



Corn production as affected by rates of nitrogen and phosphorus fertilizer at three locations in Montana
by Donald Macer Erb

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of
MASTER OF SCIENCE in Soils

Montana State University

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Abstract:

Field experiments involving 15 levels of N in combination with 2 of P, on irrigated corn, were conducted at Bozeman, Huntley and Columbus, Montana. The corn was harvested as silage at Bozeman and Columbus.

Silage and grain yields were recorded at Huntley. The harvested portion of the crop was analysed for protein and P content. The 3rd leaf from the plant base was sampled at various dates during the growing season for protein analysis. Soil samples were taken at each location prior to fertilization.

The Bozeman Experiment: Soil analysis revealed low levels of organic matter and available P at this location. Nitrogen at the rate of 47 pounds per acre increased silage production 4.5 tons per acre. Silage protein content was increased 4.4 percent, on the dry matter basis, by N application at the rate of 2.4 pounds per acre. During the last half of the growing season the protein content of the 3rd leaf increased with N rate and decreased with time. Silage P content was increased by N fertilization when P was not added. Phosphorus fertilizer did not significantly influence yield, protein content or P content of plant material.

The Huntley Experiment; Fertilization with N and/or P had no significant effect upon yield or P content of silage or grain. Nitrogen at the rate of 45 pounds per acre increased protein contents of silage 1.3 percent and grain 1.4 percent. The protein content of the 3rd leaf varied with N rate and date of sampling, but was not significantly influenced by P fertilization. Soil tests indicated a high level of available P and a low level of organic, matter at this location.

The Columbus Experiment: Nitrogen and/or fertilizer did not significantly affect yield, protein content or P content of plant material. The protein content of the 3rd leaf varied with date of sampling. Soil analysis indicated low levels of organic matter and available P at this location.

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ABSTRACT

Field experiments involving 15 levels of N in combination with 2 of P, on irrigated corn, were conducted at Bozeman, Huntley and Columbus, Montana. The corn was harvested as silage at Bozeman and Columbus. Silage and grain yields were recorded at Huntley. The harvested portion of the crop was analysed for protein and P content. The 3rd leaf from the plant base was sampled at various dates during the growing season for protein analysis. Soil samples were taken at each location prior to fertilization.

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Soil analysis revealed low levels of organic matter and available P at this location. Nitrogen at the rate of 47 pounds per acre increased silage production 4.5 tons per acre. Silage protein content was increased 4.4 percent, on the dry matter basis, by N application at the rate of 2.4 pounds per acre. During the last half of the growing season the protein content of the 3rd leaf increased with N rate and decreased with time. Silage P content was increased by N fertilization when P was not added. Phosphorus fertilizer did not significantly influence yield, protein content or P content of plant material.

The Huntley Experiment:

Fertilization with N and/or P had no significant effect upon yield or P content of silage or grain. Nitrogen at the rate of 45 pounds per acre increased protein contents of silage 1.3 percent and grain 1.4 percent. The protein content of the 3rd leaf varied with N rate and date of sampling, but was not significantly influenced by P fertilization. Soil tests indicated a high level of available P and a low level of organic matter at this location.

The Columbus Experiment:

Nitrogen and/or fertilizer did not significantly affect yield, protein content or P content of plant material. The protein content of the 3rd leaf varied with date of sampling. Soil analysis indicated low levels of organic matter and available P at this location.

INTRODUCTION

"Corn growing in Montana has passed through an era of rapid expansion during the past fifteen years and this crop has become of much importance in the agriculture of the State. The acreage in corn increased from 16,000 acres in 1910 to 42,000 acres in 1924, the largest increase occurring during the last five years of this period. While by far the larger part of this acreage is on the dry lands, the crop is increasing in importance in the irrigated valleys of the corn-growing sections of the State" (11). This introductory paragraph taken from an early Montana Agricultural Bulletin presents a very brief description of the early trends in corn production in Montana.

Trends since that time are best shown graphically. Figure I shows the total acres of corn harvested in Montana and the acres utilized for grain, silage, and grazing or forage by year from 1929 through 1963 (27, 28, 29, 30). In 1929, the largest portion of the total corn acreage was utilized as grazing and forage. Grain ranked second and silage third. Although acreages fluctuated considerably during the years that followed the same ranking held true until 1949, when the acreage of corn utilized for silage exceeded that used for corn grain. From 1949 through 1959, grazing and forage ranked 1st, silage 2nd, and grain 3rd. In 1960, the acreage harvested for silage surpassed that utilized as grazing and forage. Grain ranked third. This trend still existed in 1963. It is interesting to note that the acreages utilized for grain and for silage in 1957 are almost an exact reversal of the 1941 figures. The total acreage of corn in the State has declined rapidly since 1955.

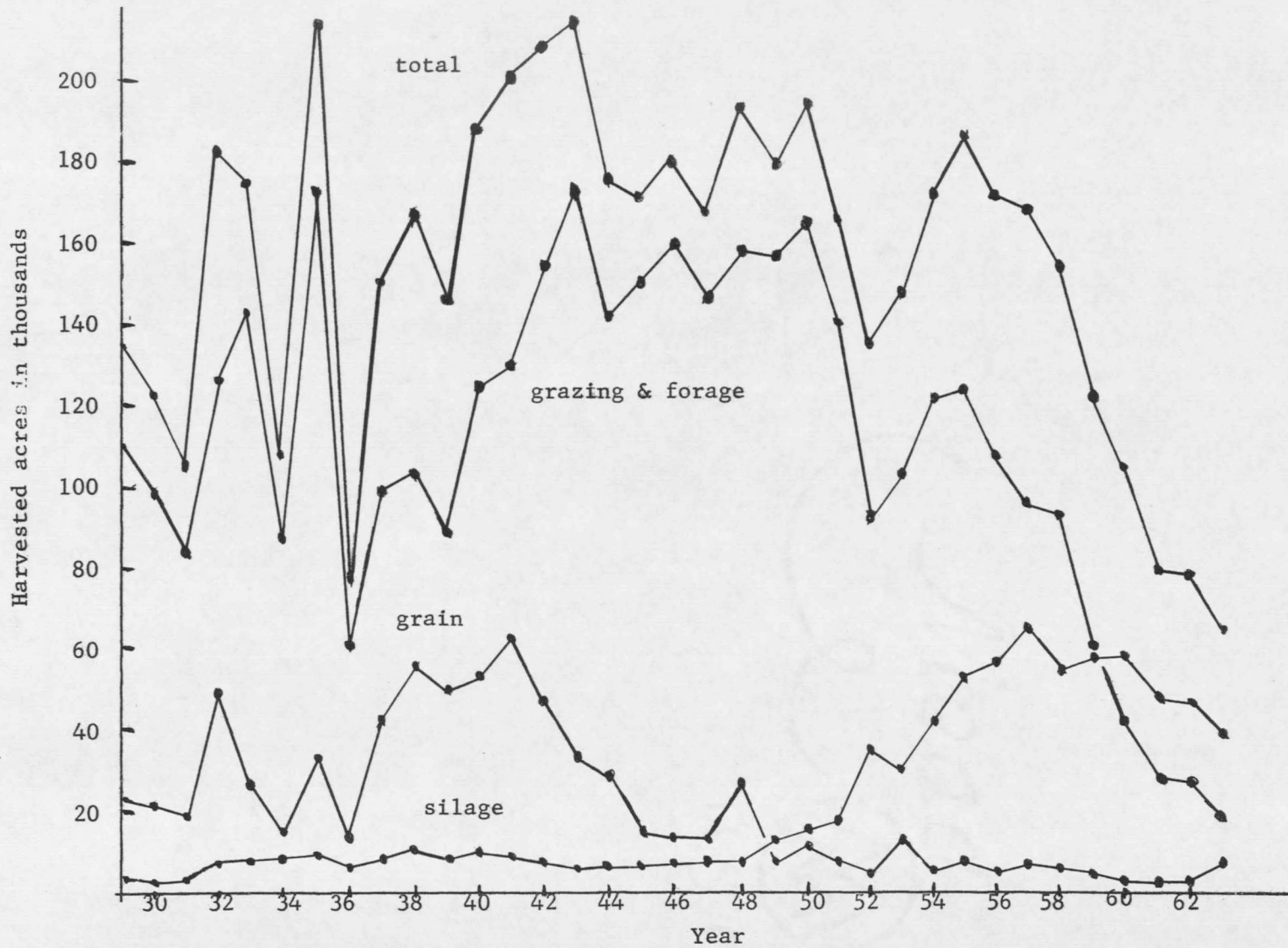


Figure I. Total acres of corn harvested and acreage utilized for silage, grain, and grazing or forage in Montana, 1929-1963.

In terms of utilization this decline is exhibited primarily in acreages utilized for grazing and forage. Acreages and the mean yields of irrigated corn harvested for silage in Montana for the years 1948 through 1963 are given in figure II. (29, 30). Acreages of irrigated silage corn increased rapidly during the fifties. The acreage harvested in 1963 was over 5 times that of 1948. In 1948, there were 4,400 acres of irrigated corn harvested as silage which represented 2.3% of the total corn acreage. In 1963, there were 23,200 acres of irrigated corn harvested as silage which represented 35.7 percent of the total corn acreage. The mean yield increased from 7.2 tons/acre in 1948 to 17.8 tons/acre in 1963.

In 1960, silage became the champion in terms of a means of utilizing corn in Montana. The production of corn silage under irrigation contributed substantially to the growth in popularity of this crop which was reflected in increasing acreages. Silage corn was a relatively new crop on irrigated lands in 1960 and being no different than any new crop, there were many problems and unanswered questions regarding its production. Soil fertility is one of the problems associated with corn silage production. With this in mind, soil fertility experiments designed to study the effect of N, P, & K fertilizer upon corn production were conducted at three locations in Montana. The experimental sites selected were located on the George Michaelis farm at Huntley (Yellowstone County), the Pierce Packing ranch at Columbus (Stillwater County) and the Montana State University Experiment Station Field Laboratory at Bozeman (Gallatin County).

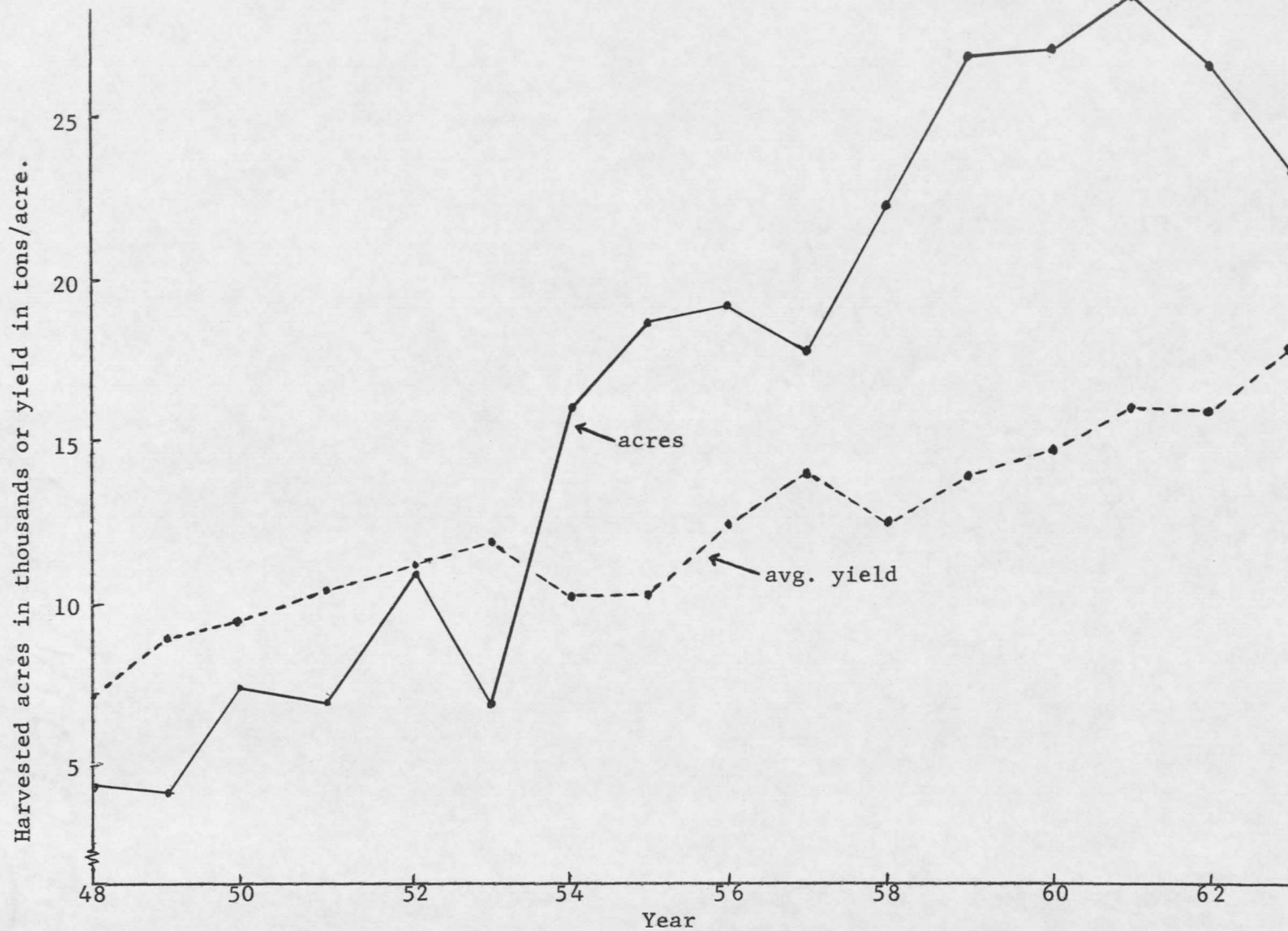


Figure II. Acreages of irrigated corn harvested for silage and mean yield, Montana, 1948-1963

The project was supported cooperatively by the Montana Agricultural Experiment Station and the Phillips Petroleum Company. Dr. Harry Kittams, then assistant professor of Soils at Montana State University, and Donald Erb were in charge of the experiments. The results of the study are reported in this paper.

REVIEW OF LITERATURE

Although many of the cultural practices involved in the production of corn grain and corn silage are quite similar, some factors such as variety, plant population, and fertilization may vary considerably.

