MINNESOTA FEED SERVICE

University of Minnesota Agricultural Extension Service, St. Paul

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WANTED: MORE TESTED SWINE

Irvin T. Omtvedt

Large litters of fast growing, efficient, meaty market hogs mean greater profits for hog producers. Although the swine industry can be proud of the improvements made in the production of meat type hogs during the past few years, far too much of the pork produced today does not meet consumer acceptance.

Most estimates state that less than 30 percent of the hogs marketed qualify as desirable meat type. Production traits, such as rate and efficiency of gain, have also been improved, but hog producers still have a big job ahead. Their future depends on the job they do in selecting the boars and gilts who will contribute their genes to the next generation.

Research has proven that sound breeding and selection programs can bring about rapid improvements. But it is up to the individual hog producer to make use of these findings.

The axiom "First things first," becomes very important in deciding which traits to consider in a breeding program. A combination of many desirable traits is required. However, the more traits included in a selection program, the slower the rate of improvement in each trait. Most emphasis must be placed on the really important traits; less important traits must remain strictly in the background.

Economic importance and heritability must be considered when deciding which traits to select. The importance of improving traits which will increase a hog producer's profits the most needs no additional explanation. Basically, sow productivity, rate and efficiency of gain, carcass desirability, and soundness have the greatest economic importance.

Heritability means the extent to which a trait is inherited and is very important in determining the amount of improvement that can be expected. Heritability tells how much of the differences or variations existing between animals will actually be passed on to their offspring. Most emphasis should be placed on the more highly heritable traits to obtain greatest permanent improvement.

Heritability of a trait is usually referred to as being high, medium, or low depending upon the extent to which offspring resemble their parents and close relatives. Highly heritable traits can be changed considerably by selecting breeding stock on the basis of their own performance. The lowly heritable traits are influenced more by environmental factors such as management, nutrition, disease control, and sanitation and as a result this change is less permanent. The average heritability estimates for some of the more economically important traits in swine are listed in table 1.

Notice that most carcass traits have a relatively high heritability while sow productivity traits are quite low. This means you'd expect greater improvement by selecting for meatiness than by selecting for litter size. Feedlot traits are in the medium range but are high enough to permit reasonable improvement through selection.

Table 1. Heritability estimates

Characteristics	Average percentage
High heritability	
Carcass length	60
Backfat thickness	50
Loin eye area	50
Percent ham (based on carcass weight)	60
Percent fat cuts (based on carcass weight)	60
Medium heritability	
Feed efficiency	30
Growth rate (weaning to market)	30
Five-month weight	25
Low heritability	
Birth weight	5
Number farrowed	10
Number weaned	10
Weaning weight	15

The first step in any breeding program is to take inventory. A breeder must know what needs improving before improvement can be made.

The next step is to improve the weak points by locating and using superior individuals in the breeding program. This involves performance testing and record keeping.

To help producers identify superior individuals and strains, swine testing stations have sprung up all over the country. Some stations evaluate only boars, others only market pigs, and others evaluate both. Minnesota's testing programs were established in 1957 under the supervision of R. J. Meade, professor of animal husbandry at the University. The Minnesota Swine Producers' Association (Martin Annexstad, Jr., St. Peter, president), operates two testing stations, the Austin station, opened in the fall of 1957, and the New Ulm station, opened the following spring. These stations have a total capacity of 512 pigs (120 at Austin and 392 at New Ulm).

Since 1957 the interest in testing has steadily increased; last year 101 Minnesota breeders tested 724 pigs at the two stations. In 1961 the University's Agricultural Extension Service accepted supervision of the evaluation programs with Glenn Ryberg as supervisor. Presently the author supervises testing programs at both station.

Minnesota's testing programs are designed to evaluate the strong and weak points in overall performance and then to assist in identifying superior stock that can be used effectively to correct weaknesses in the breeding program.

(Continued on page two)

Assistant professor and extension animal husbandman.

Swine Testing— *. . . from page one*

Most breeders participating in the testing programs prefer the standard market pen entry. This entry is designed for both commercial and purebred producers and consists of four market pigs sired by the same boar with not more than two pigs from any one litter.

Pigs are delivered to the testing station weighing between 40 and 55 pounds and are started on test when the four average 60 pounds. The four pigs are penned together until they weigh 200 pounds. Each pig is slaughtered at approximately 200 pounds and complete carcass information is obtained. At the end of the test a breeder receives a complete performance report for his pigs. This report, prepared by the University's extension animal husbandry office, contains comments about the results and suggestions concerning the producer's breeding program.

