6	18.5	24.5	25.2	18.9	39.8	183
Bolley§	28.6	22.1	21.0	21.1	19.2	26.1	17.8	22.1	24.8	18.5	42.0	185
B-5128§	29.6	22.9	22.2	20.7	10.2	20.7	11.3	18.5	25.9	10.8	40.4	174

*Averages from Uniform Regional Flax Nursery (URFN) data in 1964 and 1965; from URFN plus Standard Variety Flax (SVF) in 1966 and 1967.
†Averages from URFN data only.
‡No URFN data for Mac in 1966 or 1967.
§Varieties recommended for growing in South Dakota in 1968.

AGING OF OUR LAKES

An Acute Problem in Lake Regions of North Central United States—Which Includes South Dakota

By **Richard A. Tubb,** former assistant leader, South Dakota State University Cooperative Fisheries Unit, and **Robert W. Sharp,** supervisor of fishery services, U. S. Bureau of Sport Fisheries & Wildlife

PONDS AND lakes are some of the most transitory physical features on earth. Any depression which holds water can become a lake, pond, or a marsh. Once formed, a lake is immediately in the process of being destroyed. Headward erosion of streams dissect the land and drain all lakes. Silt from erosion and debris from plants tend to fill in the basin and further enrich the waters.

Eutrophication is a term used by biologists to describe an enriched lake. Eutrophic lakes produce large populations of warm-water fish and provide excellent fishing. As eutrophication rates increase, the oxygen content in the lake decreases and spawning beds of game fish become laden with silt or debris. In a natural progression a lake becomes a marsh and finally a flat plain. The aging of lakes is a natural process and cannot be completely halted, but careful stewardship by man can prolong the life of our lakes.

Lakes Trap Nutrients

Lakes act as traps or catch basins for plant nutrients and organic material. Most of the nutrients coming into a lake are cycled through the plant, animal, and bacteria populations and retained in the lake. In many cases, phosphates and nitrates are the nutrients in greatest demand by the algae and vascular plants. Low levels of phosphates and nitrates normally limit the extent and duration of "algal blooms." If phosphates and nitrates are added to the lake, a spring bloom of algae can last all summer.

High populations of algae and vascular plants affect the lake in other ways. An algal bloom produces an excess of oxygen during the day, but uses large amounts of oxygen at night. In extreme situations nearly all the oxygen in the water may be removed by the algae during the night. Oxygen is also consumed in the decomposition of plant and animal remains by aerobic bacteria.

During the summer, differential heating causes many lakes to stratify. The surface waters warmed by the sun become lighter than the cooler bottom waters. Wind action is not sufficient to mix the upper waters (the epilimnion) and the lower waters (the hypolimnion), and stratification results. Organic material and decomposing plant and animals settle into the hypolimnion. Aerobic decomposition proceeds until the oxygen in the hypolimnion is depleted. Decomposition then proceeds by anaerobic bacteria. Under anaerobic conditions hydrogen sulfide, methane, and ammonia are produced in the hypolimnion. In fall the lake is mixed and the smell of the entrapped gases is quite evident. During the winter, ice prevents oxygen from diffusing into the lake, and aerobic decomposition may reduce the dissolved oxygen level in a lake and cause a winterkill of fish.

Reducing Silt, Nutrient Build-up

In order to decrease eutrophication rates in lakes, the amount of silt and nutrients entering the lakes must be reduced. The use of cover crops, terraces, and adequate vegetation in drainage ditches can aid in reducing the silt and nutrient load being carried by runoff waters. Fertilizer in runoff water will contribute to a heavy concentration of algae and aquatic plants. Cottage owners should be particularly careful in the installation and use of septic systems. Inadequate sewerage in lake cottages can add large amounts of phosphates and nitrates to a lake.

Very few cities or industries discharge waste waters into natural lakes, but the Great Lakes and many reservoirs receive substantial amounts of waste waters. Accelerated eutrophication rates have been the result. Some lakes with outlets have shown a recovery from an advanced state of eutrophication when waste waters were diverted from the lake.

A complete reversal of lake eutrophication cannot be economically achieved at the present time. Some of the undesirable side effects of enriched lakes can be temporarily controlled. Herbicides can decrease aquatic vegetation and pesticides can control populations of mosquitos and midge flies for short periods, but both require frequent applications. Some pesticides accumulate in lakes and are concentrated by fish and by man, if he, in turn, eats the fish. Harvesting aquatic plants and sport and commercial fishing remove some nutrients from a lake and slow the eutrophication process in a more natural way.