During the early 1930's, Wiggans (41) reviewed the literature regarding the life cycle of the corn plant and the influence of stage of maturity, at harvest, on yield and the feeding value of corn silage. He reported that the following paralleled finding of several investigators:

1. Total dry matter percentage increases as the life cycle of the corn plant progresses.
2. Total dry matter production increases very rapidly after ear formation.
3. Maximum green weight is attained before maximum dry weight.
4. Chemical composition of dry matter changes during the development of the grain. Ash, protein and crude fiber decline while nitrogen free extract increases.
5. Late maturing varieties produce more green forage than early maturing varieties and generally produce more dry matter.
6. The more mature corn was when ensiled, the more valuable the silage per unit weight.
7. The relative value of silage per unit weight of dry matter from corn of different maturity ratings, harvested at the same time, or from successive harvests of the same variety approached equality.

8. Good silage, from the standpoint of preservation, palatability, and digestibility, can be made from corn at practically any stage of development; however, the more mature the corn is when ensiled, provided it can be properly packed, the less loss of dry matter in storage and the lower the acid content of the resulting silage.

Wiggans (41) conducted a six year study of the influence of maturity on silage production at Cornell University, Ithaca, N. Y. in the 1930's and concluded:

1. The later the variety of corn grown is in maturity, the larger will be the green weight production provided the plant has passed the flowering stage.
2. Early maturing varieties are not only higher in dry matter percentage but are higher in total dry matter production than later varieties during the period of elongation.
3. The period of rapid green matter production is relatively much shorter than the period of rapid dry matter production.
4. Dry matter production of corn varieties varying in maturity dates, although showing differences, is not as widely separated in production of feeding units as is ordinarily considered by silage producers.
5. The percentage of grain in dry matter of the varieties under consideration varied from 0 to 36.2 percent on September 20.
6. Grain produced after September 20 is largely produced at the

expense of previously elaborated plant material.

7. Extremely late varieties of corn for any given region, varieties which will produce little or no grain by the ideal harvest date, are unsuited for silage purposes. Similarly, varieties which show a material slowing down in the production of dry matter before the middle or end of the silage harvest period due to advanced maturity are too early to give the best results in silage production.
8. The best variety for silage purposes lies somewhere between the two extremes and can be described as a variety which utilizes the growing season to the best advantage in the production of dry matter but at the same time reaches, at least three years in five, a stage of maturity which may be loosely described as the dough stage. Such a variety will have utilized the greater portion of the period of internal development which is extremely efficient in dry matter production, will contain a satisfactory percentage of dry matter, will not have reached the stage where grain is developed primarily at the expense of the stored material in stems and leaves and will give a yield of dry matter approaching the maximum for corn under a given set of environmental conditions.

More recent studies have revealed findings similar to those of Wiggans (41) and the investigators he cited. Morrison et al (33) found that late maturing corn hybrids produce more tons per acre of forage in

central Washington irrigated areas than early maturing varieties. He recommended short season varieties for the short season areas of western Washington. Robertson et al (37) found that multieared hybrids yielded more than single eared varieties, but tall growing hybrids did not always produce more than shorter growing varieties. Sayre (38) and Jordan et al (22) reported general increases in total dry matter and percent dry matter throughout the season and a maximum rate of dry matter production shortly after tasseling and silking. They also indicated that dry matter accumulation in the vegetative portion of the plant had approached a maximum when grain formation began and that further increases in total dry matter could be accounted for in the grain.

Nevans (35) studied the influence of stage of maturity on dry matter content of silage and reported the following:

<u>Stage</u>	<u>% Dry Matter</u>
Ears beginning to form	15
Kernels forming	17
Early milk	20
Late milk	23
Early dent	25
Well dented	28
Kernels hardening, leaves green	30
Kernels hardening, leaves brown	32

Several investigators have studied the effects of plant population on silage corn production. Morris et al (33) considered 18 to 20 thousand plants per acre the optimum population for silage production in Washington. Viets (40) indicated that populations of 30 to 35 thousand plants per acre are needed for maximum silage yields in the irrigated

areas of the West. Robertson et al (37) stated that increased plant populations had no significant effect on nutrient composition of silage corn, but did increase yields and uptake and percent recovery of N, P, and K. Alexander (1) found that increasing plant population at low levels of N fertility decreased the digestibility of the protein in corn silage.

Hehn et al (14, 15, 16, 17, 18, 19) studied the effects of plant population and maturity on silage corn production under irrigation in Montana. A review of this work indicated the following general conclusions:

1. As corn matured, percent T.D.N., fat and N.F.E. increased and fiber content decreased.
2. Early variety silage contained proportionally less fiber of more digestible form than a late variety silage.
3. The content and digestibility of protein in early variety silage was not measurably different from that of late variety silage.
4. Early varieties contained the highest percentage of T.D.N, but late varieties produced more T.D.N. per acre.
5. Except for the greater proportion of moisture contained in late variety silage, silages made from early and late varieties were not greatly different.
6. Dry matter production is probably a more reliable indicator, of a good silage variety, than grain production.
7. Highest yields were obtained with late maturing varieties at high plant populations.

8. Yield increased as plant populations were increased. Increasing the plant population beyond 30 thousand plants per acre has little effect on the yield of early maturing varieties. Yields of late maturing varieties were increased by plant populations as high as 50 to 60 thousand plants per acre.

Many papers, regarding N and P fertilization of corn, have been written. However, most researchers have been concerned with the production of small grain and have reported yield and composition responses accordingly. Studies of the influence of fertilization on silage corn production represent the minority.

Sayre (38) studied the accumulation of N, P, and K in corn in Ohio and concluded:

1. Nitrogen, P and K entered the corn plant and moved from tissue to tissue independent of one another.
2. Nitrogen accumulated in the corn plant, reached a maximum at silking time and ceased 4 weeks later in the season studied. Nitrogen continued to move into the grain from the other tissues until maturity.
3. Potassium accumulation reached a maximum about 3 weeks after silking, there was an actual loss of K after that time, largely from the leaves and stems of the plant. No marked accumulation of K occurred in the grain.
4. Phosphorus accumulation did not cease until about maturity, this element also moved into the grain from the other tissue.

Jordan et al (22), working in Mississippi, concluded:

1. Production of dry matter increased with increasing N applications and with heavier plant stands, thus emphasizing the importance of balancing fertility and stand rates.
2. Nitrogen uptake by the whole plant was continuous throughout the season. Vegetative parts gained in N until the tassel stage; subsequently a part of the N was translocated to the developing grain. As applied N was increased the early uptake of N by vegetative parts and its subsequent translocation to grain became more pronounced.
3. Phosphorus uptake increased with increasing N and stand rates.

Harshbarger et al (12, 13) stated that the application of commercial fertilizers to soils for the production of corn forage resulted:

1. In gains in tonnage of forage as represented by both ear and leaf-stalk fractions.
2. In little or no change in the proportion of the forage which consisted of ears.
3. In little or no change in the protein content of the grain (shelled corn) except as influenced by season.
4. In an enhanced protein content of the leaf-stalk fraction of the forage when the crop was grown on soils low in available plant food.

Reichman et al (36) found that N and P were complementary in increasing yields of both grain and forage under irrigation in North Dakota. Both N and P percentages in corn leaves, grain and stover

were increased by fertilization.

Alexander (1) reported significant increases in the digestibility of protein, energy and carbohydrates contained in corn silage when high fertilization treatments were used.

Robertson et al (37) reported dominately linear silage yield responses as rates of fertilizer were increased to 600, 176 and 500 pounds per acre of N, P, and K respectively.

Hehn et al (20) working in Montana, reported average check plot yields, for 90, 110, and 130 day varieties, of 13.6, 16.6 and 16.3 tons per acre respectively. The addition of 150 pounds N and 60 pounds P_2O_5 per acre increased silage yields to 18.3, 20.4, and 24.2 tons per acre.

Other studies concerning fertilization of silage corn in Montana (M. G. Klages, unpublished data, 1959 and 1960 Progress Reports, M. S. 765, Effect of various fertilizers and manure on yield and quality of farm crops) revealed:

1. Nitrogen increased silage yields in all cases with the most economical rate ranging from 50 to 150 pounds of N per acre.
2. Phosphorus and K fertilizer had little effect on silage yield and composition.
3. Nitrogen fertilizer increased protein content of corn in all stages of growth at all locations except one.
4. The influence of N fertilization upon P content of corn varied with stage of growth and location. Both increases and decreases were noted.

5. Nitrogen source studies revealed no differences between anhydrous ammonia, aqua ammonia and ammonium nitrate.
6. There was no difference in fertilizer response of early or late hybrids.

Studies at Bozeman and Huntley Montana (R. E. Campbell, Porter Pederson, T. J. Army, E. R. Hehn, M. G. Klages. Unpublished data. Effects of started nitrogen and phosphate fertilizers on corn development and production. Annual Report, Huntley Branch Station, 1955) revealed:

1. Pre-plant broadcast application of P fertilizer gave no response.
2. Small amounts of N (15 lbs. N/A) and P (30 lbs. P_2O_5/A) fertilizer, applied in close proximity to the seed at planting time stimulated corn growth in the early stages of development. These starter fertilizers also increased the crude protein content of the young corn plants.
3. The effects of starter fertilizers were not evident in corn silage or grain yields or composition.
4. A side dressed application of N (120 lbs. N/A) at the time of second cultivation resulted in improved plant color and increased the yield of silage at Bozeman, but effects were not measureable in silage or grain yields at Huntley.

MATERIALS AND METHODS

Specific information regarding cropping history, fertilizer history and soil testing results for each experimental site is presented in appendix table 1. Climatic data (31), representative of the 1961 growing season, for each location is given in appendix table 2.

Field Experiment at the Experiment Station Field Laboratory West of Bozeman

This experiment was conducted on field 0-6 of the Experiment Station Field Laboratory, Montana State University, Bozeman, Montana. The field was fall plowed and worked down in the spring prior to selection as an experimental site.

The area was laid out in a randomized block design consisting of two replications of 15 rates of N. Nitrogen plots were split systematically with a P application making a total of 30 treatments in the basic experiment. One additional plot in each replication received both N and K fertilizer. This plot was also split with a P application resulting in two supplementary treatments which served as a check for a K deficiency. The 32 treatments involved in this experiment are listed in table 1. Plot size was 12 x 50 feet. A diagram of the plot layout is given in figure I of the appendix.

Fertilizer was applied on May 23rd. Nitrogen was applied as anhydrous ammonia at a depth of 5 to 6 inches with a small plot applicator. This applicator was equipped with an adjustable orifice and a fast action on-off valve which allowed an approximation of N rate at a given tractor speed. The tank on the applicator could be removed and weighed.

Table 1. Fertilizer treatments incorporated in the experiment at Bozeman.

Treat. no.	lbs/A		
	N	P ₂ O ₅	K ₂ O
1.	0	0	0
2.	0	100	0
3.	47	0	0
4.	47	100	0
5.	68	0	0
6.	68	100	0
7.	87	0	0
8.	87	100	0
9.	106	0	0
10.	106	100	0
11.	112	0	0
12.	112	100	0
13.	127	0	0
14.	127	100	0
15.	138	0	0
16.	138	100	0
17.	149	0	0
18.	149	100	0
19.	173	0	0
20.	173	100	0
21.	180	0	0
22.	180	100	0
23.	214	0	0
24.	214	100	0
25.	248	0	0
26.	248	100	0
27.	280	0	0
28.	280	100	0
29.	317	0	0
30.	317	100	0
31.	106	0	100
32.	106	100	100

giving the amount of material applied to a given area and thus an accurate measurement of the actual rate applied. Phosphorus in the form of triple super-phosphate and K in the form of muriate of potash were drilled in at a depth of 3 to 4 inches.

On May 29th four row plots of 'DeKalb 222' corn (*Zea mays indentata* L.) were seeded at a rate which would result in a plant population of about 75 thousand plants per acre in 36 inch rows. De Kalb 222 is a double cross variety and has a maturity rating of 108 to 112 days. On June 27th, the corn was hand thinned, leaving a six inch in-row spacing and a plant population of approximately 29 thousand plants per acre.

During the growing season the area was sprinkler irrigated 5 times, hoed twice and cultivated twice.

As the growing season progressed leaf samples were taken 49 (July 17), 67 (Aug. 4), 81 (Aug. 18), and 106 (Sept. 12) days after seeding. Ten to 12 plants were selected at random within each plot. The third leaf above the base of each plant was removed. These were dried and prepared for analysis.

Samples for silage yields were harvested on September 14th. Twenty feet of the two center rows in each plot provided a harvest area of 120 square feet. Sub-samples were taken for moisture determination. Sub-samples were dried, ground and prepared for chemical analysis.

Field Experiment on the Michaelis Farm
Two Miles North East of Huntley

This site was selected when it became apparent that the original experiment in this locality would have to be abandoned due to a very poor stand and serious weed problem. Unfortunately, the resulting delay made it impossible to find another field that had not been seeded and difficult to find one that had not already been fertilized quite heavily.

The field where the experiment was conducted had been fall plowed, worked down in the spring, fertilized with 150 lbs. of 16-20-0 and planted to 'Pride 22' corn (*Zea mays indentata* L.) on May 10th. Pride 22 is a double cross variety and has a maturity rating of 95 days. The experimental area was quite uniformly populated at the rate of about 30 thousand plants per acre in 36 inch rows.

The area was laid out in a randomized block design consisting of two replications of 15 rates of N. Nitrogen plots were split systematically with a P application making a total of 30 treatments in the basic experiment. Both N and K fertilizer were applied to one additional plot in each replication. This plot was also split with a P application resulting in two supplementary treatments which served as a check for K deficiency. The 32 treatments involved in this experiment are listed in table 2. Plots contained 40 feet of three 36 inch rows resulting in a plot area 9 x 40 feet. A diagram of the plot layout is given in appendix figure II.

Fertilizer was applied on June 8th when the corn was about 10 to 12

Table 2. Fertilizer treatments incorporated in the experiment at Huntley.

Treat. no.	lbs/A		
	N	P ₂ O ₅	K ₂ O
1.	0	0	0
2.	0	100	0
3.	45	0	0
4.	45	100	0
5.	60	0	0
6.	60	100	0
7.	75	0	0
8.	75	100	0
9.	90	0	0
10.	90	100	0
11.	105	0	0
12.	105	100	0
13.	120	0	0
14.	120	100	0
15.	135	0	0
16.	135	100	0
17.	150	0	0
18.	150	100	0
19.	165	0	0
20.	165	100	0
21.	180	0	0
22.	180	100	0
23.	210	0	0
24.	210	100	0
25.	240	0	0
26.	240	100	0
27.	270	0	0
28.	270	100	0
29.	300	0	0
30.	300	100	0
31.	105	0	100
32.	105	100	100

inches tall. Ammonium nitrate, triple super-phosphate and muriate of potash were used as sources of N, P, and K. The fertilizer was applied with a belt seeder equipped with a side dressing attachment. Fertilizer was placed 4 to 5 inches from the center of the row at a depth of about 3 inches.