To promote the use of performance tested breeding stock and to inform the swine industry as to who might have production tested stock available, a bimonthly newsletter (circulation about 2,000) is sent to all members of the Minnesota Swine Producers' Association.

A few boars are also tested at the stations each year. Boar entries consist of four boars and a companion entry of four market pigs sired by the same boar. The market pigs must be littermates to the boars and the pigs must come from at least two different litters. The four boars are fed together in one pen and the four market pigs are fed together in an adjoining pen. The companion pen is managed in the same manner as the standard market pen entry. Individual rate of gain, probe backfat thickness, and average efficiency for the pen of boars are also obtained at the end of the test.

Boars meeting minimum standards of 1.7 pounds per day average daily gain, 300 pounds or less feed per hundredweight gain, and 1.3 inches or less probed backfat at 200 pounds may be returned to the breeder or sold in an auction of performance tested boars.

Table 3. 4-year Duroc summary, Minnesota swine testing stations

	1959	1962	Change
Number of pigs	65	88	+23
Average daily gain, pounds	1.89	1.84	−.05
Age at 200 pounds, days	148	152	−4
Feed per cwt. gain, pounds	311	294	+17
Carcass length, inches	29.0	29.8	+0.8
Backfat, inches	1.65	1.54	+0.11
Loin eye area, square inches	3.51	4.05	+0.54
Percent ham and loin of liveweight	23.6	25.5	+1.9

Tested boar sales are held in the spring and fall following each testing season. Both qualifying station tested boars and on-the-farm tested boars are offered at these sales.

On-the-farm tested boars must be either littermates or half brothers to pigs tested at the Minnesota Swine Evaluation Stations during the past year. They must weigh at least 200 pounds in 165 days, probe 1.2 inches or less backfat at 200 pounds, and the market pen at the testing station must have required not over 325 pounds of feed per hundredweight gain. In 1962 181 tested boars were sold at these sales for an average of $154.86.

Since spring 1959, market pen regulations and station rations have remained unchanged. Table 2 compares the overall averages for that season with the spring 1962 season.

Considerable progress has been noticed in both numbers and quality of pigs evaluated at the stations. The fact that 178 more market pigs were tested in 1962 than in 1959 indicates that breeders are beginning to recognize the importance of production information. Pounds of feed required per hundredweight gain decreased 6 pounds during this period and rather marked improvement was also noticed in carcass quality.

Since Duroc breeders tested the most pigs in 1959, their averages are given in table 3 to illustrate effectiveness of testing for making improvement.

Most breeders feel that a weight of 200 pounds in 5 months (154 days) is a good goal for rate of gain. Since the Durocs tested already met this goal, it is apparent that their selection emphasis has been shifted to other areas.

Table 2. 4-year summary, Minnesota swine testing stations

	1959	1962	Change
Number of pigs	271	449	+178
Average daily gain, pounds	1.75	1.77	+0.02
Age at 200 pounds, days	155	155	0
Feed per cwt. gain, pounds	311	305	+6
Carcass length, inches	29.6	30.0	+0.4
Backfat, inches	1.56	1.51	+0.05
Loin eye area, square inches	3.93	4.21	+0.28
Percent ham and loin of liveweight	24.8	25.9	+1.1

Since 1959 the feed requirement per hundredweight gain has been reduced by 17 pounds. Although this increased feed efficiency appears rather minor it represents a feed saving of 34 pounds on every 200-pound hog marketed. Assuming that feed costs 3 cents per pound, the producer saves $1.02 in feed costs on every pig marketed.

Changes in carcass meatiness are even more striking—an increase of 0.8 inch in length, 0.54 square inch in loin eye area, and 1.9 percent in percent ham and loin. Backfat thickness was also reduced by 0.11 inches.

On the basis of backfat thickness the average 1959 Duroc would have graded No. 2 and would not have met lean meat certification standards with respect to backfat thickness or loin eye area. However, the average Duroc tested in 1962 met certification standards and graded No. 1.

