Relationships of factors affecting the growth and composition of corn forage on irrigated soils in Montana

by Richard Earl Watkins

A Thesis Submitted To The Graduate Faculty in Partial Fulfillment of the Requirement For The Degree Of MASTER OF SCIENCE in Agronomy
Montana State University

Abstract:
The relationship of silage yield, percent moisture at harvest, growth factors, and chemical composition of corn forage were studied. The data was collected from seven locations in Montana, punched on IBM cards, and simple-correlations were calculated by a computer.

Early planting's of late maturing varieties at high ,populations with adequate fertilization resulted in high forage yields.

High plant populations with late season plantings of late maturing varieties increased the percentage of moisture in the forage at harvest. Higher than average mean, summer- temperatures decreased the" moisture percentage of the plants at harvest.

Late maturing varieties produced tall plants which tasseled late in the season and were immature at harvest. The maturity rating had no effect on the chemical composition of the air dry forage at harvest.

The interrelationship of the components of chemical composition of the air dry forage indicates that as the percentage of crude protein in the forage increases, the percentage of crude fiber increases, and the percentage of nitrogen free extract decreases.

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ABSTRACT

The relationship of silage yield, percent moisture at harvest, growth factors, and chemical composition of corn forage were studied. The data was collected from seven locations in Montana, punched on IBM cards, and simple correlations were calculated by a computer.

Early plantings of late maturing varieties at high populations with adequate fertilization resulted in high forage yields.

High plant populations with late season plantings of late maturing varieties increased the percentage of moisture in the forage at harvest. Higher than average mean summer temperatures decreased the moisture percentage of the plants at harvest.

Late maturing varieties produced tall plants which tasseled late in the season and were immature at harvest. The maturity rating had no effect on the chemical composition of the air dry forage at harvest.

The interrelationship of the components of chemical composition of the air dry forage indicates that as the percentage of crude protein in the forage increases, the percentage of crude fiber increases, and the percentage of nitrogen free extract decreases.

INTRODUCTION

Corn silage has been used for many years in the corn belt section of the United States and its use is expanding each year. In 1955, American farmers harvested 73 million tons of silage from all crops. In 1962, corn silage alone accounted for 74 million tons; however, the acreage of corn grown for silage purposes does not approach the acreage devoted to alfalfa and grass hay. In Montana in 1962, for example, only 48,000 acres of corn were harvested for silage while 2,029,000 acres were harvested as grass hay, alfalfa hay and alfalfa silage.

The planting of varieties for silage which will mature grain by the end of the growing season is a common practice of Montana corn growers. This concept probably originated in the Midwest where corn is grown primarily for the mature grain with a small portion harvested for silage. In Montana, due to high altitude and northern latitude, only short season varieties can be expected to mature by the end of the growing season. These short season varieties do not produce sufficient forage to be competitive with other forage grasses or alfalfa. Researchers have found that more total energy can be produced from immature long season varieties than from mature short season varieties.

When entire corn plants are harvested for forage, average yield of dry matter and amount of digestible nutrients per acre exceeds all other forage crops. Corn forage is relatively high in carbohydrates and low in protein. The forage contains about half as much protein as does alfalfa forage if both are adjusted to the same moisture percentage. Corn forage is rather low in phosphorus, but high in Vitamin A.

The purpose of this research was to establish relationships useful as a guide for corn silage production in Montana. The relationships studied were:

A. Relationship of corn silage yield to maturity rating, plant population, planting date, mean summer temperature, and fertilization.

B. Relationship of moisture percentage of the plants at harvest to plant population, maturity rating and stage of maturity at harvest, planting date, and mean summer temperature.

C. The effect of plant population on the stage of maturity at harvest, tasseling date, plant height, and chemical composition of the air dry forage.

D. The effect of the maturity rating of varieties on stage of maturity at harvest, tasseling date, plant height and chemical composition of the air dry forage.

E. The effect of fertilization on percentage of crude protein in the forage.

F. Interrelationship of components of chemical composition of the air dried fodder.

G. Relationship of the stage of maturity at harvest to chemical composition of the air dry forage and the effect of mean summer temperature and planting date on the stage of maturity at harvest.

REVIEW OF LITERATURE

Work with corn silage by Whitcher (43), Schwertzer (38), Babcock (3), Ladd (26), Armsby (2), Jordan (21), Farrington (11), Jones and Huston (20), Ince (19), and Nevens (31), as cited by Wiggans (45), prior to 1940, indicated the following general concepts:

1. Total dry matter percentage increases with the life cycle of the corn plant.

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.

Prior to 1940, research had also been conducted by Jordan (21), Barlett and Merrill (22), Armsby (2), Ewing (9), Smith and Wells (10), Hayden and Perkins (14), White (44), and Nevens (31), as cited by Wiggans (45) on the feeding value of the forage:

1. The more mature corn was when ensiled, the more valuable the silage per unit weight.

2. 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.

3. 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 (45) working at Cornell University, Ithaca, N.Y., stated:

"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 widely 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 the dry matter of the varieties under considerations 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."

Planting Date for Silage Corn

Brown (6) found corn for silage should be planted early in Connecticut. When early plantings are made, the above ground portions of the plants grow very slowly in the cool spring, however, the roots can develop at a fair rate during this time. The early seeded plants have a better root system than plants of a later planting.

In central Washington, Morrison et al (30) suggested plantings should be made between April 15 and May 10. Short season varieties could be planted as late as June 1, but yields were lower. In western Washington, the best time to seed was May 1 to May 15.

Fertilization of Silage Corn

Harshbarger (12) found that applications of commercial fertilizers in the production of corn forage resulted in:

1. Gains in the tonnage of forage represented by both ear and leaf-stalk fractions.

2. Little or no change in the proportion of the forage which consisted of ears.

3. Little or no change in the protein content of the grain except as influenced by season.

4. In an increase of protein content of the forage when the crop was grown on soils high in available plant nutrients.

5. Little change in the fiber content of the forage.

Raymaley and Nau (36) reported a 20 ton per acre silage crop required 200 pounds of nitrogen, 72 pounds of phosphorus, (P_2O5) and 150 pounds of potassium, (K_2O). Banding 80 pounds of nitrogen, 80 pounds of phosphorus and 90 pounds of potassium was recommended for western Washington by Morrison, et al (30); however, in central Washington, 160 pounds of nitrogen and 40 to 60 pounds of potassium was recommended to be plowed down. In Montana, 100 to 150 pounds of nitrogen and 60 to 75 pounds of available phosphorus has been recommended.'

Placement of Fertilizer

Ohlogge, et al (35) reported starter fertilizers should be banded 2 inches to the side and 2 inches to 6 inches below the seed. When fertilizer was placed with the seed, the salts "dried out" the seed, causing poor germination. Since the band volume was very small, both nitrogen and phosphorus were necessary in the band for good root proliferation. Root proliferation was essential for maximum use of the fertilizer. Using this band method, it was possible to apply up to 400 pounds of fertilizer safely. Raymaley and Nau (36) found the major portion of the fertilizer should be plowed down with a small portion banded 2 inches to the side and 2 inches below the seed as a starter fertilizer. This practice was also recommended for western Washington (Morrison, et al 30).

Maturity Ratings as Related to Silage Production

Morrison, et al (30) found late maturing corn hybrids would yield more tons per acre of forage in central Washington irrigated areas than an early maturing variety. For the short season areas of western Washington, a short season variety was recommended over a long season variety. Brown (6) stated that varieties reaching the medium dough stage by frost time seemed to be the best for silage production. A long season hybrid was best in western areas for maximum production (Viets 40).

The Effect of Plant Population on Silage Yield

Viets (40) found that in western irrigated areas, populations of 30,000 to 35,000 plants per acre were needed for maximum silage yield. Raymaley and Nau (30) reported at least 22,000 plants per acre were needed for maximum efficiency; however, over 50,000 plants per acre was wasteful and did not show an increase in total digestible nutrients.

Morrison, et al (30) found 18,000 to 20,000 plants per acre to be the optimum in Washington. Ten to 12 pounds of good seed per acre in rows 38 to 40 inches apart gave this number of plants. Brown (6) obtained increased yields by planting the same number of plants per acre using 18 inch rows rather than 36 inch rows. In Connecticut, 27,000 to 42,000 plants per acre is recommended. Washka (41) in work in Pennsylvania, obtained highest production with 20,000 to 25,000 plants per acre.

Percent Moisture as Related to Stage of Maturity

Washka (41) found that at the well dented to glaze stage of the kernels, the entire plant was approximately 30 percent dry matter. When the kernels were in the milk stage, the plant was approximately 20 percent dry matter. According to Nevens (33) the green weight of corn plants was highest when the ears were beginning to form; however, there was only 15 to 18 percent dry matter at this time. The dry matter at the early dent stage was 25 to 30 percent. Several growth stages with corresponding dry matter percentages are given below:

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

Harvesting Stage for Corn Silage

Brown (6) believed that corn silage should be harvested when the kernels were in the soft dough stage. On the other hand, Washka (41) believed that the time to harvest was when kernels were in the well dented to glaze stage. At this time the plant was about 70 percent moisture and was considered to be the best moisture percentage for silage. Others have found the dent stages to be the best time for harvesting corn for silage (Morrison et al 30, Raymaley and Nau 35).