The experiment received 4 furrow irrigations during the growing season. The corn was cultivated twice and hoed once.

Leaf samples were taken 62 (July 11) and 84 (Aug. 2) days after seeding. The third leaf above the base was removed from 10 to 12 plants which were selected at random in each plot. These were dried and prepared for chemical analysis.

As the season progressed it became apparent that the corn would mature making it possible for grain yield measurements. For this reason the harvest area for silage yield within each plot was reduced from 120 square feet to 60 square feet.

Silage yield samples were taken from the first half of each plot on September 1. Sub-samples were taken for moisture determination, the material was dried and prepared for chemical analysis.

Grain yield samples were taken from the remaining portion of each plot on October 6. Sub-samples were taken to determine moisture content. When dry these samples were used to determine shelling percentage. A portion of the shelled grain was prepared for chemical analysis.

Field Experiment on the Pierce
Ranch Four Miles West of Columbus

This experiment was conducted on a field which was plowed and worked down in the spring prior to seeding.

The area was laid out in a randomized block design consisting of 2 replications of 15N rates. Nitrogen rates were split with a P application making a total of 30 treatments in the basic experiment. One additional plot in each replication received both N and K fertilizer. This plot was also split with a P application resulting in 2 supplemental treatments which served as a check for K deficiency. The 32 treatments involved in the experiment are given in table 3. Plot size was 12 x 50 feet. A diagram of the plot layout is given in figure III of the appendix. Each plot contained four 36 inch rows.

On May 20 'DeKalb 640' corn (*Zea mays indentata* L.) was seeded at a rate which would result in a plant population of approximately 26 to 27 thousand plants per acre. The area received 4 irrigations, 2 cultivations and one hoeing during the growing season.

As the season progressed leaf samples were taken 53 (July 12), 73 (Aug. 1) and 88 (Aug. 16) days after seeding. The third leaf from the base was removed from 10 to 12 plants which were selected at random in each plot. These were dried and prepared for chemical analysis.

The plots were harvested on May 29th. Yield samples were taken from a 20 foot section of the 2 center rows in each plot. The harvest area was 120 square feet. Sub-samples were taken for moisture determination and these, then, were prepared for chemical analysis.

Table 3. Fertilizer treatments incorporated in the experiment at Columbus.

Treat. no.	lbs/A		
	N	P ₂ O ₅	K ₂ O
1.	0	0	0
2.	0	100	0
3.	45	0	0
4.	45	100	0
5.	60	0	0
6.	60	100	0
7.	72	0	0
8.	72	100	0
9.	95	0	0
10.	95	100	0
11.	106	0	0
12.	106	100	0
13.	122	0	0
14.	122	100	0
15.	149	0	0
16.	149	100	0
17.	165	0	0
18.	165	100	0
19.	176	0	0
20.	176	100	0
21.	203	0	0
22.	203	100	0
23.	225	0	0
24.	225	100	0
25.	244	0	0
26.	244	100	0
27.	269	0	0
28.	269	100	0
29.	302	0	0
30.	302	100	0
31.	93	0	100
32.	93	100	100

Analytical Methods

Plant Analysis. Nitrogen determinations were made at the State Grain Laboratory, Montana State University, Bozeman, Montana. The standard Kjeldahl procedure was modified (2) to include nitrate N by using salicylic acid and sodium thiosulfate in the digestion process. Preliminary investigation revealed excellent recovery of nitrate N added to plant material prior to analysis. Analysis of samples selected at random by both the standard and modified procedure revealed negligible traces of nitrate N in the plant material. Protein content, in percentage, was obtained by multiplying percent N by a factor of 6.25.

Phosphorus determinations were made in the soils lab at Montana State University, Bozeman, Montana. The colorimetric procedure (3) employed ammonium molybdate and ammonium vanadate as the reagents for color development. Samples were dryashed and dissolved in 1 normal nitric acid prior to color development.

Soil Analysis. Each experimental site was sampled prior to fertilizer application. The samples were analyzed for pH, conductivity, organic matter, available phosphorus, free lime and texture at the soil testing laboratory, Montana State University, Bozeman, Montana. Conductivity was determined on a suspension, consisting of 1 part soil and 2 parts water. Conductivity of the saturation extract was estimated from the following equation: $Y=3X+0.7$ (Below conductivity of .0.7, $Y=4X$). The suspension from the conductivity measurement was decanted off and discarded, saving the sediment for pH measurement. The pH was measured with a glass electrode pH meter. The organic matter procedure (21) involved the wet combustion

of soil organic matter in potassium dichromate and concentrated sulfuric acid. Excess dichromate was titrated with ferrous ammonium sulfate. Available P_2O_5 was determined by modification of the Bray procedure (39). Phosphorus content of the extract was determined colorimetrically using chloromolybdic and chlorostannic acid for color development. Free lime was determined by reaction with 10 percent hydrochloric acid. Texture was estimated by the ribbon method.

Statistical Methods. Analysis of variance was run in the manner set forth by Leonard and Clark (24) for split plot experiments. Means were separated by Duncans multiple range (S. S. R.) (23).

RESULTS AND DISCUSSION

Bozeman Experiment

Plant Growth Characteristics. Excellent stands were obtained. As the season progressed the effect of the N treatments upon plant growth and color gradually became visible. During the latter part of the growing season various degrees of chlorosis and firing of the lower leaves developed. At harvest it was noted that firing had occurred as high as the 4th and 5th leaf from the base of corn plants grown on the check plots. Evidence of leaf firing diminished as N rates approach 100 pounds per acre. Plant color continued to improve as N rates increased to about 150 pounds per acre. Corn plants grown at high levels of N fertility were some 8 to 10 inches taller than those grown on the check plots.

Silage Yields are given in table 4. Analysis of variance, appendix table 3, revealed highly significant differences due to N fertilization. Means were separated by the S. S. R. method at the 5 percent level. The yield for the 47 pound rate of N was significantly higher than the 0 rate. Nitrogen at the rate of 47 pounds per acre increased yields 4.5 tons per acre and demonstrated excellent returns to N fertilizer investment. Yields obtained with higher rates of N were not significantly different from that of the 47 pound rate. Silage yields were not significantly influenced by P fertilization.

Potassium check plots did not indicate a K deficiency. The

Table 4. Corn silage yield and protein content as influenced by rates of N fertilizer applied at seeding, Bozeman, Montana, 1961.

N lbs/A	Yield 1) T./A.	Protein 2) %
0	12.1a	4.5a
47	16.6 b	6.1 b
68	17.6 b	6.4 bc
87	16.9 b	7.1 cd
106	17.9 b	7.4 de
112	17.3 b	7.8 def
127	17.9 b	7.3 d
138	17.8 b	7.7 def
149	17.0 b	8.2 efg
173	18.2 b	8.4 fg
180	17.3 b	8.5 fg
214	18.3 b	8.9 gh
248	17.4 b	9.4 h
280	17.5 b	9.5 h
317	17.0 b	9.4 h
Mean	17.1	7.8

1) Silage yield computed at 70% moisture.

2) % protein reported on the dry matter basis.

Note: Means followed by the same letter within a column are not significantly different at the 5% level.

mean yield for 106 pounds of N plus 100 pounds K_2O per acre was 17.2 tons per acre. In comparison, the mean yield for 106 pounds of N without K, was 17.9 tons per acre.

The corn was in the milk stage of maturity when harvested and contained about 20 percent dry matter. Dry matter yields exceeded 5 tons per acre, indicating that corn has good potential as a forage crop in the Bozeman area in spite of a relatively short growing season.

Protein Content of the silage is also reported in table 4. Analysis of variance, appendix table 4, disclosed highly significant differences due to N treatments. Mean separation by the S. S. R. method at the 5 percent level revealed significant increases in protein content, with increasing rates of N, up to 214 pounds per acre. In general, the difference in protein content, associated with N rates, decreased as the rate of N increased. Protein content was not significantly influenced by P fertilization.

Potassium did not appear to influence silage protein content. The mean protein content for 106 pounds N plus 100 pounds K_2O per acre was 7.3 percent. In contrast, the mean protein content for 106 pounds N without K_2O was 7.4 percent.

It is often difficult to put a price tag on quality factors such as protein content. The value of increased protein in silage is dependent upon the class of livestock to which it is fed and the nature of the feeding operation. Feeds that contain less than 8.3 percent protein (dry matter basis) are generally considered to be inadequate

for all classes of beef cattle (32, 34) and must be supplemented, or fed in combination with a higher protein feed to provide adequate protein in the ration. At this location, corn fertilized with N at the rate of about 170 pounds per acre, produced silage that contained sufficient protein to be considered adequate for several classes of beef cattle.

Fertilizer N Recovery in the silage, table 5, approached 100 percent for the 47 pound rate of N and exceeded 50 percent for rates as high as 173 pounds per acre. The data for the 0 rate of N fertilizer indicates that the soil contributed about 50 pounds of N to total uptake. There was little additional uptake of fertilizer N associated with rates of N above 214 pounds per acre. Nitrogen at rates of 47, 173, and 214 pounds per acre increased protein production 284, 590, and 649 pounds per acre respectively. Should it be necessary to purchase these quantities of protein in the form of a supplement these increases may be of considerable importance.

Commercial fertilizers are often mentioned in discussions regarding water pollution. Recovery data at this location indicates that proper management will allow the use of adequate N fertilizer in the production of silage corn with little danger of polluting our waters.

Silage Phosphorus Content as influenced by 5 rates of nitrogen with and without 100 pounds P_2O_5 per acre is reported in table 6. Analysis of variance for the data as a split plot, appendix table 5, revealed that P content was not significantly influenced by N or P fertilization. However, there was a significant N x P interaction.

Table 5. Fertilizer N recovery in corn silage as influenced by N fertilizer applied at seeding, Bozeman, Montana, 1961.

N lbs/A	Dry Matter lbs/A	Dry matter Protein 1) %	Total Protein Produced lbs/A	Total N Uptake lbs/A	Fert.N Recovered lbs/A	Fert. N Recovery %
0	7240	4.5	326	52	.0	.0
47	10000	6.1	610	98	46	98
68	10560	6.4	676	108	56	82
87	10160	7.1	721	115	63	72
106	10720	7.4	793	127	75	71
112	10340	7.8	807	129	77	69
127	10700	7.3	781	125	73	57
138	10640	7.7	819	131	79	57
149	10180	8.2	835	134	82	55
173	10900	8.4	916	147	95	55
180	10380	8.5	882	141	89	49
214	10960	8.9	975	156	104	49
248	10420	9.4	979	157	105	42
280	10500	9.5	998	160	108	39
317	10180	9.4	957	153	101	32

1) % protein = 6.25 x % N.

Table 6. Phosphorus content of corn silage as influenced by rates of N and P fertilizer applied at seeding, Bozeman, Montana, 1961.

N lbs/A	% P (Dry matter basis)		Mean
	0 lbs. P_2O_5 /A	100 lbs. P_2O_5 /A	
0	0.195	0.234	0.215a
47	0.195	0.235	0.215a
106	0.221	0.245	0.233a
214	0.234	0.206	0.220a
317	0.203	0.240	0.222a
Mean	0.210z	0.232z	

To assist in the interpretation of this interaction, segments of the data involving N rates with and without P were analysed independently. Analysis of variance, appendix table 6, shows that rates of nitrogen had no significant effect upon P content of the silage when P fertilizer was applied. Analysis of variance, appendix table 7, disclosed a significant increase in the P content of the silage with increasing N rates when P was not applied. It appears that N in the form of anhydrous ammonia had some affect upon P uptake. Increases in P content of plant material, associated with N fertilization, have been explained on the basis of increased solubility of phosphorus (5, 6), enhanced root growth (7, 8, 10, 26), and metabolic activity (4, 25).

Protein Content of 3rd Leaf Samples, taken at four dates during the growing season is reported in table 7. Analyses of variance by individual dates, appendix tables 8, 9, 10 and 11, revealed that N fertilization significantly increased the protein content of the 3rd leaf at all dates. Mean separation by the S. S. R. method at the 5 percent level disclosed significant increases in protein content, as rates of N increase to about 180 pounds per acre, for each date. Phosphorus fertilizer did not significantly influence the protein content of the 3rd leaf at any of the four dates.

The 3rd leaf protein data for the four dates was combined for statistical analysis as a split-split randomized block. Sampling date was incorporated as the second split. The P split and the sampling date split were both systematic.

Table 7. Protein content of the 3rd leaf of corn at 4 dates, as influenced by rates of N fertilizer applied at seeding, Bozeman, Montana, 1961.

lbs/A	% Protein (Dry matter basis)				Mean
	July 17, (49) ¹⁾	Aug. 4, (67) ¹⁾	Aug. 18, (81) ¹⁾	Sept. 12, (106) ¹⁾	
0	15.8a	11.5a	6.3a	3.8a	9.3a
47	20.5 b	16.4 b	11.4 b	6.3 b	13.6 b
68	20.8 bc	17.0 bc	12.0 b	6.9 b	14.2 b
87	21.1 bcd	18.1 cd	13.7 c	10.1 c	15.7 c
106	21.7 bcde	19.1 de	15.3 d	12.4 de	17.1 de
112	22.2 def	19.1 de	15.7 de	12.9 def	17.4 e
127	22.0 cde	19.4 de	15.9 de	12.2 d	17.3 e
138	22.2 def	19.5 e	16.5 def	13.6 defg	17.9 ef
149	21.9 cde	19.9 ef	16.6 efg	14.1 defgh	18.1 efg
173	22.0 cde	20.2 efg	16.3 def	14.4 efg	18.2 efg
180	22.7 efg	19.9 ef	17.2 fgh	14.9 fghi	18.6 fghi
214	23.4 fg	20.3 efg	17.2 fgh	15.5 ghi	19.1 ghij
248	23.5 g	21.0 fg	17.8 gh	15.3 ghi	19.4 ij
280	22.5 efg	20.9 fg	17.8 gh	15.8 hi	19.2 hij
317	22.9 efg	21.5 g	18.4 h	16.7 i	19.7 j
Mean	21.6	18.9	15.2	12.3	

Note: Means followed by the same letter within a column are not significantly different at the 5% level.

1) Days from seeding.

Analysis of variance, appendix table 12, for the combined data revealed highly significant differences due to sampling date and N treatment. Date and N means, table 7, were separated by the S. S. R. method at the 5 percent level. Protein content of the 3rd leaf decreased significantly with each date of sampling. Increases in protein content associated with N rates were significant up to 214 pounds per acre. Phosphorus fertilizer had no significant effect upon the protein content of the 3rd leaf.