More pounds of the higher priced cuts of meat increases carcass value. Since the hams and loins are the two most valuable cuts of pork, hog producers are interested in getting a greater portion of their carcass weight in these two cuts. The 1.9-percent increase in ham and loin yield is equivalent to 3.8 pounds more ham and loin in a 200-pound market hog. Figuring the wholesale price for ham and loins at 42 cents per pound and lard at 8 cents per pound, and assuming that the increased ham and loin weight replaces lard, this increase is worth $1.30 per hog marketed ($1.60 − .30 = $1.30).

A good breeding program permits producers to full-feed their hogs and still supply the quality product homemakers demand.

Testing stations alone cannot meet consumer challenges. Only a few individuals from a herd can be evaluated at a testing station and they may not be a true representative sample of the entire herd. This emphasizes the need for testing as many pigs as possible year after year. An effective breeding program involves on-the-farm testing combined with station testing. The key to progress depends on how effectively breeders use their records to select parents of the next generation.

CALCIUM AND PHOSPHORUS NEEDS OF TURKEYS

Paul E. Waibel

The turkey has been thought peculiar among poultry in having an apparently high requirement for calcium and phosphorus. The National Research Council (NRC) indicated in 1954 that the turkey required 2 percent calcium and 1 percent phosphorus (0.50 precent inorganic phosphorus from 0 to 16 weeks of age). In 1960 the NRC listed the same starting requirements, but between 8 and 16 weeks the requirements are reduced to 1.70 percent calcium and 0.85 percent phosphorus. This compared to 1.0 percent calcium and 0.6 percent phosphorus needs of the chick.

The high requirements suggested for turkeys were based on results which appeared in the 1940's. In examining the data, it appears that considerably less calcium and somewhat less phosphorus were probably acceptable, especially when the levels of these elements were decreased simultaneously.

Crookston Studies

Studies conducted at the Northwest Experiment Station, Crookston, gave evidence that satisfactory roaster turkeys needed considerably less calcium and phosphorus than suggested by NRC, especially during the growing period.

Table 1. Calcium and phosphorus levels in Crookston study

Age of turkey	Calcium	Phosphorus Total	Phosphorus Inorganic
weeks	percent of total diet		
8 to 14	1.24	0.75	0.50
14 to 20	0.89	0.58	0.35
20 to 24	0.62	0.48	0.25

So an experiment was established where the calcium and phosphorus levels indicated in table 1 (low by comparison with NRC standards) were fed to the turkeys in a complete feeding program.

Data from this experiment (table 2) show that turkeys which received the modified low calcium-low phosphorus ration actually gained somewhat more weight during the experiment, regardless of whether they were on range or in confinement. There were no apparent leg weakness problems in any of the treatments. Tibia ash was just as high with the modified rations as with the regular control ration.

Other Recent Studies

Nelson at al. (1961), of Washington State University, reported that they were able to produce satisfactory turkeys from 8 to 24 weeks of age on a ration containing 0.6 percent calcium and 0.6 percent total phosphorus.

Sullivan of Nebraska reported that male and female Broad Bronze turkeys between 8 and 20 weeks required 0.85 percent and 0.75 percent phosphorus, respectively. He used an assay diet containing 1.55 percent calcium which may account for the somewhat higher phosphorus requirement. Blaylock and associates, of International Milling Co. (1961), found that 0.80 percent calcium and 0.80 percent phosphorus produced good growth and feed utilization during the 0 to 24-week age period. They reported that the calcium: phosphorus ratio was quite critical, especially at marginal levels of phosphorus. In these cases better performance could be achieved by keeping the calcium level quite low.

Turkey Breeders

Little work has been done on the calcium and phosphorus requirements of breeding stock, but Minnesota trials have shown the voluntary calcium consumption of turkey breeder hens receiving complete feeds (except calcium) containing approximately 1.3 percent calcium and free choice of oyster shell to be as follows:

- Breeders receiving a corn-soybean meal diet consumed 2.47 percent calcium.
- Breeders receiving a diet of higher energy containing 5 percent fat consumed 2.63 percent calcium.
- Breeders receiving a low energy diet containing 25 percent oats, 15 percent wheat standard middlings, and 10 percent wheat bran consumed 3.08 percent calcium.

Calcium intake with the low energy diet was significantly higher than that of the corn-soybean meal diet, although considerably more feed was also eaten by birds receiving the low energy diet.

Recently workers at Washington State University have indicated that the calcium requirement of breeders may not be more than 1.75 percent of the diet, but these results require confirmation.