Types of Corn Silage

Three kinds of corn silage were described by Rogers (37):

1. The whole corn plant, when at the peak of its nutritive value, and right for ensiling, contains 1½ times more nutrients than the ripened grain the plant would yield. In corn silage made from the whole crop, more than 90 percent of the nutrients produced were saved.

2. By ensiling the ears, in ground earcorn silage, up to 68 percent of the nutrients produced by the crop were recovered.

3. Shelled-corn silage, consisting of the kernels only, at about 70 percent dry matter, returned 61 to 66 percent of the nutrients in the whole crop.

Brickbauer (5) reported there are two types of high sugar corn used for silage purposes:

1. Sweet dent varieties, which have a high sugar content in the grain.

2. Sweet stalk varieties which have a high sugar content in the stalks. Some of these are male sterile varieties that do not set seed.

Smith (39) found that high sugar varieties showed no superiority in silage production, were no more palatable, and would not provide as much energy as well eared dent corn. The form of the carbohydrates, either as starch or simple sugars were not important quality factors. Starch dent corn yielded 73 percent total digestible nutrients while sweet dent and sweet stalk corn yielded about 65 percent total digestible nutrients.

Henderson (15) described butt silage as the rich center cut of the plant with the tops and bottoms remaining in the field. The result of this type of silage was a complete ration for feeding cattle.

Experiments conducted by Mays, et al (28) with dwarf corn for silage indicated that the dwarf varieties yielded 10 percent less than their tall counterpart. For this reason there were no justifications for recommending dwarf varieties for silage production.

Composition of Corn Silage

The conventional total digestible nutrient standard for corn silage on a dry matter basis ranged from 65.4 percent (Lassiter 27 to 71.7 percent (Washka 41).

Alexander (1) found when plant populations were high and fertilization rates were low, protein digestibility decreased. Significant increases were noted in the digestibility of protein, energy, and carbohydrates when high fertilization treatments were used.

Comparing Corn Silage With Other Hays and Silages

Brown (6) in work in Connecticut found Buffalo alfalfa would yield 8,700 pounds of dry matter per acre while U.S. 13 corn would yield 10,600 pounds per acre over a 5-year period. In 1960, Penn. 602A, in 18 inch rows, at 29,000 plants per acre produced 16,700 pounds of dry matter per acre while Vernal alfalfa produced only 10,500 pounds per acre in two cuttings and another 3000 pounds per acre the third cutting. It was also found that corn with a fair amount of leaves had more total digestible nutrients per pound of dry matter than alfalfa silage.

Table I. Comparison of hay and silage (Huffman 18).

Crop	Yield Per Acre	Dry Matter	Digestible Protein	TDN
	Tons	Lbs.	Lbs.	Lbs.
Alfalfa Hay	2.20	3,982	453	2,231
Clover and timothy hay	1.41	2,484	132	1,438
Corn for silage	8.00	4,416	192	2,928

Huffman (18) stated that the corn yield should be considered as very low since 18 to 20 tons per acre was a common yield in Michigan.

Table II. Comparison of corn and alfalfa silage based on 200 tons of each at 70 percent moisture (Rogers 37).

Corn Silage Lbs.	Component	Alfalfa silage Lbs.
84,500	TDN	69,000
9,700	Total Protein	20,100
5,500	Digestible Protein	13,300
73,100	Carbohydrate (N-Free extract)	45,600
22,600	Crude Fiber	38,900
590	Calcium and Phosphorus	1,550

Raymaley and Nau (36) found that the total digestible nutrient yield per acre of corn was often four times that of oats, three times that of barley, two times that of all hay, and one and one half that of alfalfa.

Corn Silage Feeding Trials

The comparison of immature and mature silages in 10 trials, without grain supplement, conducted by Huffman and Duncan (17) in Michigan indicated a slight superiority of the mature silage for milk production per pound of dry matter intake. The average bodyweight of the cows tended to be slightly higher when they received the immature silage.

Waugh (42) found that alfalfa-bromegrass silage and corn silage are very similar in feeding value and for milk production. The alfalfa-bromegrass silage is higher in carotene which is reflected in higher Vitamin A content of the milk fat.

According to Lassiter (27) heifers fed oat silage as the sole source of roughage made significantly lower daily gains in body weight than heifers fed either corn silage or alfalfa hay. Heifers fed either oat or corn silage consumed significantly less roughage on a dry matter basis than animals fed alfalfa hay.

Significant differences were noted by Huffman and Duncan (16) in the percent of butterfat in the milk and in body weight of dairy cows when part of the hay was replaced with corn silage. The data showed conclusively that the grain in the corn silage contributed the unidentified "grain factor(s)" which were needed to balance the total digestible nutrients in the roughage; therefore, corn silage should not be considered a true roughage but a mixture of both roughage and grain.

Dunn, et al (8) prepared corn silage and grainless corn silage from alternate strips in the same field. The grainless corn silage was the result of harvesting the corn stalks after the ears had been removed. The ears were then dried and ground to give corn and cob meal. The two silages were compared in respect to milk production, body weights, and total digestible nutrients ingested using the whole plant silage and the recombined corn and cob meal with the stalk silage. The data indicated there were no significant difference between the two silages.

Bull (7) found that the longer steer calves were fed a heavy silage ration, the cheaper the gain, and the more desirable the carcasses in terms of reduced fat cover, more marbling, and higher yield of lean cuts.

Animals fed rations of corn silage and hay, when properly balanced for protein, required less grain than animals fed legume either as hay or silage. (Branaman and Davis 4)

Raymaley and Nau (36) reported an average yield of 60 bushels of corn for grain would produce 500 to 600 pounds of beef. This same crop in the silo as corn silage would produce 1200 pounds of beef.

MATERIALS AND METHODS

The data for this investigation was obtained as a result of 13 years, 1951 through 1963, of irrigated corn silage trials in Montana. The production factors evaluated either singly or in various combinations in the individual field trials were: varieties, maturity classes, fertilizer rates, plant populations, and planting dates.

The following observations were made on the trials:

1. Variety of corn used.
2. Yield of silage in tons per acre adjusted to 70 percent moisture.
3. Moisture percentage of the forage at harvest time.
4. Plant population.
5. Maturity rating of the varieties.
6. Stage of maturity of the corn when harvested.
7. Tasseling date.
8. Plant height at harvest.
9. Crude protein, crude fiber, nitrogen free extract, and total digestible nutrients on a dry matter basis of the forage at harvest as determined by the Montana State College Chemistry Department.
10. Planting date.
11. Mean temperature by stations for May, June, July and August.
12. Pounds of nitrogen and phosphorus (P_2O_5) fertilizer applied.

A complete set of observations were not available for all trials. The research work was conducted at the Montana Agricultural Experiment Station at Bozeman, Montana and the five branch stations, Eastern Montana Branch Station at Sidney, Northwestern Montana Branch Station at Kalispell, Western Montana Branch Station at Corvallis, Huntley Branch Station at Huntley and Northern Montana Branch Station at Havre. Some of the work was also conducted at Columbus, Montana.

The available data for each year and location was coded and recorded on large sheets. The data was then punched on IBM cards by the Montana State College Computer Center staff. The data were analyzed on the IBM 1620 model II computer. All simple correlations were calculated using a standard 60 x 60 correlation program. The coding procedure is explained in Appendix I.

The source of the data is given in Table III. The column labeled relationship of factors lists the two factors from which the statistical correlation coefficients were calculated. The column labeled type of trial and location refers to the type of experiment performed, and the location from which the data was collected. The types of experiments were coded in the following manner:

Code for the types of experiments used as the data source in Table I.

I. Corn silage variety trial.

II. Plant population growth rate trial.

III. Fertilizer trials.

IV. Variety maturity rating trials.

V. Corn silage variety and planting date trials.

VI. Fertilizer and maturity rating trials.

VII. Planting date and maturity rating trials.

The year column indicates the years in which the data was collected and the location as indicated by the X's.

The different stages of maturity were assigned numerical values from 0 through 9 as follows:

0 Pretasseling

1 Tasseling

2 Ears forming

3 Silk emergence

4 Pollen shedding

5 Kernels forming

6 Milk

7 Dough

8 Early Dent

9 Well Dented

The tasseling dates were coded with values of 0 through 30 for dates from July 1 through July 31, 31 through 62 for dates from August 1 through August 31 and 63 through 93 for dates from September 1 through September 30.

The planting dates were coded similarly with values of 1 through 31 for dates from May 1 through May 31.