The date x N interaction was highly significant. The nature of this interaction is evident in table 7. The magnitude of the total increase (lowest to highest) in protein content, resulting from N fertilizer, was much greater on Sept. 12 than on July 17. The interaction can be depicted in another way by stating that the decrease in 3rd leaf protein, during the period July 17, to Sept. 12, was greater and thus more rapid at lower rates of N than at higher rates. Decreases in the protein content of the 3rd leaf can be explained on the basis of dry matter accumulation and N translocation. A high degree of N translocation is indicated by the fact that 3rd leaf protein content at the 0 rate of N on Sept. 12, was lower than that of the silage.

Comparison of 3rd leaf protein with silage protein disclosed some interesting relationship. Fertilizer N rates of 180 to 214 pounds per acre resulted in protein contents that were near the maximum in leaf samples, at all dates, and in the silage (tables 4 and 7).

At these rates (180-214) the protein content of the 3rd leaf on July 17 was consistently greater than the protein of the silage at harvest by about 14 percent. This observation led to comparisons of 3rd leaf protein on July 17, with silage protein at other rates of N. Subtracting the protein content of the silage from the protein content of the 3rd leaf on July 17, for each rate of N from 47 to 214 pounds per acre resulted in values that ranged from 13.6 to 14.7 (mean 14.2). The similarity of these values indicates that protein trends in the 3rd leaf on July 17 were nearly identical to protein trends in the harvested silage. Subtracting 14.2 from the protein content of the 3rd leaf on July 17, for N rates ranging from 47 to 214 pounds per acre resulted in values nearly identical to the actual protein content of the silage. Thus, protein of early leaves may be a valid indicator of protein in the silage at harvest. Such information might be valuable in indicating need for additional N in order to increase protein of silage.

Huntley Experiment

Plant Growth Characteristics. Fertilizer treatments did not produce visible differences in plant growth or color at any time during the growing season. No production problems were encountered at this location.

Silage Yield data and analysis of variance are presented in appendix table 13. Nitrogen and P fertilizer did not significantly influence silage yield. Unfertilized plots (no N or P) yielded 26.8 tons per acre. The mean yield of all plots was 26.1 tons per acre.

Potassium check plots did not indicate a K deficiency. Plots fertilized with 105 pounds N plus 100 pounds K₂O per acre produced 25.4 tons of silage per acre. In contrast, plots fertilized with the same rate of N without K yielded 28.1 tons per acre.

Corn plants, at this location contained about 29 percent dry matter and had reached the stage of maturity at which kernels begin to harden when silage was harvested on Sept. 1. The average date of the first frost in the fall at Huntley is Sept. 21. A later variety would probably have produced higher yields of silage and may have responded to fertilization.

Shelled Grain Yield data and analysis of variance are shown in appendix table 14. Nitrogen and P fertilizer had no significant influence on grain yield. Yields were computed at 15.5% moisture. The mean yield for the unfertilized plots (no N or P) was 135.5 bushels per acre. The mean yield for all plots was 162.7 bushels per acre. These values indicate that a response to N and/or P fertilizer may have been masked by experimental error.

Potassium check plots did not indicate a K deficiency. Plots fertilized with 105 pounds N plus 100 pounds K_2O produced 156.8 bushels of shelled grain per acre. The same rate of N without K resulted in a yield of 167.1 bushels per acre.

The grain contained 34 percent moisture at harvest. The magnitude of the yield obtained at this location indicates that the area has considerable potential for corn grain production which could be developed should the storage of high-moisture grain, by methods similar to those now used for silage, become practical and economical. Developments of this nature may have considerable influence upon future corn production trends in Montana.

Silage and Shelled Grain Protein Contents are reported in table 8. Analysis of variance, appendix tables 15 and 16, disclosed highly significant differences in protein content, of both silage and grain, due to N treatments. Mean separation by the S. S. R. method at the 5 percent level revealed that the protein content, of both silage and grain, was significantly increased by N fertilization at the rate of 45 pounds per acre. The nature of the response to N rates higher than 45 pounds per acre is questionable.

Potassium did not appear to influence protein content of the silage or grain. The protein contents of the silage and grain from plots fertilized with 105 pounds N plus 100 pounds K_2O per acre were 7.4 and 9.4 percent.

The value of increased protein content of silage was mentioned in the

Table 8. Protein content of corn silage and shelled grain as influenced by rates of N fertilizer, side-dressed, Huntley, Montana, 1961.

lbs/A	% Protein (Dry matter basis)	
	Silage	Grain
0	6.0a	8.0a
45	7.3 bcd	9.4 bc
60	7.0 b	9.1 b
75	7.9 bcd	9.3 bc
90	7.3 bcd	9.4 bc
105	7.4 bcd	9.3 bc
120	7.6 bcd	9.7 c
135	7.1 bc	9.3 bc
150	7.5 bcd	9.2 bc
165	8.2 d	9.4 bc
180	7.4 bcd	9.3 bc
210	8.1 cd	9.4 bc
240	7.9 bcd	9.4 bc
270	7.6 bcd	9.5 bc
300	8.1 cd	9.5 bc
Mean	7.5	9.3

discussion of the Bozeman data. The importance of the increase in protein content from N fertilization at this location is debatable.

The corn was nearing maturity when silage was harvested. Protein content of the silage tended to be low compared to the 8.3 percent level which is generally considered adequate for beef cattle. The data revealed that increasing protein to an adequate level with N fertilizer would not be practical. These relationships indicate a need to consider maturity-protein relationships when selecting a silage corn variety for a given area.

Fertilizer N Recovery in Silage, table 9, exceeded 90 percent for an application of 45 pounds of N per acre. Percent recovery decreased rapidly and irregularly as N rates increased from 45 pounds per acre. The data for the 0 rate of N indicates that the soil contributed about 150 pounds of N per acre to total N uptake. There was little additional uptake of fertilizer N associated with rates of N above 45 pounds per acre. Nitrogen at the rate of 45 pounds per acre increased protein production 255 pounds per acre. The cost of this quantity of protein in supplement form would be much greater than that of 45 pounds of N.

Fertilizer N Recovery in Shelled Grain, table 10, was about 50 percent when N was applied at the rate of 45 pounds per acre. Percent recovery decreased as nitrogen rates increased. Data for the 0 rate of N indicates that the soil contributed about 90 pounds of N per acre to the total N utilized in grain production. Rates of N higher than 45 pounds per acre resulted in little additional uptake of N in the grain. The percentage of total plant N contained in the grain (about 60 percent) did not appear to be influenced by fertilization.

Table 9. Fertilizer N recovery in corn silage as influenced by rates of N fertilizer side-dressed, Huntley, Montana, 1961.

N lbs/A	Dry matter lbs/A	Dry matter protein 1) %	Total protein produced lbs/A	Total N uptake lbs/A	Fert. N recovered lbs/A	Fert. N recovery %
0	15600	6.0	936	150	0	0
45	16320	7.3	1191	191	41	91
60	15320	7.0	1072	172	22	37
75	14720	7.9	1163	186	36	48
90	15420	7.3	1126	180	30	33
105	16880	7.4	1249	200	50	48
120	15700	7.6	1193	191	41	34
135	16100	7.1	1143	183	33	24
150	14320	7.5	1074	172	22	15
165	15640	8.2	1282	205	55	33
180	15920	7.4	1178	188	38	21
210	16480	8.1	1335	214	64	30
240	14600	7.9	1153	184	34	14
270	16100	7.6	1224	196	46	17
300	15860	8.1	1285	206	56	19

1) % Protein = 6.25 x % N

Table 10. Fertilizer N recovery in shelled corn (grain) as influenced by rates of N fertilizer side-dressed, Huntley, Montana, 1961.

N lbs/A	Dry matter lbs/A	Dry matter protein 1) %	Total protein produced lbs/A	Total N uptake lbs/A	Fert. N recovered lbs/A	Fert. N recovery %
0	6928	8.0	554	89	0	0
45	7467	9.4	702	112	23	51
60	7335	9.1	667	107	18	30
75	7907	9.3	735	118	29	39
90	7893	9.4	742	119	30	33
105	7907	9.3	735	118	29	28
120	7690	9.7	746	119	30	25
135	7344	9.3	683	109	20	15
150	7614	9.2	700	112	23	15
165	7988	9.4	751	120	31	19
180	8073	9.3	751	120	31	17
210	7495	9.4	705	113	24	11
240	8219	9.4	773	124	35	15
270	7685	9.5	730	117	28	10
300	7959	9.5	756	121	32	11

1) $N \times 6.25 = \% \text{ Protein}$

Phosphorus Contents of Silage and Grain, as influenced by 5 rates of N with and without 100 pounds P_2O_5 per acre, and analysis of variance are given in appendix tables 17 and 18. Fertilization with N and P did not significantly influence the P content of silage or grain. Silage and grain produced on unfertilized plots contained 0.250 and 0.384 percent P. Plots fertilized with 100 pounds P_2O_5 without N produced silage and grain that contained 0.265 and 0.412 percent P. The mean P content of all plots was 0.264 percent in silage and 0.399 in grain.

Protein Contents of the 3rd Corn Leaf at 2 dates during the growing season, are reported in table 11. Analysis of variance appendix tables 19 and 20, revealed significant differences in protein content due to N treatments at both dates. Means were separated by the S. S. R. method at the 5 percent level. The data for the July 11, sampling was variable and the nature of the response questionable. The protein content of the 3rd leaf, on Aug. 2, was significantly increased by N fertilization at the rate of 45 pounds per acre. Differences in protein content associated with higher rates of N were not significant. Protein content was not significantly influenced by P fertilizer, on either date. Analysis of variance revealed a significant difference in the mean protein content due to date of sampling.

Leaf samples taken during the growing season gave some indication of the N rate that would result in maximum protein content in silage. However, the relationship, at this location, was not as pronounced as it was at the Bozeman site.

Table 11. Protein content of the 3rd leaf of corn at 2 dates during the growing season as influenced by rates of N fertilizer applied at seeding, Huntley, Montana 1961.

N lbs/A	% Protein (Dry matter basis)	
	July 11, (62) ¹⁾	Aug. 2, (84) ¹⁾
0	19.6a	15.1a
45	20.1abcd	17.4 b
60	20.7 cde	17.4 b
75	19.9abc	17.1 b
90	20.4 bcde	17.3 b
105	20.4 bcde	17.2 b
120	21.1 e	18.2 b
135	20.4 bcde	17.2 b
150	19.8ab	17.9 b
165	20.6 bcde	18.0 b
180	21.1 e	17.0 b
210	20.5 bcde	18.4 b
240	21.2 e	17.7 b
270	20.4 bcde	17.7 b
300	20.9 de	17.8 b
Mean	20.5	17.4

Columbus Experiment

Plant Growth Characteristics. Farmer seeding resulted in a poorly distributed population of about 25 thousand plants per acre. Variations in plant growth, which did not appear to be related to fertilizer treatments, were observed as the growing season progressed. The area was not well leveled making uniform irrigation impossible. Variations in growth were attributed to lack of uniformity in soil moisture and plant population, until harvest, when a conversation with a party well versed on the history of the field revealed the probable cause of the variation. The area, once described as a grass pasture which contained very little alfalfa, was actually an old alfalfa field which had often been used as a winter feed grounds.

Silage Yield was not significantly influenced by N and P fertilization. Unfertilized plots (no N or P) yielded 24.3 tons per acre. The mean yield for all plots was 21.8 tons per acre. Yield data and analysis of variance are presented in appendix table 21.

Potassium check plots did not indicate a K deficiency.. Plots fertilized with 95 pounds N plus 100 pounds K_2O per acre yielded 22.4 tons per acre. In comparison, plots which received the same rate of N without K yielded 19.6 tons of silage per acre.

Kernels were just beginning to form when the silage was harvested at this location. The silage contained about 17 percent dry matter which indicates that an earlier maturing variety would probably be more desirable.

Silage Protein was not significantly affected by N and P fertilization. Unfertilized plots produced silage that contained 7.9 percent protein. The mean protein content for all plots was 10.0 percent. Protein data and analysis of variance are shown in appendix table 22.

Potassium did not appear to influence protein content. Silage from plots fertilized with 95 pounds N plus 100 pounds K_2O per acre contained 10.7 percent protein. The protein content of silage from plots which received the same rate of N without K was 10.7 percent.

Fertilizer N Recovery, table 12, was negligible at all rates of N application. Total N uptake at the 0 rate of N indicated that the soil contributed 205 pounds of N to corn production.

Silage P Data and analysis of variance are shown in appendix table 23. Nitrogen and P fertilizer did not significantly influence P content of silage. Silage produced on plots that received no N or P fertilizer contained 0.261 percent P. Plots fertilized with P at the rate of 100 pounds of P_2O_5 per acre produced silage that contained 0.278 percent P. The mean P content for all plots was 0.267 percent.

Protein Contents of the 3rd Corn Leaf at 3 dates during the growing season are reported in table 13. Analyses of variance, appendix table 24, 25 and 26 revealed no significant differences in protein content due to N and P fertilization at any of the 3 dates. Analysis of variance revealed significant decreases in mean protein content as the season progressed.

Table 12. Fertilizer N recovery in corn silage as influenced by rates of N fertilizer applied at seeding, Columbus, Montana, 1961.

N lbs/A	Dry matter lbs/A	Dry matter protein ¹⁾ %	Total protein produced lbs/A	Total N uptake lbs/A	Fert. N recovered lbs/A	Fert. N recovery %
0	14220	9.0	1280	205	0	0
45	12620	9.3	1174	188	-17	0
65	12760	10.2	1302	208	3	5
72	13840	9.4	1301	208	3	4
95	13440	9.3	1250	200	-5	0
106	12020	10.7	1286	206	1	1
122	13360	9.2	1229	197	-8	0
149	10400	12.0	1248	200	-5	0
165	13580	10.6	1439	230	25	15
176	13540	9.7	1313	210	5	3
203	13420	9.7	1302	208	3	1
225	13200	9.6	1267	203	-2	0
244	13220	10.3	1362	218	13	5
269	12760	10.6	1353	216	11	4
302	13500	10.0	1350	216	11	4

1) % protein = % N x 6.25

Table 13. Protein content of the 3rd leaf of corn at 3 dates, during the growing season as influenced by rates of N and P fertilizer applied at seeding, Columbus, Montana, 1961.

N lbs/A	% Protein (Dry matter basis)		
	July 12, (53) ¹⁾	Aug. 1, (73) ¹⁾	Aug. 16, (88) ¹⁾
0	21.6a	16.7a	14.9a
45	23.2a	17.3a	11.4a
60	25.4a	18.9a	14.2a
72	23.4a	18.0a	13.4a
95	23.5a	17.5a	14.2a
106	24.8a	19.5a	13.6a
122	23.6a	18.3a	14.9a
149	25.6a	20.3a	14.2a
165	24.8a	19.1a	15.6a
176	22.8a	19.4a	15.6a
203	25.1a	18.9a	16.5a
225	24.0a	18.7a	15.7a
244	25.4a	19.6a	15.7a
269	24.4a	21.2a	16.5a
300	24.6a	19.9a	15.5a
Mean	24.2	18.9	14.9

Note: Means followed by the same letter within a column are not significantly different at the 5% level.