Wilcox et al. (1957, 1961), of South Dakota, obtained responses in egg production, hatchability, and egg size by adding inorganic phosphorus to a purified diet containing 0.06 to 0.08 percent phosphorus. With a practical diet containing 0.34 percent total phosphorus, apparently satisfactory egg production, fertility, and hatchability resulted. From these studies the phosphorus requirement of a laying turkey hen was estimated between 0.25 and 0.43 percent total phosphorus.

The calcium level recommended in our departmental publication entitled "Turkey Rations"[1] is 2.27 percent calcium in a complete ration. Total phosphorus level in this ration is 0.66 percent; inorganic phosphorus level is 0.46 percent.

Related Nutritional Requirements

Vitamin D—Studies conducted decades ago indicated that calcium levels could be reduced if sufficient vitamin D was present in the diet (calcium requirement increases with vitamin D deficiency). Some of the earlier high calcium requirements may have been caused by vitamin D stability problems in the assay diets. With the more recent lower levels of calcium, turkey

[1] Available on request from the Department of Poultry Science, Institute of Agriculture, University of Minnesota, St. Paul 1, Minnesota.

Table 2. Growth and bone ash of growing turkeys from 8 to 24 weeks of age

Treatment	Weight at 24 weeks Males	Weight at 24 weeks Females	Weight at 24 weeks Average	Pounds feed per pound of gain	Bone ash
	pounds				percent
Confinement:*					
Regular	22.6	15.0	18.8	4.78	63.9
Modified	23.2	15.8	19.5	4.54	64.8
Range:†					
Regular	25.3	16.4	20.8	4.25	
Modified	25.9	16.8	21.4	4.21	

* Each 15 x 17 foot pen contained 25 male and 25 female turkeys.
† Each 1 acre brome pasture lot contained 50 male and 50 female turkeys.

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rations should be formulated to contain approximately 800 I.C.U. of vitamin D per pound.

Dietary energy—The requirements listed for calcium and phosphorus should be satisfactory for corn-soybean meal type diets. However, if energy level is increased it is wise to increase the levels of calcium and phosphorus proportionally.

Dietary fat—Studies conducted in our department have shown that one advantage of using the lower calcium levels with turkeys is that added saturated fats yield a greater amount of metabolizable energy. By similar reasoning, if high levels of saturated fats were fed—above 5 percent of the diet—the calcium level probably should be raised somewhat, due to formation of indigestible calcium soaps.

Other minerals—The increased requirement for zinc and other nutrients with high calcium diets is well documented in a number of species. Excessive calcium will also increase phosphorus, manganese, and iodine requirements. Dietary calcium must be kept in proper balance with other nutrients.

Potentiation—A further advantage of using reduced calcium levels in formulation is more efficient use of the tetracycline-type antibiotics, such as Aureomycin and Terramycin. If a potentiated feeding program is required, it appears feasible and safe, for short periods of time (such as 1 week), to reduce calcium levels shown in table 3 to the same level as phosphorus. Thus a 1 to 1 ratio would be employed during the potentiation program.

Table 3. Suggested calcium and phosphorus allowances for growing turkeys

Age of turkey	Calcium	Phosphorus Total	Phosphorus Inorganic
weeks	percent of total diet		
0 to 8	1.2	0.85	0.55
8 to 14	1.0	0.75	0.50
14 to 20	0.80	0.70	0.45
20 to 24	0.60	0.60	0.35

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NEEDED: A QUALITY FORAGE PROGRAM

William F. Hueg, Jr.

A year ago *Minnesota Feed Service* reported results of 2 years' date and frequency of forage cutting demonstrations in Minnesota. Originally established as a 3-year project, the demonstrations were completed during 1962. Data gathered by cooperating county agents and branch experiment station researchers conclusively point to the value of a sound forage crop management program by each farmer.

As a dealer in agricultural supplies you can help yourself and your customers by promoting a forage management program that leads to extra profit from every forage acre. A successful forage program develops from careful planning—including the right crop variety, adequate lime and fertilizer, and appropriate use of herbicides and insecticides.

You may see to it that your customers invest in good seed, lime, fertilizers, and chemicals. But they will miss the mark if they fail to adopt good management practices. The difference between top profits and just breaking even may depend on how early they harvest and how well they handle their forage crops for hay and silage.