Significance of the correlation coefficients are indicated as follows:

* 5 percent level of significance (significant).

** 1 percent level of significance (highly significant).

Table III. The source of the data to be correlated as to the factors studied, type of trial, location, and years in which the data was collected.

Factors Compared	Type of Trial	Location	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
Silage yield x plant population.	I	Bozeman						x	x					x	
		Sidney	x	x	x			x	x	x					
		Huntley		x	x	x	x	x	x	x					
		Kalispell		x											x
		Corvallis	x												
		Havre								x					
	II	Bozeman		x									x		
	V	Corvallis					x								
	VI	Bozeman											x		
		Huntley					x						x		
		Kalispell					x								
		Corvallis					x								
		Columbus											x		
	VII	Huntley					x								
		Kalispell					x								
Silage yield x maturity rating.	I	Bozeman						x	x	x	x	x	x		
		Sidney						x	x	x	x	x	x		
		Huntley						x	x	x	x	x	x		
		Kalispell							x	x	x	x	x		
		Havre								x					
	II	Bozeman											x		

Years: 1951–1963

Table III. The source of the data to be correlated as to the factors studied, type of trial, location, and years in which the data was collected. (continued).

Factors Compared	Type of Trial	Location	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
	V	Corvallis					x								
Silage x maturity rating.	VI	Bozeman											x		
		Huntley					x						x		
		Kalispell					x								
		Corvallis					x								
		Columbus											x		
	VII	Huntley					x								
Silage yield x stage of maturity.	I	Bozeman	x						x	x	x		x		
		Sidney	x						x	x					x
		Huntley					x	x					x		x
		Kalispell			x					x					x
		Corvallis		x											
	IV	Huntley					x								
Silage yield x tasseling date	I	Bozeman							x	x			x		
		Huntley		x	x	x	x	x	x	x					x
Silage yield x plant height	I	Bozeman							x						
		Sidney		x											
		Huntley			x	x		x	x	x		x	x	x	
		Corvallis		x											
		Columbus							x						

Table III. The source of the data to be correlated as to the factors studied, type of trial, location, and years in which the data was collected. (continued)

Factors Compared	Type of Trial	Location	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
Silage yield x planting date	I	Bozeman						x	x	x	x			x	
		Sidney		x	x			x		x	x			x	x
		Huntley	x	x	x	x	x	x	x	x	x		x	x	x
		Kalispell		x	x				x	x	x		x		x
		Corvallis			x	x									
		Havre								x					
	II	Bozeman		x											
	V	Corvallis					x								
	VI	Bozeman											x		
		Huntley											x		
		Columbus											x		
	VII	Huntley					x								
		Kalispell					x								
Silage yield x mean temperature	I	Bozeman	x					x	x	x	x	x	x	x	x
		Sidney	x	x	x			x	x	x	x	x	x	x	x
		Huntley		x	x	x	x	x	x	x	x	x	x	x	x
		Kalispell		x	x	x	x	x	x	x	x	x	x	x	x
		Corvallis		x											
		Havre								x					
	II	Bozeman		x									x		

Table III. The source of the data to be correlated as to the factors studied, type of trial, location, and years in which the data was collected. (continued)

Factors Compared	Type of Trial	Location	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
Silage yield x mean summer temperature	III	Sidney									x				
		Huntley					x				x				
	VI	Bozeman											x		
		Huntley					x						x		
		Kalispell					x								
		Columbus											x		
	VII	Huntley					x								
		Kalispell					x								
Silage yield x fertilizer treatment of nitrogen and phosphorus	III	Sidney										x			
		Huntley										x			
	VI	Bozeman											x		
		Huntley											x		
		Columbus													
Percent moisture x plant population	I	Bozeman						x	x					x	
		Sidney	x					x		x					
		Huntley					x	x	x	x					
		Kalispell													x
		Corvallis	x												
		Havre								x					

Table III. The source of the data to be correlated as to the factors studied, type of trial, location, and years in which the data was collected. (continued)

Factors Compared	Type of Trial	Location	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
Percent moisture x plant population.	I	Bozeman											x		
	V	Corvallis													
	VI	Bozeman											x		
		Huntley											x		
		Columbus											x		
	VII	Huntley					x								
Percent moisture x maturity rating.	I	Bozeman						x	x	x	x	x	x		
		Sidney						x		x	x	x	x		
		Huntley						x	x	x	x	x	x		
		Kalispell							x	x	x		x		x
		Havre								x					
	II	Bozeman											x		
	V	Corvallis				x									
	VI	Bozeman											x		
		Huntley											x		
		Columbus											x		
	VII	Huntley					x								

Table III. The source of the data to be correlated as to the factors studied, type of trial, location, and years in which the data was collected. (continued)

Factors Compared	Type of Trial	Location	Years 1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
Percent moisture x stage of maturity.	I	Bozeman							x	x	x		x		
		Sidney	x							x					x
		Huntley					x	x					x		x
		Kalispell								x					x
	IV	Huntley					x								
Percent moisture x tasseling date	I	Bozeman							x	x			x		
		Huntley					x	x	x						x
Percent moisture x plant height	I	Bozeman							x						
		Huntley						x	x	x			x	x	x
		Havre								x					
Percent moisture x planting date	I	Bozeman						x	x	x	x			x	
		Sidney						x		x	x			x	x
		Huntley					x	x	x	x	x		x	x	
		Kalispell							x	x	x		x		x
		Havre								x					

Table III. The source of the data to be correlated as to the factors studied, type of trial, location, and years in which the data was collected. (continued)

Factors Compared	Type of Trial	Location	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
	V	Corvallis					x								
	VI	Bozeman													
		Huntley											x		
		Columbus											x		
	VII	Huntley					x								
Percent moisture x mean summer temperature	I	Bozeman						x	x	x	x	x	x	x	x
		Sidney	x					x		x	x	x	x	x	x
		Huntley					x	x	x	x	x	x	x	x	x
		Kalispell							x	x	x	x	x	x	x
		Havre								x					
	II	Bozeman											x		
	IV	Huntley					x								
	VI	Bozeman											x		
		Huntley											x		
		Columbus											x		
	VII	Huntley					x								

Table III. The source of the data to be correlated as to the factors studied, type of trial, location, and years in which the data was collected. (continued)

Factors Compared	Type of Trial	Location	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
Plant population x stage of maturity	I	Bozeman							x						
		Sidney	x						x	x					
		Huntley					x	x							
		Kalispell													x
Plant population x tasseling date	I	Bozeman							x				x		
		Huntley		x	x	x	x	x	x						
Plant population x plant height	I	Bozeman							x						
		Sidney		x											
		Huntley			x	x		x	x	x					
		Havre								x					
Plant population x crude protein	I	Bozeman												x	
		Kalispell													x
	II	Bozeman											x		
	VI	Bozeman											x		
		Huntley											x		
		Columbus											x		

Table III. The source of the data to be correlated as to the factors studied, type of trial, location, and years in which the data was collected. (continued)

Factors Compared	Type of Trial	Location	Years 1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
Plant population x crude protein.	VII	Huntley					x								
Plant population x crude fiber	I	Bozeman												x	
		Kalispell													x
	II	Bozeman											x		
	VII	Huntley					x								
Plant population x nitrogen free extract.	I	Bozeman												x	
		Kalispell													x
	II	Bozeman											x		
	VII	Huntley					x								
Maturity rating x stage of maturity.	I	Bozeman							x	x	x		x		
		Sidney							x	x					
		Huntley						x					x		
		Kalispell								x					x

Table III. The source of the data to be correlated as to the factors studied, type of trial, location, and years in which the data was collected. (continued)

Factors Compared	Type of Trial	Location	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
Maturity rating x tasseling date.	I	Bozeman							x	x			x		
		Huntley						x	x						
Maturity ratings x plant height	I	Bozeman							x						
		Huntley						x	x	x			x		
		Havre								x					
Maturity rating x crude protein.	I	Bozeman									x	x			
		Sidney											x		
		Huntley									x		x		
		Kalispell											x		x
	II	Bozeman											x		
	III	Sidney										x			
		Huntley										x			
	VI	Bozeman											x		
		Huntley											x		
		Columbus											x		
	VII	Huntley					x								

Table III. The source of the data to be correlated as to the factors studied, type of trial, location, and years in which the data was collected. (continued)

Factors Compared	Type of Trial	Location	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
Maturity rating x crude fiber.	I	Bozeman									x		x		
		Sidney											x		
		Huntley									x		x		
		Kalispell											x		x
	II	Bozeman											x		
	VII	Huntley					x								
Maturity rating x percent nitrogen free extract.	I	Bozeman									x		x		
		Sidney											x		
		Huntley									x		x		
		Kalispell											x		x
	II	Bozeman											x		
	VII	Huntley					x								
Stage of maturity x tasseling date	I	Bozeman								x	x		x		
		Huntley					x	x	x						x