1) days from seeding.

SUMMARY AND CONCLUSIONS

Field experiments, involving N and P fertilization of irrigated corn were conducted at Bozeman, Huntley and Columbus, Montana. Phosphorus fertilizer had no effect on corn production at any of the locations. A different level of N fertility existed at each location. Potassium check plots, included at each location, disclosed no evidence of K deficiency.

At Bozeman, where the soil contributed only 50 pounds of N per acre to corn production, a severe N deficiency was exhibited. Nitrogen check plots began to show symptoms of N deficiency near mid-season. Various degrees of chlorosis and firing of the lower leaves developed at the lower rates of N as the season progressed. Protein content of 3rd leaf samples, taken at 4 dates during the latter half of the growing season, indicated extensive translocation of N from the lower leaves of plants grown at lower levels of N fertility. Nitrogen, at the rate of 47 pounds per acre, increased silage yield 4.5 tons per acre and silage protein content 1.6 percent. Silage protein content was nearly doubled by N fertilization at the rate of 214 pounds per acre. Nitrogen, in the form of anhydrous ammonia, increased the P content of silage when P fertilizer was not applied. The response at Bozeman demonstrated excellent returns to N fertilizer investment. Fertilizer N recovery approached 100 percent at the 47 pound rate and exceeded 50 percent for rates as high as 173 pounds per acre.

The level of N fertility at the Huntley site was slightly less than optimum for silage corn production. The soil contributed about 150 pounds of N per acre to total N uptake. Nitrogen fertilization did not affect

silage or grain yields. Protein content of the silage was increased 1.3 percent when N was applied at the rate of 45 pounds per acre. The same rate of N increased the protein content of shelled corn grain 1.4 percent. Fertilizer N recovery at the 45 pound rate exceeded 90 percent in the silage and 50 percent in the grain. The magnitude of the response at Huntley may have been greater had a later maturing variety been planted and fertilizer applied preplant rather than side-dressed some 30 days after seeding.

A high level of N fertility existed at the Columbus site. The soil contributed over 200 pounds of N per acre to corn production. Nitrogen fertilizer did not influence yield, protein content or P content. Fertilizer N recovery was negligible at all rates.

The results of this study clearly demonstrate the importance of accurate information regarding cropping and fertilizer history when making fertilizer recommendations based on laboratory analyses.

Total degree days, for the months of April through September, provide some indication of the nature of the growing seasons at these locations. Total degree days for Bozeman, Huntley and Columbus, for the 1961 season, were 1702, 1255 and 1352. The mean silage yields, computed at 70 percent moisture, for the respective locations were 17.1, 26.1 and 21.8 tons per acre. These values indicate good correlation between temperature and corn silage production in spite of the fact that varieties were not well matched with the respective seasons.

APPENDIX

Appendix Figure I. Field plot diagram--Bozeman experiment.

Rep. I

26	24	6	28	22	16	2	14	30	20	32	4	8	18	12	10
.....															
25	23	5	27	21	15	1	13	29	19	31	3	7	17	11	9

Plot size 12' x 50', not to scale

Rep. II

24	22	8	6	28	10	2	18	4	20	15	12	30	16	32	26
.....															
23	21	7	5	27	9	1	17	3	19	14	11	29	15	31	25



Treatments used at the field experiment at Bozeman.

Treat. No.	lbs/A			Treat. No.	lbs/A		
	N	P ₂ O ₅	K ₂ O		N	P ₂ O ₅	K ₂ O
1.	0	0	0	17.	149	0	0
2.	0	100	0	18.	149	100	0
3.	47	0	0	19.	173	0	0
4.	47	100	0	20.	173	100	0
5.	68	0	0	21.	180	0	0
6.	68	100	0	22.	180	100	0
7.	87	0	0	23.	214	0	0
8.	87	100	0	24.	214	100	0
9.	106	0	0	25.	248	0	0
10.	106	100	0	26.	248	100	0
11.	112	0	0	27.	280	0	0
12.	112	100	0	28.	280	100	0
13.	127	0	0	29.	317	0	0
14.	127	100	0	30.	317	100	0
15.	138	0	0	31.	106	0	100
16.	138	100	0	32.	106	100	100

Appendix Figure II. Field plot diagram--Huntley Experiment.

Rep. I

	24	23	20	19	12	11	14	13	4	3	10	9	30	29	22	21
															
↑	18	17	32	31	6	5	8	7	28	27	16	15	2	1	26	25
N																

Plot size 18' x 40', not to scale

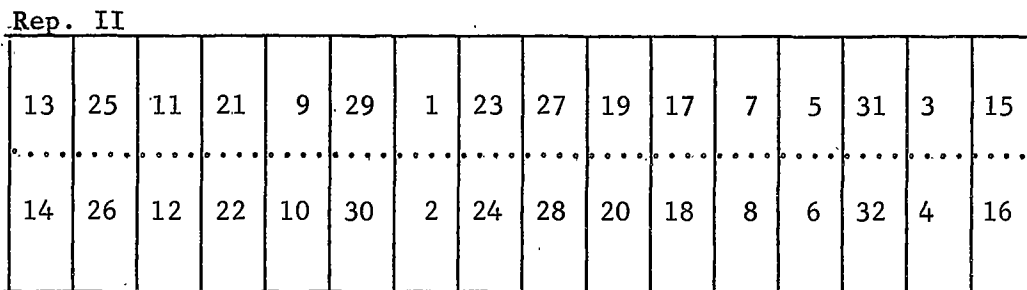
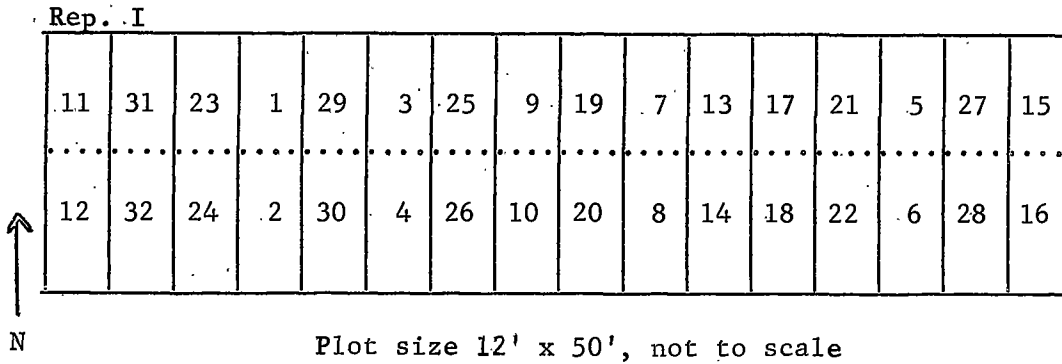
Rep. II

20	19	8	7	24	23	10	9	18	17	2	1	32	31	26	25
.....															
30	29	4	3	14	13	28	27	12	11	6	5	16	15	22	21

Treatments used at the field experiment at Huntley

Treat. No.	lbs/A			Treat. No.	lbs/A		
	N	P ₂ O ₅	K ₂ O		N	P ₂ O ₅	K ₂ O
1.	0	0	0	17.	150	0	0
2.	0	100	0	18.	150	100	0
3.	45	0	0	19.	165	0	0
4.	45	100	0	20.	165	100	0
5.	60	0	0	21.	180	0	0
6.	60	100	0	22.	180	100	0
7.	75	0	0	23.	210	0	0
8.	75	100	0	24.	210	100	0
9.	90	0	0	25.	240	0	0
10.	90	100	0	26.	240	100	0
11.	105	0	0	27.	270	0	0
12.	105	100	0	28.	270	100	0
13.	120	0	0	29.	300	0	0
14.	120	100	0	30.	300	100	0
15.	135	0	0	31.	105	0	100
16.	135	100	0	32.	105	100	100

Appendix figure III. Field plot diagram--Columbus experiment.



Treatments used at the field experiment at Columbus.

Treat. No.	lbs/A			Treat. No.	lbs/A		
	N	P ₂ O ₅	K ₂ O		N	P ₂ O ₅	K ₂ O
1.	0	0	0	17.	165	0	0
2.	0	100	0	18.	165	100	0
3.	45	0	0	19.	176	0	0
4.	45	100	0	20.	176	100	0
5.	60	0	0	21.	203	0	0
6.	60	100	0	22.	203	100	0
7.	72	0	0	23.	225	0	0
8.	72	100	0	24.	225	100	0
9.	95	0	0	25.	244	0	0
10.	95	100	0	26.	244	100	0
11.	106	0	0	27.	269	0	0
12.	106	100	0	28.	269	100	0
13.	122	0	0	29.	302	0	0
14.	122	100	0	30.	302	100	0
15.	149	0	0	31.	93	0	100
16.	149	100	0	32.	93	100	100

Appendix table 1. Cropping history and soil testing results for the Bozeman, Huntley, and Columbus experiments.

Information	Location		
	Bozeman	Huntley	Columbus
	<u>Crop History</u>		
1960	Barley	Sugar Beets	Alfalfa degenerated to grass
1959	Sweet Clover plowed down	Sugar Beets	"
1958	Winter wheat	Beans	"
1957	Peas	Sugar Beets	"
1956	?	Beans	"
	<u>Fert. History</u>		
1960	none	60 lbs N + 70 lbs P ₂ O ₅	none
1959	none	60 lbs N + 70 lbs P ₂ O ₅	none
1958	none	none	none
1957	P ₂ O ₅	none	none
1956	?	none	none
	<u>Soil Test</u>		
pH	7.2	7.8	7.6
Cond. mmhos/c.m.	0.7	2.1 - sl. salty	0.2
% O. M.	2.8 - low	2.3 - low	2.8 - low
P ₂ O ₅ - lbs/A	195 - low	380 - high	160 - low
Lime	-	+	+
Texture	SL. Med.	Si. L. Med.	SL. Med.

Appendix table 2. Climatological data (31) 1961 growing season, Huntley, Columbus, Bozeman.

Location	Month	Temperature (F ⁰)			Degree days 1)	Precip. in.	Evap 2) in.	Wind 3)	4" Soil Temp.	
		Max.	Min.	Mean					Max.	Min.
Bozeman	April	51.3	28.5	39.9	741	2.49	B3.26	2,431	---	---
"	May	64.7	39.0	51.9	406	1.39	6.11	2,819	---	---
"	June	81.1	50.1	65.6	60	0.82	8.74	2,202	---	---
"	July	86.0	52.9	69.5	5	0.71	10.07	2,258	---	---
"	Aug.	86.1	52.8	69.5	13	0.58	B7.54	1,792	---	---
"	Sept.	<u>60.5</u>	<u>37.1</u>	<u>48.8</u>	<u>477</u>	<u>4.90</u>	<u>B3.81</u>	<u>1,663</u>	---	---
Average Total		71.6	43.4	57.5	1,702	10.89	39.53	13,165		
.....										
Huntley	April	59.0	29.8	44.4	610	1.43	B4.59	3,041	52.3	43.1
"	May	71.9	42.6	57.3	257	1.75	6.31	2,168	65.1	54.9
"	June	87.1	51.0	69.1	17	0.47	8.99	1,522	81.1	68.0
"	July	89.2	55.7	72.5	0	0.70	10.25	1,995	84.0	71.6
"	Aug.	92.7	54.2	73.5	4	0.28	9.27	1,651	82.3	70.4
"	Sept.	<u>66.4</u>	<u>39.1</u>	<u>52.8</u>	<u>367</u>	<u>4.75</u>	<u>B4.11</u>	<u>1,707</u>	<u>62.3</u>	<u>53.5</u>
Average Total		77.7	45.4	61.6	1,255	9.38	43.52	12,084	71.2	60.3
.....										
Columbus	April	58.7M	28.4	43.6M	632	1.41	---	---	---	---
"	May	69.8	39.5	54.7	321	2.76	---	---	---	---
"	June	88.0	50.0	69.0	10	0.10	---	---	---	---
"	July	89.4	56.0	72.7	0	0.53	---	---	---	---
"	Aug.	91.7	52.7	72.2	9	0.44	---	---	---	---
"	Sept.	<u>66.6</u>	<u>38.2</u>	<u>52.4</u>	<u>380</u>	<u>3.48</u>				
Average Total		77.4	44.1	60.8	1,352	8.72				

- 1) Monthly degree day totals are the sums of the negative departures of average daily temperatures from 65°F.
 - 2) Evaporation measured in standard weather bureau type pan 4 feet in diameter.
 - 3) Air movement in miles.
- B. Adjusted to a full month.
M. One or more days of record missing; if is entered, less than 10 days record is missing.

Appendix table 3. Assembly of individual plot data and analysis of variance for yields of corn silage as influenced by rates of N and P fertilizer applied at seeding, Boseman, Montana, 1961.

N rate lbs/A	Silage Yield (Tons/Acre. at 70% Moisture)						Mean
	0 lbs P ₂ O ₅ /A			100 lbs P ₂ O ₅ /A			
	Rep. I	Rep. II	Mean	Rep. I	Rep. II	Mean	
0	11.9	12.8	12.4	11.1	12.4	11.8	12.1a
47	16.4	17.4	16.9	16.3	16.2	16.3	16.6 b
68	18.7	16.6	17.7	17.2	17.7	17.5	17.6 b
87	16.1	17.3	16.7	17.1	17.1	17.1	16.9 b
106	17.7	18.4	18.1	17.4	18.0	17.7	17.9 b
112	16.9	17.2	17.1	16.9	17.8	17.4	17.3 b
127	17.1	18.1	17.6	18.3	17.8	18.1	17.9 b
138	18.4	17.1	17.8	16.8	18.5	17.7	17.8 b
149	18.1	16.8	17.5	16.6	16.3	16.5	17.0 b
173	17.3	21.0	19.2	16.7	17.6	17.2	18.2 b
180	17.7	17.3	17.5	17.4	16.8	17.1	17.3 b
214	19.8	17.8	18.8	18.7	16.7	17.7	18.3 b
248	17.1	17.2	17.2	17.5	17.6	17.6	17.4 b
280	18.8	15.9	17.4	18.1	17.1	17.6	17.5 b
317	17.3	15.4	16.4	18.6	16.6	17.6	17.0 b
Mean			17.0z			17.0z	17.1

Sources of variation	d.f.	Sum of squares	Mean square	s	Cal. F.
Replication	1	0.2	0.2		0.133
N rates	14	120.9	8.6		5.733**
Error A	14	20.9	1.5	1.23	
Plots of N	29	142.0			
Replication	1	0.2	0.2		0.2
P rates	1	0.8	0.8		0.8
Error B	1	0.1	0.1	0.33	
Plots of P	3	1.1			
N x P Inter	14	8.8	0.6		1.0
Error C	14	8.3	0.6	0.78	
Grand total	59	160.0			

** Significant at 1% level

Appendix table 4. Assembly of individual plot data and analysis of variance for protein content of corn silage as influenced by rates of N and P fertilizer applied at seeding, Bozeman, Montana, 1961.