Each day of delay changes plant composition by lowering protein and total digestible nutrients (TDN) and increasing fiber. These daily changes rapidly reduce the feeding value of forage. Early cutting may produce less total forage from each acre, but the improved quality means extra dollars from livestock feeding because of better use of the forage. Table 1 shows the composition of alfalfa-grass mixtures for protein, fiber, and TDN.

The date and frequency demonstrations covered Minnesota from the southeast corner to the extreme northwest (see map). The percent composition for each of the quality factors was in close agreement for any given date regardless of location.

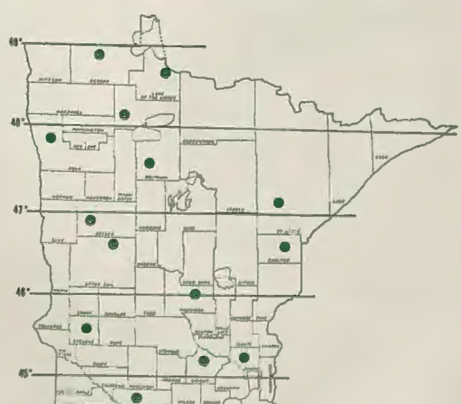
The greatest change in forage quality is in the first crop, and variability is wide when compared to changes in the second and third crops. During the first 2 weeks of June fiber increases rapidly. About 60 percent of the total increase is during this period. The increased fiber markedly affects TDN.

Of the total change in TDN, 56 percent is during the first 2 weeks of June. Of the total change in protein, about 50 percent is during this 2-week period.

Forage digestibility declines about one-half of 1 percent each day after June 1. Because of increased forage, the intake of forage decreases at least one-half of 1 percent for each day delay. Data in table 1 support the rule of thumb that states, **"For each day delay in harvest after June 1, the feeding value of first crop forage decreases 1 percent per day."** Quality deterioration is rapid and goes on at about the same rate for any given date and location in Minnesota. That is why it pays to avoid harvest delays.

Yield data was also obtained from these demonstration, and two-time and three-time cuttings were compared. Table 2 shows the 3-year average for dry matter, protein, and TDN from the 19 demonstrations. Compare the production of TDN from the alfalfa-brome mixtures (table 2) with that produced from corn. Have you ever considered that alfalfa-brome might be this valuable as a feed? When early cut and properly handled it can be an excellent souce of both high protein and high energy.

(*Continued on page five*)



Heavy lines across map indicate degrees latitude; dots show 19 locations of date and frequency of cutting demonstrations, 1960-62.

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Forage— *. . . from page four*

Compare treatments I and II with treatment IV and note the marked improvement in forage quality. This improved quality is shown by yields of 200 to 300 pounds more protein or 300 to 600 pounds more TDN per acre from three cuttings. This extra protein or TDN will more than pay for the extra trip over the field. These figures clearly illustrate that total yield of forage per acre is a poor basis for determining the success of any forage program.

The total number of acres of forage to be harvested in any one cutting dictates the starting time to harvest the crop at highest quality. Harvest plans should be such that all of the first crop is under cover by mid-June.

The extra protein and TDN as a result of earlier cutting increases the dollar value of forage. If forage harvested in treatment IV is worth $20 per ton as hay and extra protein is worth 10 cents per pound, treatment I or II hay is worth $26 to $29 per ton. With 3-ton per acre yields this improved quality means $18 to $27 more income from each forage acre. This extra value is best realized when the forage is fed to livestock.

- The extra protein and TDN from these cuttings mean more animal production; 300 pounds of protein and 400 pounds of TDN will produce approximately 1,000 pounds of milk. At 3 cents per pound this is $30 extra income from each acre of early-cut forage.

- Farmers who get greater returns from forages by adopting an improved cutting schedule are better customers for quality seed of superior varieties, fertilizers, insecticides, and other supplies needed for high yields and profitable production. Improved forage acres means improved cash position and could remove some farmers from your credit list.

- Using preemergence herbicides with row crops may mean earlier first crop harvest by delaying the first cultivation. Herbicide cost will be covered adequately by improved forage quality. Corn and soybean yields may be boosted by eliminating weeds when they are most demanding.

- Extra equipment, such as field conditioners, mow drying systems, or a new silo to handle hay crop silage, may be needed to accomplish early cutting. Based on 100 tons of hay equivalent (1 ton of good hay equals 3 tons of good silage), 6 to 9 acres of hay-crop forage producing 3 tons per acre will meet the annal cost of such equipment. This equipment further assures high quality forage due to reduced leaf loss.