Table III. The source of the data to be correlated as to the factors studied, type of trial, location, and years in which the data was collected. (continued)

Factors Compared	Type of Trial	Location	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
Stage of maturity x plant height.	I	Bozeman							x						
		Huntley						x					x		x
		Corvallis		x											
Stage of maturity x crude protein.	I	Bozeman	x								x		x		
		Sidney												x	
		Huntley											x	x	
		Kalispell												x	
	IV	Huntley					x								
Stage of maturity x crude fiber.	I	Bozeman	x								x		x		
		Sidney												x	
		Huntley											x	x	
		Kalispell												x	
	IV	Huntley					x								
Stage of maturity x nitrogen free extract.	I	Bozeman	x								x		x		
		Sidney												x	
		Huntley											x	x	
		Kalispell												x	
	IV	Huntley					x								

Table III. The source of the data to be correlated as to the factors studied, type of trial, location, and years in which the data was collected. (continued)

Factors Compared	Type of Trial	Location	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
Stage of maturity x planting date	I	Bozeman								x	x	x			
		Sidney									x		x		x
		Huntley					x	x							
		Kalispell			x					x					x
Stage of maturity x mean summer temperature	I	Bozeman	x						x	x	x		x		
		Sidney	x						x	x					x
		Huntley					x	x					x		x
		Kalispell			x					x					x
		Corvallis		x											
	IV	Huntley					x								
Tasseling date x plant height	I	Bozeman			x	x		x	x						x
		Huntley													
Tasseling date x planting date	I	Bozeman							x	x					
		Huntley		x	x	x	x	x	x						
Tasseling date x mean summer temperature	I	Bozeman							x	x			x		x
		Huntley		x	x	x	x	x	x						

Table III. The source of the data to be correlated as to the factors studied, type of trial, location, and years in which the data was collected. (continued).

Factors Compared	Type of Trial	Location	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
Plant height x planting date	I	Bozeman							x						
		Sidney		x											
		Huntley			x	x		x	x	x			x	x	
		Havre								x					
Plant height x mean summer temperature	I	Bozeman							x						
		Sidney		x											
		Huntley			x	x		x	x	x			x	x	x
		Corvallis		x											
		Havre								x					
Crude protein x crude fiber	I	Bozeman	x								x		x	x	x
		Sidney											x	x	x
		Huntley	x								x		x	x	x
		Kalispell											x		x
	II	Bozeman											x	x	x
	II	Huntley					x								
	VII	Huntley					x								
Crude protein x nitrogen free extract.	I	Bozeman	x								x		x	x	x
		Sidney											x	x	x

Table III. The source of the data to be correlated as to the factors studied, type of trial, location, and years in which the data was collected. (continued)

Factors Compared	Type of Trial	Location	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
Crude protein x nitrogen free extract.	I	Huntley	x								x		x	x	x
		Kalispell											x		x
	II	Bozeman											x		
	IV	Huntley					x								
	VII	Huntley					x								
Crude protein x planting date	I	Bozeman									x			x	
		Sidney												x	x
		Huntley	x								x		x	x	
		Kalispell											x		x
	VI	Bozeman											x		
		Huntley											x		
		Columbus											x		
	VII	Huntley				x									
Crude protein x fertilizer treatment of nitrogen and phosphorus	III	Sidney										x			
		Huntley										x			

Table III. The source of the data to be correlated as to the factors studied, type of trial, location, and years in which the data was collected. (continued)

Factors Compared	Type of Trial	Location	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
Crude protein x fertilizer treatment of nitrogen and phosphorus	VI	Bozeman											x		
		Huntley											x		
		Columbus											x		
Crude fiber x nitrogen free extract	I	Bozeman	x								x		x	x	x
		Sidney											x	x	x
		Huntley	x								x		x	x	x
		Kalispell											x		x
	II	Bozeman											x		x
	IV	Huntley					x								
	VII	Huntley					x								
Crude fiber x planting date	I	Bozeman									x			x	
		Sidney												x	x
		Huntley	x								x		x	x	
		Kalispell											x		x
	VII	Huntley					x								
Nitrogen free extract planting date	I	Bozeman									x			x	
		Sidney												x	x

Table III. The source of the data to be correlated as to the factors studied, type of trial, location, and years in which the data was collected. (continued)

Factors Compared	Type of Trial	Location	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
Nitrogen free extract planting date.	I	Huntley	x								x		x		
		Kalispell									x		x		
	VII	Huntley					x								

RESULTS AND DISCUSSIONS

The results of the analysis of the data are given in Table IV. The comparison made and the location where the data was obtained are given in the column labeled relationship tested and location. The combined relationship is the result of all the data available for analysis of a single comparison. The analysis of each location was the result of all the data available for that comparison at the specific location. The N column is the number of paired observations used for the comparison. The mean of X column is the average of all the data used for a specific comparison and is related to the first variable that was compared. The mean of Ȳ column is the average of all the data used for a specific comparison and is related to the second variable that was compared. The r column is the correlation coefficient of the two variables, X and Y, that were compared. The average r column is the average correlation coefficient of all locations. The average correlation coefficient was calculated from the sums of squares and products associated with the average regression.

The Relationship of Growth Factors

Results

The following growth factors were considered:

1. The plant population in plants per acre.
2. The maturity rating of the varieties grown in days.
3. The stage of maturity of the plants at the time of harvest.
4. The tasseling date of the plants.
5. The plant height at the time of harvest in inches.
6. The planting date of the experimental plot.
7. The mean summer temperature as determined by the average temperature for the months, May, June, July and August.

Correlations of these growth factors were as follows:

The combined correlation coefficient of the plant population and stage of maturity was -.2214 which was highly significant based on 281 paired observations. The correlation coefficients based upon individual location data were non-significant. An experiment was conducted at only one location, Kalispell (1963), in which the plant population was not constant for any one year. This correlation coefficient was -.2433 and found to be non-significant based on 12 paired observations.

When the plant population and tasseling date were correlated, a correlation coefficient of .6863 resulted from the combined data for all years at all locations. This value was found to be highly significant based on 337 paired observations. The Huntley Branch Station was the only location that conducted this comparison for more than a single year and a correlation coefficient of .4415 was calculated. This value was highly significant based on 302 paired observations. No yearly correlations could be made at a single location since the plant population was held constant for any one year.

The comparison of the plant population and the plant height resulted in a combined correlation coefficient of -.1685 which was highly significant based on 337 paired observations. This comparison could be conducted only on data from the Huntley Branch Station for correlations at separate locations since the other locations contributed only one year's data. This correlation coefficient at Huntley was found to be .0743 and was not significant based on 246 paired observations.

The combined correlation coefficient for the maturity rating and the stage of maturity was -.6256. This value was found to be highly significant based on 312 paired observations. The correlation coefficient for each location was found to be highly significant and ranged from -.4835 at Kalispell to -.8269 at Huntley.

When the maturity rating and the tasseling date were correlated for all years at Bozeman and Huntley, the two locations that contributed data, a correlation coefficient of .5457 resulted. This value was highly significant based on 175 paired observations. For the years studied, a correlation coefficient of .5174 existed at Bozeman and a value of .6574 at Huntley. These values were highly significant. Correlations using the data from individual years at each location ranged from .7565 to .8827 and were highly significant.

The combined correlation coefficient based on 230 paired observations for maturity rating and plant height was .5724 and was highly significant. The correlation coefficient for the individual locations ranged from .4945 to .7049 and from .4945 to .8083 for the individual years at each location that could be studied. The higher values were at Huntley and Havre and the lowest value at Bozeman.

The stage of maturity was correlated with the tasseling date and found to be highly significant with a value of -.6578 based on 199 paired observations for the combined experiments. The correlation coefficients for this comparison at Bozeman for all years was -.3778 and at Huntley was -.4319. The correlation coefficients for the individual years at each location ranged from -.4844 to -.9080.

The combined correlation coefficient of the stage of maturity and plant height, based on 146 paired observations was .1042 and was not significant; however, the individual location correlation coefficients were found to be highly significant with values of -.5792, -.5921 and -.6381. This negative correlation was also true for the individual years at each location. The combined average correlation coefficient was calculated by removing the effect of locations and found to be -.5809 which was highly significant.

When the stage of maturity and planting date were correlated a combined r value of -.2955 results and was highly significant based on 340 paired observations. A correlation coefficient of -.5056 was found at Bozeman and was highly significant. All other locations were found to be non-significant. Yearly correlations could not be made since the planting date at a location was held constant for any one year.

Based on 483 paired observations a combined correlation coefficient for the comparison of the stage of maturity and the mean summer temperature was found to be .4171 which was highly significant. The only location where a significant correlation coefficient existed for this comparison was Kalispell with a value of -.5147. Individual yearly correlations could not be made since the mean summer temperature was constant for any single year.

The combined correlation coefficient for the comparison of tasseling date and plant height was found to be non-significant; however, the individual location coefficients were found to be highly significant with values of .4540 at Bozeman and .4712 at Huntley. The average correlation coefficient, removing the effects of locations, was .3210 and was highly significant.