N rate lbs/A	% Protein (Dry matter basis)							Mean	
	0 lbs P ₂ O ₅ /A			100 lbs P ₂ O ₅ /A					
	Rep I	Rep II	Mean	Rep I	Rep II	Mean			
0	4.5	4.7	4.6	4.3	4.6	4.5	4.5a		
47	6.0	6.1	6.1	5.5	6.9	6.2	6.1 b		
68	6.3	6.4	6.4	6.4	6.3	6.4	6.4 bc		
87	6.9	7.3	7.3	6.7	7.2	7.0	7.1 cd		
106	7.9	6.9	7.4	7.8	7.0	7.4	7.4 de		
112	7.5	7.9	7.7	8.2	7.7	8.0	7.8 def		
127	7.1	7.6	7.4	6.7	7.8	7.3	7.3 d		
138	7.3	8.2	7.8	7.6	7.5	7.6	7.7 def		
149	7.2	8.9	8.1	8.4	8.2	8.3	8.2 efg		
173	8.3	8.3	8.3	8.4	8.4	8.4	8.4 fg		
180	8.2	8.2	8.2	8.3	9.1	8.7	8.5 fg		
214	8.6	9.6	9.1	8.2	9.1	8.7	8.9 gh		
248	8.9	9.2	9.1	9.9	9.4	9.7	9.4 h		
280	9.5	9.8	9.7	9.2	9.5	9.4	9.5 h		
317	9.1	9.3	9.2	9.6	9.4	9.5	9.4 h		
Mean			7.7z			7.8z	7.8		

Sources of variation	d.f.	Sum of squares	Mean square	s	Cal. F.
Replication	1	1.1	1.1		4.78
N rates	14	105.0	7.5		32.61**
Error A	14	3.2	0.23	0.480	
Plots of N	29	109.3			
Replication	1	1.1	1.1		5.5
P rates	1	0.0	0.0		0.0
Error B	1	0.2	0.2	0.448	
Plots of P	3	1.3			
N x P Inter	14	1.3	0.1		0.67
Error C	14	2.1	0.15	0.388	
Grand total	59	112.9			

** Significant at 1% level

Appendix table 5. Assembly of individual plot data and analysis of variance for P content of corn silage as influenced by rates of N and P fertilizer applied at seeding, Bozeman, Montana, 1961.

N rate lbs/A	% P (Dry matter basis)						
	0 lbs P ₂ O ₅ /A			100 lbs P ₂ O ₅ /A			
	Rep I	Rep II	Mean	Rep I	Rep II	Mean	Mean
0	0.195	0.195	0.195	0.230	0.237	0.234	0.215a
47	0.195	0.195	0.195	0.212	0.257	0.235	0.215a
106	0.237	0.205	0.221	0.245	0.245	0.245	0.233a
214	0.237	0.230	0.234	0.200	0.212	0.206	0.220a
317	0.205	0.200	0.203	0.230	0.250	0.240	0.222a
Mean			0.210z			0.232z	0.221

Source of variation	d.f.	Sum of squares	Mean square	s	Cal. F.
Replications	1	0.0001	0.0001		0.500
N rate	4	0.0009	0.00023		1.150
Error A	4	0.0008	0.0002	0.01414	
Plots of N	9	0.0018			
Replications	1	0.0001	0.0001		0.125
P rate	1	0.0025	0.0025		2.125
Error B	1	0.0008	0.0008	0.02829	
Plots of P	3	0.0034			
P x N Inter	4	0.0033	0.00083		27.667**
Error C	4	0.0001	0.00003	0.00548	
Grand total	19	0.0085			

** Significant at 1% level

Appendix table 6. Analysis of variance for P content of corn silage as influenced by rates of N, with P fertilizer, applied at seeding, Bozeman, Montana, 1961.

Source of variation	d.f.	Sum of squares	Mean square	s	Cal. F.
Replication	1	0.00071	0.00071		4.733
N rate	4	0.00184	0.00046		3.067
Error	4	0.00060	0.00015	0.01225	
Total	9	0.00315			

Appendix table 7. Analysis of variance for P content of corn silage as influenced by rates of N, without P fertilizer, applied at seeding, Bozeman, Montana, 1961.

Source of variation	d.f.	Sum of squares	Mean square	s	Cal. F.
Replications	1	0.00020	0.00020		2.222
N rate	4	0.00236	0.00059		6.556*
Error	4	0.00035	0.00009	0.00949	
Total	9	0.00291			

* Significant at 5 % level

Appendix table 8. Assembly of individual plot data and analysis of variance for protein content of the 3rd leaf of corn on July 17, (49 days from seeding) as influenced by rates of N and P fertilizer applied at seeding, Bozeman, Montana, 1961.

N rate lbs/A	% Protein (Dry matter basis)						
	0 lbs P ₂ O ₅ /A			100 lbs P ₂ O ₅ /A			Mean
	Rep I	Rep II	Mean	Rep I	Rep II	Mean	
0	14.9	16.9	15.9	15.1	16.2	15.7	15.8a
47	20.2	21.5	20.9	18.6	21.3	20.0	20.5 b
68	20.8	21.1	21.0	20.4	20.8	20.6	20.8 bc
87	20.4	21.5	21.0	21.1	21.1	21.1	21.1 bcd
106	22.6	20.6	21.6	21.5	21.9	21.7	21.7 bcde
112	22.4	22.6	22.5	21.9	21.7	21.8	22.2 def
127	21.5	21.3	21.4	22.1	22.8	22.5	22.0 cde
138	22.4	21.9	22.2	22.1	22.1	21.1	22.2 def
149	21.9	22.1	21.5	22.4	22.1	22.3	21.9 cde
173	21.9	21.9	21.9	22.4	21.7	22.1	22.0 cde
180	22.8	23.2	23.0	22.1	22.6	22.4	22.7 efg
214	23.2	24.3	23.7	22.6	23.5	23.1	23.4 fg
248	23.9	23.5	23.7	23.5	22.8	23.2	23.5 g
280	21.4	23.0	22.2	22.8	22.6	22.7	22.5 efg
317	22.4	23.0	22.7	22.8	23.2	23.0	22.9 efg
Mean			21.7z			21.6z	21.6

Source of variation	d.f.	Sum of squares	Mean square	s	Cal. F.
Replication	1	1.9	1.9		3.167
N rates	14	189.9	13.6		22.667**
Error A	14	8.1	0.6	0.775	
Plots of N	29	199.9			
Replication	1	1.910	1.910		272.86
P rates	1	0.183	0.187		26.71
Error B	1	0.007	0.007	0.084	
Plots of P	3	2.100			
N x P Inter	14	4.2	0.30		1.15
Error C	14	3.6	0.26	0.51	
Grand total	59	207.9			

** Significant at 1% level

Appendix table 9. Assembly of individual plot data and analysis of variance for protein content of the 3rd leaf of corn on Aug. 4, (67 days from seeding) as influenced by rates of N and P fertilizer applied at seeding, Bozeman, Montana, 1961.

N rate lbs/A	% Protein (Dry matter basis)						Mean	
	0 lbs P ₂ O ₅ /A			100 lbs P ₂ O ₅ /A				
	Rep I	Rep II	Mean	Rep I	Rep II	Mean		
0	11.2	12.1	11.7	11.0	11.6	11.3	11.5a	
47	16.2	18.0	17.1	14.7	16.7	15.7	16.4 b	
68	17.1	16.7	16.9	17.3	16.7	17.0	17.0 bc	
87	17.5	18.4	18.0	18.4	17.8	18.1	18.1 cd	
106	19.7	18.0	18.9	19.7	18.9	19.3	19.1 de	
112	20.4	18.6	19.5	18.9	18.4	18.7	19.1 de	
127	19.5	19.3	19.4	19.3	19.5	19.4	19.4 de	
138	19.3	18.9	19.1	19.7	20.0	19.9	19.5 e	
149	19.5	20.2	19.9	19.5	20.0	19.8	19.9 ef	
173	20.2	20.0	20.1	20.2	20.4	20.3	20.2 efg	
180	20.2	20.2	20.2	19.7	19.5	19.6	19.9 ef	
214	20.4	20.4	20.4	20.4	20.0	20.2	20.3 efg	
248	20.4	21.5	21.0	20.8	21.1	21.0	20.0 fg	
280	21.5	20.6	21.1	20.8	20.4	20.6	20.9 fg	
317	21.1	20.6	20.9	21.1	21.1	21.1	21.5 g	
Mean			18.9z			18.8z	18.9	

Source of variation	d.f.	Sum of squares	Mean square	s	Cal. F.
Replication	1	0.0	0.0		0.00
N rates	14	336.9	24.1		4.02**
Error A	14	8.7	0.6	0.775	
Plots of N	29	345.6			
Replication	1	0.001	0.001		.034
P rates	1	0.281	0.281		9.690
Error B	1	0.029	0.029	0.170	
Plots of P	3	0.311			
N x P Inter.	14	4.0	0.286		2.103
Error C	14	1.9	0.136	0.369	
Grand total	59	351.8			

** Significant at 1% level

Appendix table 10. Assembly of individual plot data and analysis of variance for protein content of the 3rd leaf of corn on Aug. 18 (81 days from seeding) as influenced by rates of N and P fertilizer applied at seeding, Bozeman, Montana, 1961.

N rate lbs/A	% Protein (Dry matter basis)						Mean	
	0 lbs P ₂ O ₅ /A			100 lbs P ₂ O ₅ /A				
	Rep I	Rep II	Mean	Rep I	Rep II	Mean		
0	6.6	6.5	6.6	5.9	5.9	6.0	6.3a	
47	11.7	11.8	11.8	10.1	11.6	10.9	11.4 b	
68	12.0	12.4	12.2	11.2	12.1	11.7	12.0 b	
87	13.6	13.3	13.5	13.7	14.0	13.9	13.7 c	
106	16.0	14.1	15.1	16.0	14.9	15.5	15.3 d	
112	16.2	15.4	15.8	15.5	15.6	15.6	15.7 de	
127	16.7	15.7	16.2	15.3	15.9	15.6	15.9 de	
138	16.3	16.0	16.2	16.7	16.9	16.8	16.5 def	
149	16.2	16.4	16.3	16.9	16.6	16.8	16.6 .efg	
173	15.9	17.0	16.5	15.5	16.7	16.1	16.3 def	
180	17.5	17.1	17.3	17.1	16.8	17.0	17.2 fgh	
214	16.8	17.4	17.1	16.8	17.5	17.2	17.2 fgh	
248	17.8	17.3	17.6	18.1	17.9	18.0	17.8 gh	
280	18.1	17.4	17.8	18.3	17.3	17.8	17.8 gh	
317	18.6	18.3	18.5	18.0	18.6	18.3	18.4 h	
Mean			15.2z			15.1z	15.2	

Source of variation	d.f.	Sum of squares	Mean square	s	Cal. F.
Replication	1	0.0	0.0		0.0
N rate	14	577.7	41.3		82.6**
Error A	14	6.3	0.5	0.71	
Plots of N	29	584.0			
Replication	1	0.0	0.0		0.0
P rates	1	0.2	0.2		0.25
Error B	1	0.8	0.8	0.89	
Plots of P	3	1.0			
N x P Inter	14	3.2	0.2		2.0
Error C	14	1.1	0.1	0.32	
Grand total	59	589.3			

** Significant at the 1% level

Appendix table 11. Assembly of individual plot data and analysis of variance for protein content of the 3rd leaf of corn on Sept. 12, (106 days from seeding) as influenced by rates of N and P fertilizer applied at seeding, Bozeman, Montana, 1961.

N rate lbs/A	% Protein (Dry matter basis)						Mean	
	0 lbs P ₂ O ₅ /A			100 lbs P ₂ O ₅ /A				
	Rep I	Rep II	Mean	Rep I	Rep II	Mean		
0	3.6	4.2	3.9	3.5	3.7	3.6	3.8a	
47	7.3	6.4	6.9	4.8	6.3	5.6	6.3 b	
68	7.5	8.4	8.0	6.1	7.3	6.7	6.9 b	
87	10.9	10.5	10.7	8.4	10.3	9.4	10.1 c	
106	13.6	11.6	12.6	13.7	10.7	12.2	12.4 de	
112	13.6	12.5	12.1	13.8	11.4	12.6	12.9 def	
127	11.6	13.5	12.6	10.1	13.4	11.8	12.2 d	
138	13.2	13.6	13.4	12.8	14.5	13.7	13.6 defg	
149	14.0	14.7	14.4	13.3	14.1	13.7	14.1 defgh	
173	15.2	14.4	14.8	13.8	14.0	13.9	14.4 efgh	
180	14.8	15.4	15.1	14.4	14.8	14.6	14.9 fghi	
214	15.9	15.2	15.6	15.6	15.0	15.3	15.5 ghi	
248	15.8	15.1	15.5	15.1	15.0	15.1	15.3 ghi	
280	16.3	15.8	16.1	15.9	15.1	15.5	15.8 hi	
317	17.0	16.7	16.9	16.2	16.7	16.5	16.7 i	
Mean			12.6z			12.0z	12.3	

Source of variation	d.f.	Sum of squares	Mean square	s	Cal. F.
Replication	1	0.1	0.1		0.067
N rate	14	820.8	58.6		39.1**
Error A	14	20.9	1.5	1.22	
Plots of N	29	841.8			
Replication	1	0.1	0.1		0.125
P rates	1	5.7	5.7		7.13
Error B	1	0.8	0.8	0.9	
Plots of P	3	6.6			
N x P Inter	14	2.7	0.19		0.655
Error C	14	4.1	0.29	0.54	
Grand total	59	855.1			

** Significant at the 1% level

Appendix table 12. Analysis of variance 1) for protein content of the 3rd leaf of corn as influenced by date of sampling and rates of N and P fertilizer, applied at seeding, Bozeman, Montana, 1961.