- When commercial fertilizer is used on forage crops three-time early cutting should be adopted. Fertilizer can't do the job by itself. But used in combination with timely harvest, it can bring you more pounds of protein and TDN from each forage acre.

Management changes can mean extra profits from each forage acre in Minnesota. As a dealer you gain from a more prosperous agriculture.

Promoting a quality forage program is good business.

Table 1. Composition of alfalfa-grass mixtures harvested at different dates and growth stages, average of 19 locations in Minnesota, 1960-62.

Cutting date and stage of growth	Composition, percent		
	TDN*	Fiber	Protein
1st cutting			
June 1 (prebud)	68.4	25.8	20.0
June 14 (late bud-1/10 bloom)	60.3	32.2	16.6
June 23 (½ bloom)	57.4	34.5	15.1
July 1 (full bloom-mature)	54.0	37.0	13.2
2nd cutting			
6-8 weeks regrowth	59.0	32.3	16.7
3rd cutting			
5-6 weeks regrowth	67.0	27.1	19.2

* TDN is calculated by formula from protein and fiber.

Table 2. Effect of date and frequency of cutting on dry matter yield, protein and TDN per acre—average of 19 locations in Minnesota, 1960-62

Treatments		Cutting dates	Dry matter per acre	Protein per acre	TDN per acre*
			tons	pounds	pounds
I	3X early	June 1, July 15, August 31	3.4	1,295	4,435
II	3X medium	June 14, July 26, August 31	3.8	1,382	4,770
III	2X late	June 23, August 15	3.6	1,105	4,125
IV	2X very late	July 1, August 31	3.8	1,059	4,160

* The TDN in this forage is equivalent to 98, 106, 92, and 92 bushels of No. 2 corn respectively. Protein is 2½ to 3 times greater in forage than in corn.

PROFIT POSSIBILITIES WITH FERTILIZER ON CORN

C. J. Overdahl, J. L. App, J. Grava

Most everyone enjoys a look at possibilities for increased profit. Yet while numerous reports of field fertilizer trials show yield increases, few show the effect on net profit. Considering the increased production cost, the net return may not always be as satisfactory as yield increase alone might indicate.

In 1961 extension specialists in soils and farm management, soil testing personnel, county agents, and the fertilizer industry teamed up to obtain massive field data from various rates and placement of nitrogen (N), potassium (K), and phosphorus (P) on soils of the corn growing area at various original fertility levels. Except for broadcast treatment of K in the eastern portion of the state and P in western Minnesota, the design was the same for all plots. County extension agents or vo-ag teachers established, tended, and harvested the plots.

Often averages give a more accurate overall picture than individual plots. Too often, however, important facts regarding special soil conditions, soil management, and weather differences are masked out when plot results are used in averages. In order to narrow the differences table 1 shows fertilizer profits on corn only from fields that test less than high in P and K, the soils where greater fertilizer profits would be expected. Table 1 also shows simple relationships between cost and returns. Numerous small costs enter under various yield response situations, but are not included. No evaluation could be made of probable carryover benefits with the plot design used.

Where soils tested high in P and K only small yield increases were obtained and profits were greatest from low rates.

Starter fertilizer alone appears to give the largest return per dollar invested but not necessarily the highest profit. The eastern portion of the state shows the greatest profit from the combination of starter, broadcast potassium, and sidedressed nitrogen (table 1). Larger profits are obtained from the broadcast K if there is carryover bene-

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Table 1. 1962 profits in the eastern portion of Minnesota with medium phosphorus and low potassium soil tests, (8 fields, excludes sands and sandy loams); and in western Minnesota with low phosphorus and medium potassium soil tests (15 fields).

Treatment*	Yield	Increase over check	Fertilizer Cost	Fertilizer Net profit	Fertilizer Return/dollar	Labor and management return/acre
	bu./acre					
Eastern Minnesota						
Check	73					$23.00
Starter	90	17	$ 7.10	$ 9.90	$ 2.40	32.90
Starter + N	101	28	14.80	13.20	1.89	36.20
Starter + N + broadcast K	106	33	18.80	14.20	1.88	37.20
Western Minnesota						
Check	66					21.00
Starter	82	16	7.10	8.90	2.26	29.90
Starter + N	93	27	14.80	12.20	1.85	33.20
Starter + N + broadcast P	95	29	18.80	13.20	1.54	31.20

* Starter was 200 pounds per acre of 5-20-20; N was 70 pounds per acre sidedressed; broadcast K was 80 pounds per acre of K_2O, broadcast P was 40 pounds per acre of P_2O_5.