When the tasseling date and planting date were correlated, a combined coefficient of .2694 exists and was highly significant based on 367 paired observations. The correlation coefficients at the individual locations were not significant. No individual yearly correlations could be made.

Correlation of tasseling date and the mean summer temperature yielded a combined coefficient of -.6464 and was highly significant based on 405 paired observations. This comparison at the individual locations yielded a correlation coefficient of -.2222 at Bozeman, which was significant, and -.2991 at Huntley, which was highly significant. No individual year correlations could be made.

When the plant height and planting date were correlated, a combined coefficient of .1014 was found and was significant based on 405 paired observations. A highly significant correlation was found at Huntley, the only location that could be correlated since the other locations contributed data for only one year.

A combined correlation coefficient of .2309 was found when the plant height and the mean summer temperature were compared. This value was highly significant based on 423 paired observations. A non-significant coefficient existed at Huntley, the only location that could be compared. No individual yearly correlations could be made at the separate locations.

Discussion

The combined comparison of the plant population and the stage of maturity showed a negative correlation coefficient. The data indicated as the plant population increased the stage of maturity at harvest decreased. This could be due to increased plant competition for water, sunlight, and nutrients at high populations which resulted in slower growth and maturity. The reason for the positive value at Sidney was because low populations were studied. High populations were studied at Kalispell and the correlation coefficient was negative. There was a small negative correlation coefficient at Huntley and the populations studied ranged between that at Sidney and Kalispell. This indicated that as population increased the stage of maturity may increase to a point and then decrease so this would not be a linear relationship.

The combined comparison of plant population and tasseling date showed a strong positive relationship. This indicated that as the plant population increased, the tasseling date was later in the season. The reason for this could be due to increased plant competition for water, sunlight, and soil nutrients.

The combined comparison of plant population and the plant height resulted in a negative correlation coefficient. From this it was concluded that as the plant population increased the plants may be shorter at harvest. This could be due to the increased plant competition at high plant populations. A non-significant correlation coefficient was found at Huntley since only a narrow range of plant populations were studied.

The correlation coefficient for the comparison of maturity rating and the stage of maturity at harvest showed a strong negative value for the combined data at the individual locations. This indicated that as the maturity rating of the varieties grown increased, the stage of maturity of the plants at harvest decreased. Correlation coefficients of high values existed at Huntley and Sidney because these locations have long growing seasons; thus, the early maturity rated varieties reached maturity while at Bozeman and Kalispell, due to the short season these early maturity rated varieties did not reach maturity.

The combined comparison of the maturity rating and the tasseling date showed a strong positive correlation. This indicated that as the maturity rating was increased, the tasseling date was later in the season. Both locations used to determine this relationship, Bozeman and Huntley, showed strong positive values when the locations were correlated individually. The length of the growing season does not affect this relationship since both the early and late maturing varieties reached the tasseling stage.

The combined correlation of the maturity rating and the plant height showed a strong positive correlation. This indicated that as the maturity rating of the varieties grown was increased, the plants were taller at harvest. The primary reason for this could be that short season varieties use the last part of the season for seed production while the long season varieties continue vegetative growth. This relationship was stronger at the locations which had longer growing seasons, Huntley and Havre. This indicated that the long season varieties may not have reached maximum height by the time of harvest at Bozeman, due to the short growing season.

The combined comparison of the stage of maturity and the tasseling date showed a strong negative relationship. This indicated that as the tasseling date was later in the season the plants were more immature at harvest. This relationship held for all locations and for all individual years at each location.

The combined comparison of the stage of maturity and the plant height showed a non-significant positive value; however, when the average combined correlation coefficient was calculated, removing location effect, a strong negative value resulted. The negative value indicated that tall varieties should mature later in the season than short varieties. This relationship held for all the individual locations and for all individual years at each location studied.

The combined comparison of the stage of maturity and the planting date showed a negative correlation value. This indicated that the earlier the date of planting, the more advanced stage of maturity would be achieved by harvest time. This value was negative at all locations except Sidney where a positive value existed. This was probably due to the year effects.

The combined comparison of the stage of maturity and the mean summer temperature showed a strong positive relationship. This indicated that years when the mean summer temperature was high, a more advanced stage of plant maturity could be expected at harvest. The location correlation coefficients were low or negative due to a narrow range of mean summer temperatures for the individual years at a specific location.

The combined correlation coefficient between the tasseling date and the plant height resulted in a non-significant negative value. The average correlation coefficient was positive as were the individual locations and the individual years at each location. This indicated that plants which tasseled late in the season would be taller at harvest than plants which tasseled early in the season.

The combined comparison of tasseling date and planting date showed a positive relationship. This indicated that early planting dates may result in early tasseling dates. This was as expected since the plants have more time to grow. At the individual locations there were no significant correlations since the planting dates varied only slightly from year to year.

A strong negative combined correlation coefficient was found when tasseling date and mean summer temperatures were compared. This indicated that years when the mean summer temperatures were high, the tasseling date would be early in the season. This relationship also held for the individual locations.

A weak positive combined correlation coefficient was found when the plant height and the planting dates were compared. This indicated there was a slight affect of the planting date on the plant height at harvest. If the planting date was early in the spring, there may be a slight decrease in the plant height at harvest. At Huntley, the only location which contributed data that could be correlated, this relationship also existed.

A positive combined correlation coefficient was found when the plant height and the mean summer temperatures were compared. The data indicated that in years when the mean summer temperatures were higher than average, taller plants could be expected at harvest. At Huntley, there was no affect of mean summer temperatures on the plant height. This could be due to moisture stress during years of higher than average mean summer temperatures.

Several general concepts may be concluded from the relationships of the growth factors. High plant populations, contributed to later tasseling, shorter plants, and more immature plants at harvest. This may be due to increased competition. When late maturing varieties were grown, immature tall plants which tasseled late in the season may be expected. In years when the mean summer temperatures were higher than average, corn plants tended to be taller, more mature and tasseled earlier in the season. Early plantings contributed to early tasseling, more matured plants, and slightly shorter plants.

The Relationship of Silage Yield in Tons Per Acre Adjusted to 70 Percent Moisture and Growth Factors.

Results

When the silage yield was correlated with the plant population, a combined correlation coefficient of .1100 results. This value was highly significant based on 911 paired observations. The calculated average correlation coefficient, removing location effect was .2305. The individual location coefficients ranged from .2154 to .7115. The correlation coefficients for individual years at each location that contributed data ranged from .2864 to .6861. For this comparison, Figure 1 illustrates the regression lines for all locations studied.