Analysis of Variance

Source of variation	d.f.	Sum of squares	Mean square	s	Cal. F.
Replications	1	0.7	0.7		1.75
Dates (D)	3	3030.5	1010.2		2525.5**
Error A	3	1.3	0.4	0.64	
Plots of Dates	7	3032.5			
Replications	1	0.7	0.7		0.78
Phosphorus (P)	1	3.4	3.4		3.78
Error B	1	0.9	0.9	0.95	
Plots of P	3	5.0			
Replications	1	0.7	0.7		0.47
Nitrogen (N)	14	1738.6	124.2		82.8**
Error C	14	21.1	1.5	1.23	
Plots of N	29	1760.4			
D x P	3	2.9	1.0		3.33
Error D	3	0.8	0.3	0.55	
Plots of D x P	15	3040.5			
D x N	42	186.6	4.4		8.80**
Error E	42	21.1	0.5	0.71	
Plots of D x N	119	5001.7			
N x P	14	7.1	0.5		1.00
Error F	14	6.5	0.5	0.71	
Plots of N x P	59	1778.3			
D x N x P	42	7.0	0.167		1.18
Error G	42	6.0	0.1430	.38	
Grand total	239	5034.5			

1) For this analysis dates were considered as the second systematic split.

** Significant at the 1% level

Appendix table 13. Assembly of individual plot data and analysis of variance for yield of corn silage, as influenced by rates of N and P fertilizer side-dressed, Huntley, Montana, 1961.

N rate lbs/A	Yield (Tons/Acre at 70% moisture)						Mean
	0 lbs P ₂ O ₅ /A			100 lbs P ₂ O ₅ /A			
	Rep I	Rep II	Mean	Rep I	Rep II	Mean	
0	25.8	27.7	26.8	26.2	24.3	25.3	26.0a
45	25.6	25.4	25.5	27.6	30.2	28.9	27.2a
60	28.4	23.3	25.9	23.2	27.1	25.2	25.5a
75	26.0	23.3	24.7	24.2	24.5	24.4	24.5a
90	26.8	26.4	26.6	25.4	23.2	24.8	25.7a
105	24.3	30.1	27.2	28.5	29.5	29.0	28.1a
120	23.4	26.8	25.1	27.2	27.2	27.2	26.2a
135	25.5	31.5	28.5	25.6	24.6	25.1	26.8a
150	21.6	25.6	23.6	21.7	26.5	24.1	23.9a
165	28.3	24.2	26.3	26.0	25.6	25.8	26.0a
180	21.4	30.0	25.7	25.3	29.5	27.4	26.6a
210	30.2	25.2	27.7	31.1	23.3	27.2	27.5a
240	23.6	25.9	24.8	22.7	25.1	23.9	24.4a
270	26.1	27.6	26.9	24.9	28.6	26.8	26.8a
300	25.1	28.3	26.7	21.9	30.5	26.2	26.5a
Mean			26.1z			26.1z	26.1

Source of variation	d.f.	Sum of squares	Mean square	s	Cal. F.
Replication	1	22.1	22.1		2.08
N rates	14	78.6	5.6		0.53
Error A	14	158.6	10.6	3.26	
Plots of N	29	259.3			
Replication	1	22.1	22.1		221.0
P rates	1	0.0	0.0		0.0
Error B	1	0.1	0.1	0.32	
Plots of P	3	22.2			
N x P Inter.	14	41.5	3.0		0.6
Error C	14	69.6	5.0	2.24	
Grand total	59	370.5			

Appendix table 14. Assembly of individual plot data and analysis of variance for yield of shelled corn (grain), as influenced by rates of N and P fertilizer side-dressed, Huntley, Montana, 1961.

N rates lbs/A	Yield (56 pound bushels/A at 15.5% moisture)						
	0 lbs P ₂ O ₅ /A			100 lbs P ₂ O ₅ /A			Mean
	Rep I	Rep II	Mean	Rep I	Rep II	Mean	
0	136.1	134.9	135.5	143.1	171.1	157.2	146.4a
45	133.9	159.9	146.9	174.3	162.9	168.6	157.8a
60	159.0	147.8	153.4	184.3	128.3	156.6	155.0a
75	159.5	167.1	163.3	167.9	173.9	170.9	167.1a
90	145.3	173.0	159.2	174.0	174.6	174.3	166.7a
105	174.3	166.8	170.8	176.0	151.0	163.5	167.0a
120	172.4	168.5	170.5	149.4	158.6	154.0	162.2a
135	145.8	137.6	141.7	174.3	162.8	168.6	155.1a
150	167.9	163.8	165.9	145.9	165.8	155.9	160.9a
165	181.8	177.5	179.7	152.9	162.6	157.8	168.7a
180	172.6	185.4	179.0	159.9	164.5	162.2	170.6a
210	155.3	169.3	162.3	143.8	165.1	154.5	158.4a
240	168.1	164.4	166.3	183.8	178.1	181.0	173.6a
270	172.6	121.3	147.0	172.4	183.1	177.8	162.5a
300	148.8	167.6	158.2	158.2	197.6	178.1	168.1a
Mean			159.9z			165.4z	162.7

Source of variation	d.f.	Sum of squares	Mean square	s	Cal. F.
Replication	1	44.5	44.4		0.171
N rates	14	2929.0	209.2		0.803
Error A	14	3647.1	260.5	16.14	
N totals	29	6620.6			
Replication	1	44.5	44.5		3.22
P rates	1	442.2	442.2		32.04
Error B	1	13.8	13.8	3.72	
P totals	3	500.5			
N x P Inter	14	4320.2	308.6		1.64
Error C	14	2637.2	188.4	13.73	
Grand total	59	14034.0			

Appendix table 15. Assembly of individual plot data and analysis of variance for protein content of corn silage, as influenced by rates of N and P fertilizer, side-dressed, Huntley, Montana, 1961.

N rate lbs/A	% Protein (Dry matter basis)						
	0 lbs P ₂ O ₅ /A			100 lbs P ₂ O ₅ /A			Mean
	Rep I	Rep II	Mean	Rep I	Rep II	Mean	
0	6.3	5.5	5.9	6.1	6.0	6.1	6.0a
45	7.7	7.3	7.5	7.1	7.2	7.2	7.3 bcd
60	7.9	6.1	7.0	7.6	6.5	7.1	7.0 b
75	7.9	7.9	7.9	8.2	7.4	7.8	7.9 bcd
90	7.2	7.0	7.1	7.7	7.3	7.5	7.3 bcd
105	8.0	6.8	7.4	8.4	6.4	7.4	7.4 bcd
120	8.0	7.1	7.6	8.0	7.1	7.6	7.6 bcd
135	7.3	7.1	7.2	7.1	6.8	7.0	7.1 bc
150	8.1	7.0	7.6	7.9	7.0	7.5	7.5 bcd
165	8.0	8.2	8.1	8.4	8.2	8.3	8.2 d
180	8.2	6.9	7.6	7.6	6.9	7.3	7.4 bcd
210	8.7	8.0	8.4	8.4	7.4	7.9	8.1 cd
240	8.7	7.3	8.0	8.6	6.8	7.7	7.9 bcd
270	8.2	7.2	7.7	8.1	6.8	7.5	7.6 bcd
300	8.9	7.8	8.4	8.3	7.3	7.8	8.1 cd
Mean			7.5z			7.4z	7.5

Source of variation	d.f.	Sum of squares	Mean square	s	Cal. F.
Replication	1	9.9	9.9		33.0
N rate	14	17.2	1.2		4.00**
Error A	14	3.8	0.3	0.55	
Plots of N	29	30.9			
Replication	1	9.8414	9.8414		2288.7
P rates	1	1.2281	0.2281		53.0
Error B	1	0.0043	0.0043	0.0655	
Plots of P	3	10.0738			
N x P Inter	14	1.0	0.071		1.25
Error C	14	0.8	0.057	0.239	
Grand total	59	32.9			

** Significant at the 1% level

Appendix table 16. Assembly of individual plot data and analysis of variance for protein content of shelled corn (grain) as influenced by rates of N and P fertilizer, side-dressed, Huntley, Montana, 1961.

N rate lbs/A	% Protein (Dry matter basis)						Mean
	0 lbs P ₂ O ₅ /A			100 lbs P ₂ O ₅ /A			
	Rep I	Rep II	Mean	Rep I	Rep II	Mean	
0	8.4	7.7	8.1	8.0	8.0	8.0	8.0a
45	9.3	9.9	9.6	9.0	9.2	9.1	9.4 bc
60	9.1	8.8	9.0	9.0	9.5	9.3	9.1 b
75	9.2	9.5	9.4	9.4	9.2	9.3	9.3 bc
90	9.6	9.7	9.7	8.7	9.4	9.1	9.4 bc
105	9.5	9.0	9.3	9.8	9.0	9.4	9.3 bc
120	9.3	9.9	9.6	9.9	9.7	9.8	9.7 c
135	9.4	9.4	9.4	9.2	9.2	9.2	9.3 bc
150	9.2	9.2	9.2	9.2	9.2	9.2	9.2 bc
165	9.6	9.7	9.7	9.3	9.1	9.2	9.4 bc
180	9.1	9.3	9.2	9.4	9.3	9.4	9.3 bc
210	9.6	9.1	9.4	9.4	9.4	9.4	9.4 bc
240	9.1	9.6	9.4	9.4	9.4	9.4	9.4 bc
270	9.2	9.5	9.4	9.5	9.7	9.6	9.5 bc
300	9.8	9.3	9.6	9.2	9.6	9.4	9.5 bc
Mean			9.3z			9.3z	9.3

Source of variation	d.f.	Sum of squares	Mean square	s	Cal. F.
Replication	1	0.0	0.0		0.0
N rate	14	7.7	0.55		7.05**
Error A	14	1.1	0.078	0.279	
Plots of N	29	8.8			
Replication	1	0.0	0.0		0.0
P rates	1	0.1	0.1		1.0
Error B	1	0.1	0.1	0.32	
Plots of P	3	0.2			
N x P Inter	14	1.1	0.078		1.22
Error C	14	0.9	0.064	0.253	
Grand total	59	11.0			

** Significant at the 1% level

Appendix table 17. Assembly of individual plot data and analysis of variance for P content of corn silage as influenced by rates of N and P fertilizer, side-dressed, Huntley, Montana, 1961.

N rate lbs/A	% of P (Dry matter basis)						Mean
	0 lbs P ₂ O ₅ /A			100 lbs P ₂ O ₅ /A			
	Rep I	Rep II	Mean	Rep I	Rep II	Mean	
0	0.250	0.250	0.250	0.265	0.265	0.265	0.258a
60	0.282	0.250	0.266	0.223	0.257	0.240	0.253a
105	0.273	0.245	0.259	0.305	0.237	0.271	0.265a
210	0.305	0.273	0.289	0.223	0.265	0.244	0.267a
300	0.282	0.305	0.294	0.237	0.282	0.260	0.277a
Mean			0.272z			0.256z	0.264

Source of variation	d.f.	Sum of squares	Mean square	s	Cal. F.
Replication	1	0.00005	0.00005		0.058
N rates	4	0.00130	0.00033		0.384
Error A	4	0.00345	0.00086	0.02933	
Plots of N	9	0.00480			
Replication	1	0.00005	0.00005		0.071
P rates	1	0.00122	0.00122		1.720
Error B	1	0.00071	0.00071	0.02665	
Plots of P	3	0.00198			
P x N inter	4	0.00302	0.00076		1.357
Error C	4	0.00225	0.00056	0.02367	
Grand total	19	0.01200			

Appendix table 18. Assembly of individual plot data and analysis of variance for P content of shelled corn (grain) (dry matter basis) as influenced by rates of N and P fertilizer, side-dressed, Huntley, Montana, 1961.

N. rate lbs/A	% P (Dry matter basis)						Mean
	0 lbs P ₂ O ₅ /A			100 lbs P ₂ O ₅ /A			
	Rep I	Rep II	Mean	Rep I	Rep II	Mean	
0	0.377	0.390	0.384	0.418	0.405	0.412	0.398a
60	0.405	0.500	0.453	0.390	0.432	0.411	0.432a
105	0.447	0.405	0.426	0.405	0.390	0.398	0.412a
210	0.432	0.377	0.405	0.418	0.405	0.412	0.409a
300	0.418	0.377	0.398	0.325	0.367	0.346	0.372a
Mean			0.413z			0.399z	0.404

Source of variation	d.f.	Sum of squares	Mean square	s	Cal. F
Replication	1	0.0001	0.0001		0.0613
N rates	4	0.0078	0.00195		1.196
Error A	4	0.0065	0.00163	0.0404	
Plots of N	9	0.0144			
Replication	1	0.0001	0.0001		0.500
P rates	1	0.0015	0.0015		7.500
Error B	1	0.0002	0.0002	0.01414	
Plots of P	3	0.0018			
N x P Inter	4	0.0045	0.00113		1.449
Error C	4	0.0031	0.00078	0.02794	
Grand total	19	0.0237			

Appendix table 19. Assembly of individual plot data and analysis of variance for protein content of the 3rd leaf of corn on July 11, as influenced by rates of N and P fertilizer, side-dressed, Huntley, Montana, 1961.

N rate lbs/A	% Protein (Dry matter basis)						Mean
	0 lbs P ₂ O ₅ /A			100 lbs P ₂ O ₅ /A			
	Rep I	Rep II	Mean	Rep I	Rep II	Mean	
0	20.4	18.9	19.7	19.7	19.3	19.5	19.6a
45	20.6	19.7	20.2	20.0	20.2	20.1	20.1abcd
60	20.8	21.1	21.0	21.3	19.7	20.5	20.7 cde
75	20.0	20.4	20.2	19.1	20.0	19.6	19.9abc
90	20.8	20.2	20.5	20.6	20.0	20.3	20.4 bcde
105	20.4	19.7	20.1	21.3	20.0	20.7	20.4 bcde
120	21.1	20.6	20.9	21.3	21.3	21.3	21.1 e
135	20.2	20.6	20.4	20.4	20.4	20.4	20.4 bcde
150	19.5	20.2	19.9	19.7	19.7	19.7	19.8ab
165	20.6	19.7	20.2	20.8	21.1	21.0	20.6 bcde
180	21.3	20.8	21.1	21.1	21.3	21.2	21.1 e
210	20.4	20.4	20.4	20.2	20.8	20.5	20.5 bcde
240	21.5	20.8	21.2	21.3	21.1	21.2	21.2 e
270	20.4	20.6	20.5	20.4	20.2	20.3	20.4 bcde
300	21.7	20.8	21.3	20.6	20.6	20.6	20.9 de
Mean			20.5z			20.5z	20.5

Source of variation	d.f.	Sums of squares	Mean square	s	Cal. F.
Replication	1	0.9	0.9		4.5
N rates	14	13.4	1.0		5.0**
Error A	14	3.2	0.2	0.45	
Plots of N	29	17.5			
Replication	1	0.9	0.9		9.0
P rates	1	0.0	0.0		0.0
Error B	1	0.1	0.1	0.32	
Plots of P	3	1.0			
N x P Inter	14	2.5	0.2		1.0
Error C	14	2.6	0.2	0.45	
Grand total	59	22.7			

** Significant at the 1% level

Appendix table 20. Assembly of individual plot data and analysis of variance for protein content of the 3rd leaf of corn on Aug. 2, as influenced by rates of N and P fertilizer, side-dressed, Huntley, Montana, 1961.