Artificial mixing of lakes by compressed air systems may slow the rate of eutrophication. Mixing eliminates lake stratification and allows aerobic decomposition to proceed through the lake. Mixing may cause

(concluded next page)

Effects of Water in Laundering Nylon Slips

By **Lillian O. Lund,** professor, SDSU; **S. Davison,** professor, University of Minnesota; and **Cora Sivers,** assistant professor, SDSU, all of Textiles and Clothing

DIFFERENT sources of water for home use are rain water, river water and well water. These may vary in composition.

Rain water is usually soft and acceptable for home laundering. When rain water falls it sinks into the ground and dissolves minerals as it flows through the soil. The amount of mineral matter that water will dissolve, and hence its degree of hardness, depends on the types of soil through which it passes. Water that seeps through a limestone deposit will dissolve a large amount of mineral and becomes hard, whereas water that passes through a granite-like solid will not dissolve much mineral matter and will be only moderately hard. Water that runs along the surface and finds its way into a stream does not dissolve as many minerals and therefore will not be particularly hard.

Cooperative Study

In certain areas of South Dakota and Minnesota the waters contain minerals that cause problems in laundering. A study to learn the effects of water on whiteness retention in home laundering is being conducted cooperatively by the South Dakota and Minnesota Agricultural Experiment Stations and Extension Services. Home Economics Agents in Moody County, S. D., and Nobles County, Minn., contacted and enlisted homemakers to cooperate in the study. Information was obtained on the sources of laundry water, plumbing and equipment. Based on this information, participants were selected.

Slips were selected as the garment to be used in a preliminary study because they are a staple item of apparel and require frequent laundering. The fabric selected for this study was nylon tricot (pronounced TREE-co), which is a knitted fabric commonly used for slips.

Few controls were established in the study since it seemed necessary to learn what the common laundry practices were and what results were obtained. Each time the homemakers laundered the slips they recorded the method, equipment and laundry products used.

Color Change Evaluated

The slips were worn at least one day between launderings. Each slip

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AGING LAKES . . .
(from page 25)

a reducation in organic content in some lakes. However, artificial mixing has not been helpful in all eutrophic lakes.

Newer Methods Expensive

Newer methods aimed at eliminating phosphates and other nutrients from waste water are being developed, but will be expensive. The best method of decreasing lake eutrophication rates is to keep all the excess silt, organic compounds, and plant nutrients out of lakes.

The problem of eutrophication is most acute in the lake regions of North Central United States and particularly in areas of concentrated human population. Two classic examples of accelerated aging in large lakes are Lake Erie and Lake Onandaga, near Syracuse, N. Y. Smaller lakes suffer a similar fate but are less likely to make headlines.

The problem is not unique to the United States; it has been studied in Europe and is of international concern.

While the normal aging process in lakes cannot be completely halted or reversed, it can be slowed down by good soil conservation practices on the watersheds and by well planned community action in sewage and industrial waste disposal. Individuals and groups who are concerned in this problem are urged to enter into community action programs designed to alleviate the situation as far as possible. □

was returned to the laboratory for evaluation after 5, 10 and 15 launderings. Visual means and measurement by instrument were used to evaluate color change such as yellowing and graying.

Each participant sent samples of water to the laboratory for analysis. These waters were analyzed for hardness minerals and iron.

The homemakers were instructed to wash the garments as they normally do in order to learn about their laundry customs and the effect these have on a given garment. Laundry records revealed that not only did the homemakers use a diversity of laundry products but often an individual used several products of the same type in one washing.

In most instances the slips grayed with continued use and laundering. One slip, which was laundered in soft water with home made soap and machine washed with no other laundry aids, retained its original whiteness throughout 15 launderings. The slip that grayed the most was hand washed using a mild liquid detergent. The slips laundered in the hardest water (33 and 47 grains) were the grayest after 15 launderings.

The slips washed in water of unusually high iron content did not show excessive changes. Laundry records for these slips indicated the water had been softened either mechanically or by package softener.

Severest Yellowing Problem

The severest yellowing problem occurred in a slip which discolored in the upper areas where the garment was apparently in direct contact with the skin. This garment was hand washed in mild detergent and the yellowing intensified with continued wear and laundering.

Although this was a pilot study and the number of participants limited, the results seem to indicate that machine washing with a built, or heavy duty, detergent was more effective in whiteness retention than hand washing with mild liquid detergent.

On the basis of this study further research is underway in Roberts County, S. D. ,and Itasca County, Minn., which are also water problem areas. For this work certain controls were established.

Other textile research cooperative between the two Agricultural Experiment Stations is concerned with carpeting composed of different fibers subjected to wear and cleaning, and blankets of differing fiber content and fabric structure. □

Reading whiteness of laundered fabrics on a reflectometer.

The Oahe Dam, an earth structure across the Missouri River about 5 miles upstream from Pierre, South Dakota, was constructed by the Corps of Engineers, Department of the Army, and forms a reservoir for the irrigation of thousands of acres in addition to its other uses. (Corps of Engineers Photo.)

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