Table 2. Profits from individual nutrients N, P, and K as listed table 1, 1962.

Nutrients, pounds per acre and placement	Yield increase over no treatment	Added nutrient cost per acre*	Added value	Return over no treatment	Return per dollar spent for fertilizer
	bu./acre				
Eastern Minnesota					
Nitrogen 70 sidedressed	11	$ 7.70	$ 11.00	$ 3.30	$ 1.43
Phosphorus 40 P_2O_5 row	7	4.00	7.00	3.00	1.75
Potassium 40 K_2O row	10	2.00	10.00	8.00	5.00
80 K_2O broadcast	9	2.00	—1.00	5.00	2.25
120 K_2O (40 row + 80 broadcast)	15	2.00	6.00	9.00	1.66
Western Minnesota					
Nitrogen 70 sidedressed	11	7.70	11.00	3.30	1.43
Phosphorus 40 P_2O_5 row	10	4.00	10.00	6.00	2.50
40 P_2O_5 broadcast	8	4.00	—2.00	4.00	2.00
80 P_2O_5 (40 row + 40 broadcast)	12	8.00	2.00	4.00	1.50
Potassium 40 K_2O row	7	2.00	7.00	5.00	3.50

* Note that where more than one rate per acre is used the added cost is that over the preceding lower rate. For example, the 120 pound-per-acre rate of K_2O costs a total of $6 per acre.

fit on next year's crop. These plots represent all fields testing medium in phosphorus and low in potassium.

Yields were lower in western Minnesota but increases were similar to the eastern part of the state (table 1). For this area it appears that starter fertilizer and sidedressed nitrogen was more profitable than treatment with additional phosphorus broadcast. In some individual cases this was not true. Six of 15 fields in western Minnesota showed higher profits from the additional broadcast phosphorus in the year applied; others could possibly move into the profit category from carryover benefits. These data are from fields testing low in P and medium in K. Table 2 gives an evaluation of individual nutrients according to rates and placement that contribute to the yield increases found in table 1.

Table 3 shows summaries for all fields regardless of soil test level according to general soil areas of the state for 1961 and 1962. Approximate fertilizer costs are shown in the column on the right. To estimate profit subtract this cost from the yield increase. Yield increase and gross dollar return are equal when corn is valued at $1 per bushel. The fairly large number of fields at various soil test levels represented in each category indicate what is happening throughout the state regarding fertilizer response and the corresponding profits.

More detailed information is presented in two publications, *Soil Series 65* (1961 results) and *Soil Series 67* (1962 results). In these publications profit estimates are calculated for the best treatments of each individual plot as well as for each nutrient and nutrient level within each plot. Single copies of each of these booklets can be obtained by writing to Extension Soils Specialists or Extension Farm Management Specialists at the Institute of Agriculture, St. Paul 1, Minnesota.

Table 3. Yield increases by treatment and by years in 4 major soil areas of the state, 1961 and 1962.

	Southeast Fayette, Skyberg Lester, etc. 1961	1962	South-central Clarion-Nicollet-Webster soils 1961	1962	West Barnes-Aastad and Moody soils 1961	1962	East-central Zimmerman, Isanti, other coarsely textured soils 1961	1962	Fertilizer cost
Number of fields	14	19	15	14	17	11	9	5	....
Yield with no treatment, bu/acre	91	80	87	78	68	75	55	83	....
Average yield increases, bu/acre with:									
Starter	16	8	11	21	4	11	8	5	$ 7
Starter + N	26	19	23	25	9	20	25	19	15
Starter + N + broadcast P or K	27	22	29	41	12	18	34	20	19

Southeast and east-central areas had broadcast potassium. South-central and west areas had broadcast phosphorus. These treatments are given in table 1. Subtract fertilizer cost from yield increase for profit estimates for individual treatments.

AGRICULTURAL EXTENSION SERVICE
Institute of Agriculture
University of Minnesota
St. Paul 1, Minnesota

SKULI RUTFORD, director. Cooperative agricultural extension work, acts of May 8 and June 30, 1914.

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