N rate lbs/A	% Protein (Dry matter basis)						Mean
	0 lbs P ₂ O ₅ /A			100 lbs P ₂ O ₅ /A			
	Rep I	Rep II	Mean	Rep I	Rep II	Mean	
0	15.8	13.8	14.8	15.8	14.9	15.4	15.1a
45	17.1	17.8	17.5	16.2	18.6	17.4	17.4 b
60	18.0	16.4	17.2	17.8	17.5	17.7	17.4 b
75	17.3	17.3	17.3	17.3	16.4	17.3	16.9 b
90	17.3	17.3	17.3	17.1	17.5	17.3	17.3 b
105	17.8	16.9	17.4	17.8	16.4	17.1	17.2 b
120	18.2	18.2	18.2	17.8	18.6	18.2	18.2 b
135	16.7	17.3	17.0	17.1	17.5	17.3	17.2 b
150	18.0	17.3	17.7	18.4	17.8	18.1	17.9 b
165	17.8	18.4	18.1	17.5	18.4	18.4	18.0 b
180	16.2	17.5	16.9	17.3	17.1	17.2	17.0 b
210	19.1	17.9	18.5	18.0	18.4	18.2	18.4 b
240	17.3	16.9	17.1	18.4	18.4	18.3	17.7 b
270	17.8	18.0	17.9	17.3	17.8	17.6	17.7 b
300	17.8	19.1	18.5	16.7	17.5	17.1	17.8 b
Mean			17.4z			17.4z	17.4

Source of variation	d.f.	Sum of squares	Mean square	s	Cal. F.
Replication	1	0.0	0.0		0.0
N rate	14	32.9	2.4		3.4*
Error A	14	10.2	0.7	0.837	
Plots of N	29	43.1			
Replication	1	0.0	0.0		0.0
P rates	1	0.0	0.0		0.0
Error B	1	0.6	0.6	0.775	
Plots of P	3	0.6			
N x P Inter	14	4.7	0.3		1.5
Error C	14	2.6	0.2	0.45	
Grand total	59	51.0			

* Significant at the 5% level

Appendix table 21. Assembly of individual plot data and analysis of variance for yield of silage corn, as influenced by rates of N and P fertilizer applied at seeding, Columbus, Montana, 1961.

N rate lbs/A	Yield (Tons/Acre at 70% Moisture)						Mean
	0 lbs P ₂ O ₅ /A			100 lbs P ₂ O ₅ /A			
	Rep I	Rep II	Mean	Rep I	Rep II	Mean	
0	23.0	25.6	24.3	25.2	20.9	23.1	23.7a
45	19.3	23.7	21.5	21.8	19.3	20.6	21.0a
60	20.2	21.2	20.7	21.4	22.2	21.8	21.3a
72	23.9	22.3	23.1	23.8	22.1	23.0	23.0a
95	21.9	23.3	22.6	21.0	23.4	22.2	22.4a
106	22.0	22.1	22.1	20.1	15.9	18.0	20.0a
122	24.1	18.8	21.5	22.9	23.2	23.1	22.3a
149	19.2	14.4	16.8	21.6	14.1	17.9	17.3a
165	20.5	27.7	24.1	21.4	20.9	21.2	22.6a
176	25.8	17.4	21.6	26.6	20.5	23.6	22.6a
203	22.6	22.2	22.4	21.9	22.8	22.4	22.4a
225	21.6	21.1	21.4	21.9	21.3	23.6	22.0a
244	22.6	22.5	22.6	22.3	20.6	21.5	22.0a
269	19.8	21.3	20.6	22.2	21.6	21.9	21.2a
302	21.6	24.0	22.8	23.3	21.1	22.2	22.5a
Mean			21.9z			21.6z	21.8

Source of variation	d.f.	Sum of squares	Mean square	s	Cal. F
Replication	1	11.2	11.2		1.42
N rates	14	128.5	9.2		1.16
Error A	14	110.9	7.9	2.81	
Plots of N	29	250.6			
Replication	1	11.2	11.2		1.07
P rates	1	0.6	0.6		0.06
Error B	1	10.5	10.5	3.24	
Plots of P	3	22.3			
N x P Inter	14	40.8	2.9		0.78
Error C	14	52.3	3.7	1.92	
Grand total	59	354.8			

Appendix table 22. Assembly of individual plot data and analysis of variance for protein content of corn silage, as influenced by rate of N and P fertilizer applied at seeding, Columbus, Montana, 1961.

N rate lbs/A	% Protein (Dry matter basis)						
	0 lbs P ₂ O ₅ /A			100 lbs. P ₂ O ₅ /A			
	Rep I	Rep II	Mean	Rep I	Rep II	Mean	Mean
0	8.1	7.6	7.9	9.2	11.1	10.1	9.0a
45	7.5	10.2	8.9	8.9	10.7	9.8	8.3a
60	10.1	10.5	10.3	9.5	10.7	10.1	10.2a
72	8.7	10.5	9.6	8.0	10.5	9.3	9.4a
95	8.6	8.2	8.4	10.4	10.1	10.2	9.3a
106	9.1	10.5	9.8	10.6	12.6	11.6	10.7a
122	8.9	9.4	9.2	8.1	10.4	9.3	9.2a
149	12.0	11.6	11.8	10.5	13.7	12.1	12.0a
165	10.6	10.4	10.5	10.1	11.3	10.7	10.6a
176	9.1	10.1	9.6	8.8	10.7	9.8	9.7a
203	9.2	10.1	9.7	9.4	10.0	9.7	9.7a
225	9.2	8.0	8.6	10.9	10.2	10.6	9.6a
244	8.9	10.7	9.8	10.3	11.2	10.8	10.3a
269	11.3	8.6	10.0	11.2	11.4	11.3	10.6a
302	10.1	9.2	9.7	9.9	10.9	10.4	10.0a
Mean			9.6z			10.4z	10.0

Source of variation	d.f	Sum of squares	Mean square	s	Cal. F
Replication	1	9.6	9.6		8.73
N rates	14	33.9	2.4		2.18
Error A	14	15.3	1.1	1.05	
Plots of N	29	58.8			
Replication	1	9.6	9.6		2.29
P rates	1	9.6	9.6		2.29
Error B	1	4.2	4.2	2.05	
Plots of P	3	23.4			
N x P Inter	14	10.4	0.74		1.80
Error C	14	5.8	0.41	0.64	
Grand total	59	88.8			

Appendix table 23. Assembly of individual plot data and analysis of variance for content of corn silage, as influenced by rates of N and P fertilizer applied at seeding, Columbus, Montana, 1961.

N rate lbs/A	% Protein (Dry matter basis)							Mean
	0 lbs P ₂ O ₅ /A			100 lbs P ₂ O ₅ /A			Mean	
	Rep I	Rep II	Mean	Rep I	Rep II	Mean		
0	0.223	0.298	0.261	0.257	0.298	0.278	0.270a	
60	0.290	0.273	0.282	0.256	0.265	0.261	0.272a	
106	0.200	0.245	0.223	0.305	0.290	0.298	0.261a	
203	0.217	0.290	0.254	0.282	0.290	0.286	0.270a	
302	0.265	0.298	0.282	0.250	0.250	0.250	0.266a	
Mean			0.260z			0.275z	0.267	

Source of variation	d. f.	Sum of squares	Mean square	s	Cal. F
Replication	1	0.0032	0.0032		5.333
N rates	4	0.0004	0.0001		0.167
Error A	4	0.0023	0.0006	0.0245	
Plots of N	9	0.0059			
Replication	1	0.0032	0.0032		2.462
P rates	1	0.0011	0.11		0.846
Error B	1	0.0013	0.0013	0.0361	
Plots of P	3	0.0056			
N x P Inter	4	0.0073	0.00183		5.229
Error C	4	0.0014	0.00035	0.0187	
Grand Total	19	0.0170			

Appendix table 24. Assembly of individual plot data and analysis of variance for protein content of the 3rd leaf of corn on July 12, as influenced by rates of N and P fertilizer applied at seeding, Columbus, Montana, 1961.

N rate lbs/A	% Protein (Dry matter basis)						Mean
	0 lbs P ₂ O ₅ /A			100 lbs P ₂ O ₅ /A			
	Rep I	Rep II	Mean	Rep I	Rep II	Mean	
0	20.4	20.8	20.6	21.3	23.7	22.5	21.6a
45	20.8	24.6	22.7	22.1	25.4	23.8	23.2a
60	26.1	23.9	25.0	26.8	24.6	25.7	25.4a
72	23.2	23.2	23.2	22.6	24.6	23.6	23.4a
95	22.8	22.8	22.8	24.3	23.9	24.1	23.5a
106	24.1	25.4	24.8	24.6	25.2	24.9	24.8a
122	24.3	22.6	23.5	23.7	23.7	23.7	23.6a
149	25.4	25.4	25.4	25.9	25.7	25.8	25.6a
165	24.6	24.8	24.7	24.6	25.2	24.9	24.8a
176	22.4	23.0	22.7	21.9	24.0	23.0	22.8a
203	25.2	24.6	24.9	25.7	25.0	25.4	25.1a
225	24.8	21.5	23.2	25.4	24.3	24.9	24.0a
244	24.3	26.5	25.4	25.7	25.0	25.4	25.4a
269	23.2	24.6	23.9	23.7	25.9	24.8	24.4a
302	24.1	24.1	24.1	25.0	25.2	25.1	24.6a
Mean			23.8z			24.5z	24.1

Source of variation	d.f.	Sum of squares	Mean square	s	Cal. F
Replication	1	1.8	1.8		0.82
N rates	14	71.6	5.1		2.32
Error A	14	31.3	2.2	1.48	
Plots of N	29	104.7			
Replication	1	1.8	1.8		3.60
P rates	1	7.5	7.5		15.00
Error B	1	0.5	0.5	0.71	
Plots of P	3	9.8			
N x P Inter	14	4.8	0.34		0.72
Error C	14	6.6	0.47	0.69	
Grand total	59	124.1			

Appendix table 25. Assembly of individual plot data and analysis of variance for protein content of the 3rd leaf of corn on Aug. 1, as influenced by rates of N and P fertilizer applied at seeding, Columbus, Montana, 1961.

N rate lbs/A	% Protein (Dry matter basis)						Mean
	0 lbs P ₂ O ₅ /A			100 lbs P ₂ O ₅ /A			
	Rep I	Rep II	Mean	Rep I	Rep II	Mean	
0	16.0	15.4	15.7	17.1	18.4	17.8	16.7a
45	14.3	19.3	16.8	15.4	20.2	17.8	17.3a
60	18.0	18.9	18.5	19.5	19.1	19.3	18.9a
72	16.0	18.9	17.5	16.7	20.4	18.6	18.0a
95	16.7	15.8	16.3	18.4	18.9	18.7	17.5a
106	19.8	20.2	20.0	18.4	19.5	19.0	19.5a
122	18.4	16.7	17.6	18.6	19.3	19.0	18.3a
149	20.8	19.7	20.3	20.2	20.6	20.4	20.3a
165	18.0	19.5	18.8	19.1	19.7	19.4	19.1a
176	17.1	19.7	18.4	19.1	21.7	20.4	19.4a
203	17.3	19.5	18.4	19.7	19.1	19.4	18.9a
225	19.5	15.6	17.6	19.7	20.0	19.9	18.7a
244	16.7	21.5	19.9	19.7	20.6	20.2	19.6a
269	21.5	20.2	20.9	21.9	21.3	21.6	21.2a
302	19.5	19.1	19.3	20.4	20.4	20.4	19.9a
Mean			18.3z			19.4z	18.9

Source of variation	d.f.	Sum of squares	Mean square	s	Cal. F
Replication	1	11.0	11.0		3.33
N rate	14	80.5	5.8		1.77
Error A	14	45.9	3.3	1.82	
Plots of N	29	137.4			
Replication	1	11.0	11.0		27.5
P rates	1	18.7	18.7		46.8
Error B	1	0.4	0.4	0.63	
Plots of P	3	30.1			
N x P Inter	14	10.9	0.78		0.77
Error C	14	14.2	1.01	1.005	
Grand total	59	181.6			

Appendix table 26. Assembly of individual plot data and analysis of variance for protein content of the 3rd leaf of corn on Aug. 16, as influenced by rates of N and P fertilizer applied at seeding, Columbus, Montana, 1961.

N rate lbs/A	% Protein (Dry matter basis)						Mean
	0 lbs P ₂ O ₅ /A			100 lbs P ₂ O ₅ /A			
	Rep I	Rep II	Mean	Rep I	Rep II	Mean	
0	16.9	12.2	14.5	14.4	15.9	15.2	14.9a
45	6.3	14.3	10.3	10.4	14.5	12.5	11.4a
60	15.0	13.9	14.5	12.9	15.1	14.0	14.2a
72	10.5	15.5	13.0	11.5	16.0	13.8	13.4a
95	13.3	10.3	11.8	17.3	15.8	16.6	14.2a
106	14.4	10.0	12.2	14.9	14.9	14.9	13.6a
122	15.2	14.8	15.0	15.2	14.5	14.9	14.9a
149	14.9	12.5	13.7	16.9	12.3	14.6	14.2a
165	16.2	14.1	15.2	15.1	16.8	16.0	15.6a
176	14.6	16.2	15.4	15.1	16.6	15.9	15.6a
203	15.6	16.3	16.0	16.1	17.8	17.0	16.5a
225	18.1	11.0	14.6	17.2	16.3	16.8	15.7a
244	14.9	17.0	16.0	18.0	16.8	17.4	16.7a
269	15.9	14.8	15.4	17.4	17.9	17.7	16.5a
302	15.8	13.9	14.9	16.1	16.2	16.2	15.5a
Mean			14.1z			15.5z	14.9

Source of variation	d.f.	Sum of squares	Mean square	s	Cal. F
Replication	1	0.0	0.0		0.0
N rates	14	112.2	8.01		1.06
Error A	14	105.5	7.54	2.75	
Plots of N	29	217.7			
Replication	1	0.0	0.0		0.0
P rates	1	28.7	28.7		4.42
Error B	1	6.5	6.5	2.55	
Plots of P	3	35.2			
N x P Inter	14	23.5	1.68		0.69
Error C	14	34.1	2.44	1.56	
Grand total	59	310.5			

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