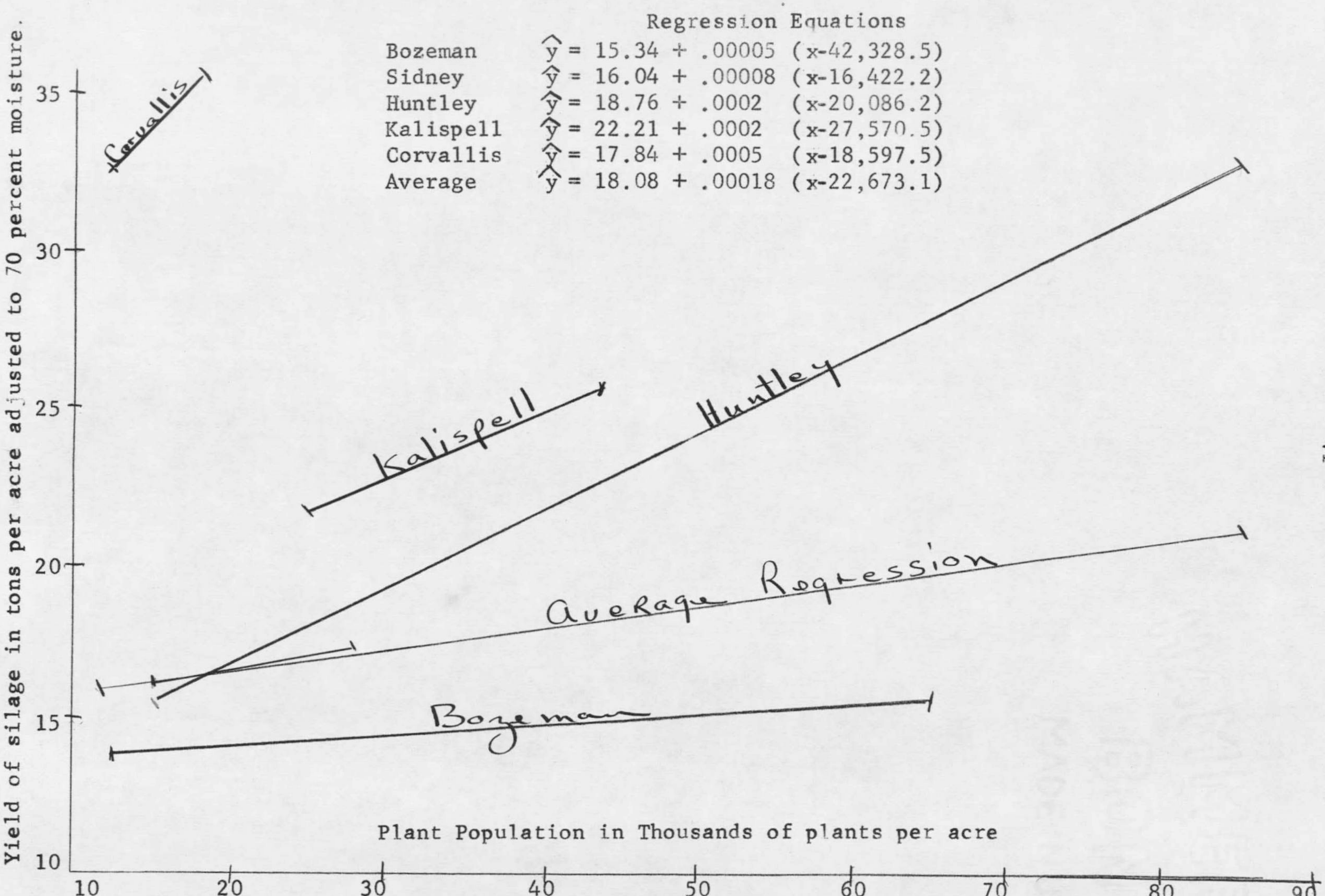

Figure 1. Regression lines for the relationship of silage yield in tons per acre adjusted to 70 percent moisture and plant population.

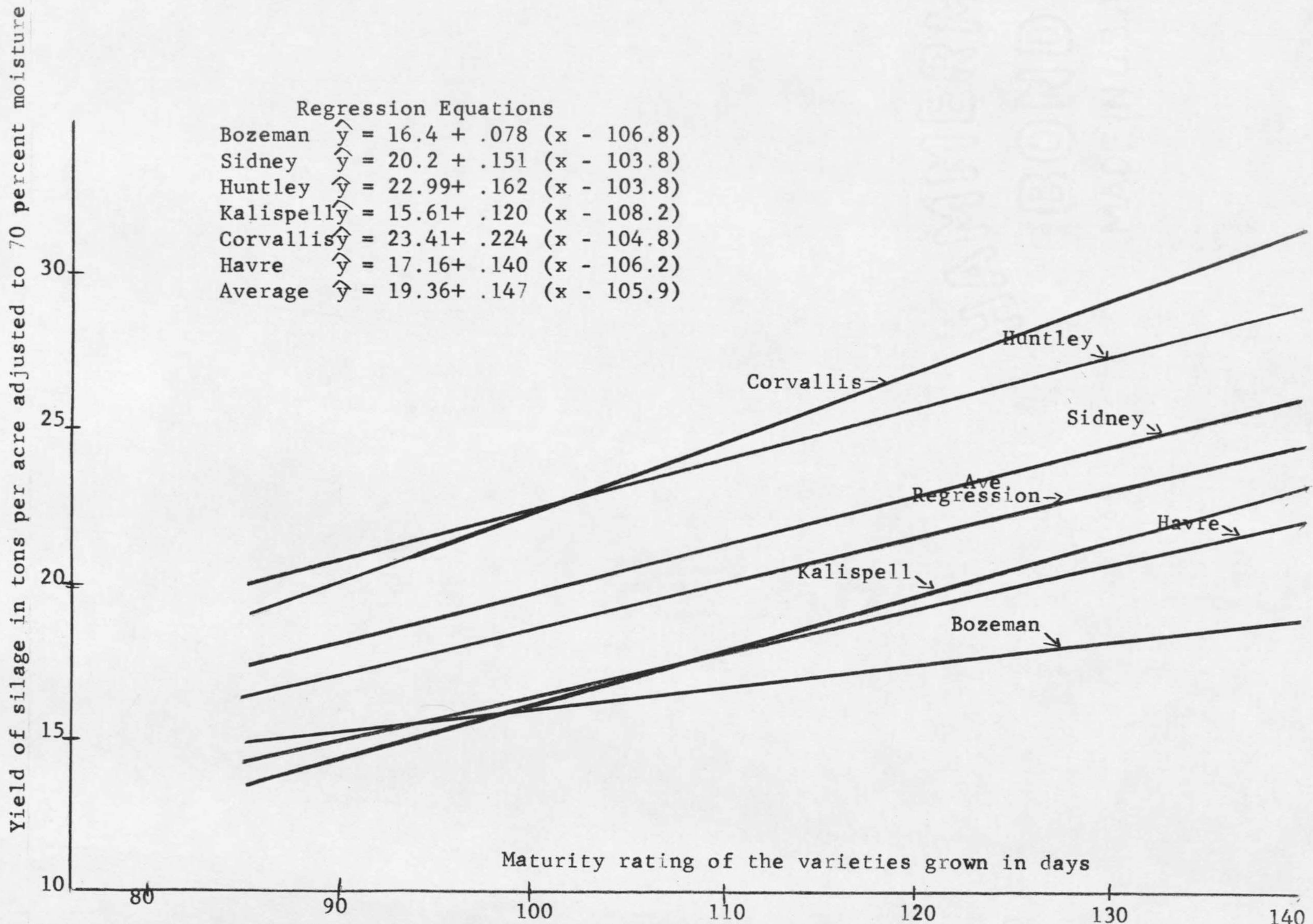

Figure 2. Regression lines for the relationship of silage yield in tons per acre adjusted to 70 percent moisture and the maturity ratings of the varieties grown

Correlation of the silage yield and the maturity rating resulted in a combined r-value of .3278 which was highly significant based on 1030 paired observations. The average combined correlation coefficient removing location effect is .4802. The individual location coefficients ranged from .4161 to .7110. The correlation coefficients for the individual years at each location ranged from .2331 to .7730. The regression line for each location and the average regression line for all locations are indicated in Figure 2.

The comparison of the silage yield and the stage of maturity resulted in a combined correlation coefficient of -.0778 which was significant based on 495 paired observations. By removing the location effect, an average coefficient of -.1278 resulted. This value was found to be highly significant. The correlation coefficients were all negative for all locations except Sidney which was .0288. The individual years at each location gave correlation coefficients which ranged from -.1879 to .7313 except Bozeman with .6750 and Sidney with .8379 in 1951.

The combined comparison of the silage yield and the tasseling date yielded a correlation coefficient of .0891 which was not significant. The individual location coefficients were .0022 at Bozeman, which was not significant, and .2216 at Huntley, which was highly significant. The individual years at each location ranged from .2686 to .7604 at Bozeman and from .5021 to .8429 at Huntley.

When the silage yield and the plant height were correlated a combined correlation coefficient of .5496 resulted which was highly significant based on 435 paired observations. The individual location coefficients ranged from .2199 to .5757. The individual years at each location ranged from .2199 to .7374.

The combined comparison of silage yield and planting date gave a correlation coefficient of -.2737 which was highly significant based on .1181 paired observations. The individual yearly data at Huntley and Kalispell in 1955, for these variables resulted in r-values of -.1064 and -.4981 respectively.

The combined correlation of the silage yield and the mean summer temperature gave a coefficient of .2664 which was highly significant based on 1571 paired observations. Correlation coefficients for the individual locations gave three positive values and one negative value which was at Kalispell. The individual years at each location could not be correlated since the mean summer temperature was constant at any one location for any one year.

Discussion

The combined comparison of the silage yield and plant population showed a positive correlation which indicated that as the plant population was increased the silage yield was also increased. This relationship held for all individual locations and for all individual years within each location. This indicated that when corn was grown at most locations, high plant populations tended to increase forage yields. This was supported by the regression lines (Figure 1) of the individual locations and the average regression line after the effects of locations were removed. At Bozeman and Sidney, the data indicated a slight increase in yield when the plant populations were over 20,000 plants per acre. At Huntley, Kalispell and Corvallis, a large increase was noted as the plant population was increased over 20,000 plants per acre. Plant populations of 20,000 to 50,000 plants per acre have been recommended for other parts of the United States. (30,36, 40).

The combined comparison of the silage yield and the maturity ratings of the varieties grown showed a strong positive relationship which indicated that plantings of late maturing varieties may be necessary to get high forage yields. This relationship was very strong for all individual locations and for all individual years at each location. This indicated that maturity rating was one of the strongest variables that may be controlled by the corn silage grower in relationship to yield of forage. The regression lines (Figure 2) indicated that at all locations, yield increased as the maturity rating increased. From this, it was concluded that 130 to 140 day varieties should be used at the locations studied for maximum forage yield. This concept was mentioned by Morrison, et al (30) for western Washington. Wiggans (45) found that the period of elongation or green matter production was shorter than the period after flowering or dry matter production. These data indicate that for forage production in Montana, this period of green matter production may be extended by the use of late maturing varieties for high forage yields.

The combined comparison of the silage yield and the stage of maturity gave a negative correlation coefficient. This indicated that the more immature the plants were at harvest the higher the yields that could be expected. Sidney showed a non-significant positive correlation coefficient which was due to the large positive value found at this location in 1951. A nitrogen deficiency may have contributed to the large positive value. All other locations showed a strong negative correlation which was true at all individual years at each location.

A non-significant positive correlation coefficient was found when silage yields and tasseling date were compared; however, a significant positive value was found at Huntley and at Bozeman--a non-significant value existed. The data for the individual years at each location yielded strong positive values. From this, one could conclude that the later the tasseling date takes place during the growing season, the higher the forage yield that may be expected.

The combined comparison of silage yield and planting date gave a negative correlation coefficient. The individual years at the locations that could be correlated also gave negative values. From this it may be concluded that plantings should be early for maximum yields. The reason for the positive values at some locations was probably due to yearly effects. Brown (6) suggested that the plantings should be early in the season in Connecticut.

The combined comparison of silage yield and the mean summer temperature yielded a positive value. This was true for the individual locations studied except Kalispell. No correlation coefficients could be calculated for the individual years at each location. The negative value at Kalispell could have been due to improper irrigation late in the season when the long season varieties were still growing. This indicated that years when the mean summer temperatures were higher than average, yields may be expected to be higher than years when the mean summer temperatures were lower than average.

From the results of the relationship of growth factors to the silage yield it was concluded that for high yields at most locations, plant populations of over 20,000 plants per acre should be used. In some areas, populations over 50,000 plants per acre may be used. The population is not the only factor to be considered. The maturity rating was probably the most important factor. The data indicated that most locations in Montana, a 130 to 140 day variety should be planted for maximum yields. Since the stage of maturity and plant height is directly related to the maturity ratings, a highly significant correlation value was found for these factors. The data indicated that the planting date should be early for high yields.

The Relationship of the Percent Moisture in the Forage at Harvest and Growth Factors

Results

The combined correlation coefficient for the relationship of percent moisture and the plant population was .2288. This value was highly significant based on 561 paired observations. Correlation of the data for the individual locations resulted in one location having a significant value of .4453. All other locations were non-significant. The individual years that could be correlated yielded coefficients that were positive.

The correlation of percent moisture and maturity rating resulted in a combined coefficient of .4112. This value was highly significant based on 884 paired observations. Correlations for this comparison at the individual locations resulted in coefficients which ranged from -.0233 to .7642. Correlations for the individual years at each location gave positive values which ranged from .4024 to .8980 except Bozeman in 1956 which gave a value of -.2912.

When the comparison of percent moisture and stage of maturity were correlated, a combined coefficient of -.5400 results. This value was highly significant based on 411 paired observations. The correlation of the data for individual locations resulted in coefficients which ranged from -.4144 to -.6046. Correlation coefficients for the data from individual years at each location ranged from -.2698 to -.8088.

When percent moisture and the tasseling date were correlated, a combined coefficient of .4790 resulted. The two locations studied gave correlation coefficients of .4098 at Bozeman and .1848 at Huntley. The individual yearly data for each location yielded coefficients which ranged from .4600 to .8342.

When the percent moisture and the planting date were correlated, a combined correlation coefficient of .5577 resulted. This value was highly significant based on 838 paired observations. The correlation coefficient for the individual locations were .4474, .4600, .8812 and -.0196 for Bozeman, Huntley, Kalispell and Sidney respectively. All values were highly significant except Sidney where no significant correlation existed.

The combined correlation of the percent moisture and the mean summer temperature resulted in a value of -.2709 which was highly significant based on 1108 paired observations.

Discussion

The relationship of the percent moisture in the forage at harvest and the plant population showed a positive combined correlation coefficient. This indicated that as the plant population was increased, the percent moisture at harvest also increased. This could be due to competition that tended to reduce maturity, thus the plants were more immature and contained more moisture at harvest. The relationship held for the individual years at each location studied. The negative values at Bozeman and Corvallis were probably due to yearly effects.

The relationship of percent moisture and maturity rating resulted in a strong positive correlation coefficient. The negative value at Kalispell was due to the yearly effects since the coefficient for the individual years at this location were all positive. The Bozeman data from 1956 gave a correlation coefficient of -.2912. The reason for this was because a killing frost occurred on September 3 and the corn was not harvested until September 13. It was concluded that the longer season varieties would contain a higher percent moisture at harvest than short season varieties. A difference was noted in the magnitude of the r-values between eastern and western Montana. Due to the short growing seasons in western Montana, the short season varieties did not have a chance to mature.

The relationship of percent moisture at harvest and the stage of maturity at harvest yielded a strong negative combined correlation coefficient. The individual locations as well as all individual years at each location yielded strong negative coefficients. From this it could be concluded that the more mature the plants were at harvest, the less moisture would be contained in the forage at this time.

The combined comparison of the percent moisture and the tasseling date showed a strong positive correlation coefficient. All individual locations and all individual years at each location studied also showed this relationship. This indicated that plants which tasseled early in the season contained a lower percent moisture at harvest than plants that tasseled late in the season.

The combined relationship of the percent moisture and plant height gave a positive correlation coefficient. This was true for the individual locations and for all individual years at each location studied. This indicated that plants which are tall at harvest may contain a higher percent moisture than plants that were short at harvest.

The combined correlation coefficient for the relationship of percent moisture and planting date yielded a strong positive value. Three locations, Bozeman, Huntley and Kalispell, gave strong positive values while there was no significant correlation at Sidney. This indicated that in most areas if the planting date was late in the season a higher percent moisture could be expected in the forage at harvest than if earlier plantings were made.

The combined relationship of the percent moisture at harvest and the mean summer temperature resulted in a correlation coefficient of a negative value. The individual locations gave both positive and negative results. No correlation coefficients could be calculated for the individual years at each location. The combined relationship indicated that if the mean summer temperatures were high the forage tended to contain a lower percent moisture than in years when the mean summer temperatures were lower than average.

From the results of the relationship of the growth factors to percent moisture, it was concluded that the maturity rating was one of the most important factor related to the percent moisture. Not only was this exhibited by the large r-values for this comparison, but with other factors related to the maturity rating such as stage of maturity, tasseling date and plant height. The data indicated that late maturing varieties would contain a higher percent moisture than early maturing varieties at harvest. It was also found that other factors can contribute to the moisture percentage. The data indicated that high plant populations, late plantings and lower than average mean summer temperatures tended to increase the moisture percentage.

The Relationship of Components of Corn Forage Composition

Results

The following components of corn forage were studied:

1. The percent crude protein in the forage on a dry weight basis at harvest.
2. The percent crude fiber in the forage on a dry weight basis at harvest.
3. The percent nitrogen free extract in the forage on a dry weight basis at harvest.

The combined correlation of the comparison of the percent crude protein and the percent crude fiber resulted in a coefficient of .4880. This value was highly significant based on 196 paired observations. Two locations

Bozeman and Sidney, gave negative values and the Huntley data showed a positive correlation of .7018.

The combined comparison of the percent crude protein and the percent nitrogen free extract yielded a correlation coefficient of -.0107 which was non-significant. At Sidney and Huntley, positive coefficients were found. At Bozeman and Kalispell, negative coefficients were found. The Kalispell correlation coefficient was based on one year's data.

The comparison of the percent crude fiber and the percent nitrogen free extract yielded a combined correlation coefficient of -.1501 which was highly significant based on 196 paired observations. All individual locations also showed negative values which ranged from -.2127 to -.8095.

Discussion

The relationship of the percent crude protein and the percent crude fiber showed a strong positive combined correlation coefficient. The Kalispell data also showed this relationship and was based on one year's data. The negative relationship at two locations were probably due to yearly effects. From this it was concluded that as the percent crude protein in the forage increased the percent crude fiber was increased also.

The relationship of the percent crude protein and the percent nitrogen free extract showed a non-significant negative value. Two locations that showed positive values which were probably due to the effect contributed by the different years. Two other locations showed negative values with the strongest value at Kalispell which was based on one year's data. From this it was concluded that as the percent crude protein of the forage increased, the percent nitrogen free extract decreased.

The combined comparison of the percent crude fiber and percent nitrogen free extract in the forage showed a negative value as did all the individual locations. From this it was concluded that as the percent crude fiber increased in the forage, the percent nitrogen free extract was decreased.

The interrelationship of the components of chemical composition indicated that in most cases as the percent crude protein was increased, the percent crude fiber was increased and the percent nitrogen free extract (carbohydrates) was decreased. This was also substantiated when the percent crude fiber and percent nitrogen free extract was compared. It was found that as the percent crude fiber was increased, the percent nitrogen free extract decreased.

Factors Affecting the Components of Composition of Corn Forage at Harvest

Results

The following factors were considered to have an effect on the chemical composition of corn forage at harvest.

1. Plant population.
2. Maturity rating of the varieties.
3. Stage of maturity of the plants at the time of harvest.
4. Planting date.

When the percent crude protein was correlated with the plant population, a combined correlation coefficient of -.2702 resulted. This value was highly significant based on 124 paired observations. The individual location coefficients ranged from -.1387 to -.4138. Only one year at a single location (Kalispell) could be correlated and a coefficient of -.3623 resulted.

The combined comparison of the percent of crude protein and maturity rating yielded a correlation coefficient of .2873. The average calculated, combined coefficient, removing location effects, yielded an average correlation coefficient of -.1300. This value was non-significant based on 197 paired observations. The individual location coefficients ranged from -.0315 to -.4190; however, these values were non-significant. The individual years at each location yielded correlation coefficients which ranged from -.0558 to -.5696.

The combined comparison of the percent crude protein and the stage of maturity was .0547 which was not significant. No significant correlation was found for the individual locations or for any individual year at any location.

The combined correlation coefficient for the comparison of the percent crude protein and the planting date resulted in a value of .2514. This value was highly significant based on 222 paired observations. The individual location correlation coefficients ranged from -.3793 to .6654. The combined average correlation coefficient, removing location effects, resulted in a coefficient of .4970.

The combined correlation of the percent crude fiber and the plant population yielded a coefficient of .3707 which was significant based on 34 paired observations. The individual location correlation coefficient were .2982 at Bozeman and .6394 at Kalispell. The Kalispell coefficients was based on one year's data since more than one population was used.

When the percent crude fiber and the maturity ratings were correlated, a combined coefficient of .1685 resulted which was not significant based on 66 paired observations. The individual location coefficients ranged from .1053 to .5417 all of which were non-significant. The coefficients for the individual years at each location also were not significant.

The combined correlation of the percent crude fiber and the stage of maturity resulted in a coefficient of -.3913 which was highly significant based on 85 paired observations. The individual location correlation coefficients ranged from -.1249 to -.6433. The correlation of the individual years at each location were also all negative values.

The correlation of the percent crude fiber and the planting date resulted in a combined coefficient of .5518 which was highly significant based on 132 paired observations. The individual locations gave coefficients which ranged from .2332 to .7076 and one location (Sidney) gave -.3995.

When the percent nitrogen free extract was correlated with the plant population, a combined coefficient of .3883 resulted. This value was significant based on 34 paired observations. The individual locations yielded coefficients of -.0213 at Bozeman and -.3340 at Kalispell. The

Kalispell coefficient was based on one year's data. No other individual years at any location could be correlated since only one population was used for any one year.

The combined correlation of the percent nitrogen free extract and the maturity rating resulted in a coefficient of -.0514 which was not significant. All individual locations and individual years at each location were also found to be non-significant.

The combined correlation of percent nitrogen free extract and the stage of maturity resulted in a coefficient of -.1470. The average combined correlation value was calculated, removing location effects and found to be .3544 which was highly significant based on 85 paired observations. The individual location correlation coefficients ranged from .3453 to .5166. Coefficients for the individual years at each location ranged from .4821 to .5933.

The comparison of percent nitrogen free extract and planting date yielded a correlation coefficient of .3386 which was highly significant based on 132 paired observations. The individual location coefficients ranged from -.1114 to -.5419.

Discussion

When the percent crude protein and the plant population were correlated, a negative relationship resulted. This negative relationship also existed for the individual locations and for the individual years at each location studied. This indicated that as the plant population was increased, the precent crude protein in the forage at harvest decreased.

The relationship of percent crude protein and maturity rating of the varieties grown at all locations in all years, showed a positive value. When the location effects were removed, a negative value existed. This negative value also existed at all individual locations and for all individual years at each location. Since the correlation coefficients were not significant, indications were that the maturity rating had no affect on the percent crude protein in the forage at harvest.

The relationship of percent crude protein and the stage of maturity yielded a non-significant correlation coefficient. From this, it was concluded that the stage of maturity had no affect on the percent crude protein in the forage at harvest.

The correlation of the percent crude protein and the planting date showed a positive relationship. This positive relationship was also shown at all individual locations except Bozeman. The reason the Bozeman data indicated a negative relationship was probably due the effect of years. The positive relationship indicated the later the planting date the higher the percent crude protein in the forage at harvest.

The correlation of the percent crude fiber and the plant population showed a positive relationship. This relationship was also positive for the individual locations. From this it was concluded that as the plant population was increased, the percent crude fiber at harvest was also increased.

The correlation of the percent crude fiber and the maturity rating yielded a non-significant correlation coefficient as did the individual locations and individual years at each location. From this it was concluded that the maturity rating of the varieties grown had no affect on the percent crude fiber at harvest.

When the percent crude fiber and the stage of maturity was correlated, a negative relationship existed. This was true for the individual locations and for all individual years at each location studied. From this it was concluded that plants which were more mature at harvest would contain a lower percent crude fiber than immature plants. The correlation of the percent crude fiber and planting date showed a strong positive relationship. This relationship existed for all individual locations studied except Sidney where a negative relationship existed. This was probably due to the differences between years. The Kalispell correlation coefficient was positive and based on one year's data. From this, it was concluded that if the planting date was late in the season, a higher percent crude fiber may be expected at harvest than if the planting date was early in the season.

The correlation of the percent nitrogen free extract and the plant population showed a positive relationship which was significant. Two locations studied showed a negative relationship which was not significant. From this, it was concluded that plant populations had no affect on the percent nitrogen free extract at harvest.

The combined correlation of the percent nitrogen free extract and the maturity rating showed a non-significant value. This was also true for all individual locations and for all individual years at each location. This indicated that the maturity rating of the varieties grown had no affect on the percent nitrogen free extract at harvest.

The combined average correlation of the percent nitrogen free extract and the stage of maturity at harvest showed a positive relationship. This relationship was also true for all individual locations and for all individual years at each location. This indicated that the mature plants had a higher percent nitrogen free extract than the immature plants.

The correlation of the percent nitrogen free extract and the planting date showed a negative relationship. This relationship existed for all the individual locations studied. This indicated that a higher percent.

From the preceeding, it was concluded that late plantings of corn increased the percent crude protein and percent crude fiber while the percent nitrogen free extract was decreased. This also showed the interrelationship of the components of chemical composition. It was found that as the plant population was increased the percent crude protein was decreased, the percent crude fiber increased and there was no significant change in the percent nitrogen free extract. Nitrogen was probably a limiting factor causing the decreased crude protein percentage. The data indicated the stage of maturity had no affect on the percent crude protein; however the percent crude fiber decreased and the percent nitrogen free extract increased as maturity increased. Wiggans (45) also mentioned this. The data indicated the maturity rating had no affect on the percent crude fiber or the pe percent nitrogen free extract. However, a decreased percent crude protein was noted as the maturity rating increased.

The Effect of Fertilization on Yield of Forage and Percent Crude Protein in the Forage at Harvest

Results

The combined correlation of the pounds of nitrogen fertilizer added to the soil and the yield of forage gave a coefficient of .1318 which was not significant. The individual years at each location yielded correlation coefficients which ranged from .0960 to .8532.

The combined correlation of the pounds of nitrogen fertilizer added to the soil and the percent crude protein in the forage at harvest yielded a coefficient of .4244. This value was highly significant based on 130 paired observations. Correlation of individual years at each location gave correlation coefficients which ranged from .2776 to .9366.

The combined correlation of the pounds of phosphorus fertilizer added to the soil and the forage yield gave a coefficient of -.0101 which was not significant based on 150 paired observations. Correlation of the individual years at each location also yielded non-significant values.

The combined correlation of the pounds of phosphorus fertilizer added to the soil and the percent crude protein in the forage at harvest yielded, a coefficient of .0340, which was not significant based on 130 paired observations. Correlations of the individual years at each location also yielded values which ranged from -.0380 to .6928.

Discussion

The combined comparison of pounds of nitrogen fertilizer added to the soil and the silage yield showed a positive relationship which was not significant. Some of the coefficients for the individual years at each location showed a strong positive relationship. The reason some years did not show a strong positive relationship was because the corn was grown on plots after alfalfa in a rotation program, thus, adequate plant nutrients were available.

Figure 3 shows the plotted data for an experiment conducted at Huntley, Montana in 1960. Rates of 50, 100, 150 and 200 pounds of nitrogen were used with both 0 pounds of phosphorus and 50 pounds of phosphorus. The figure illustrates an increase in yield with the addition of up to 150 pounds of nitrogen per acre, when no phosphorus is used.

When the pounds of nitrogen added to the soil is correlated with the percent crude protein in the forage at harvest, a strong positive relationship existed for the combined data. This was also true for the individual years at each location studied. This indicated that nitrogen fertilization may be necessary for the presence of high percentages of crude protein in the forage.

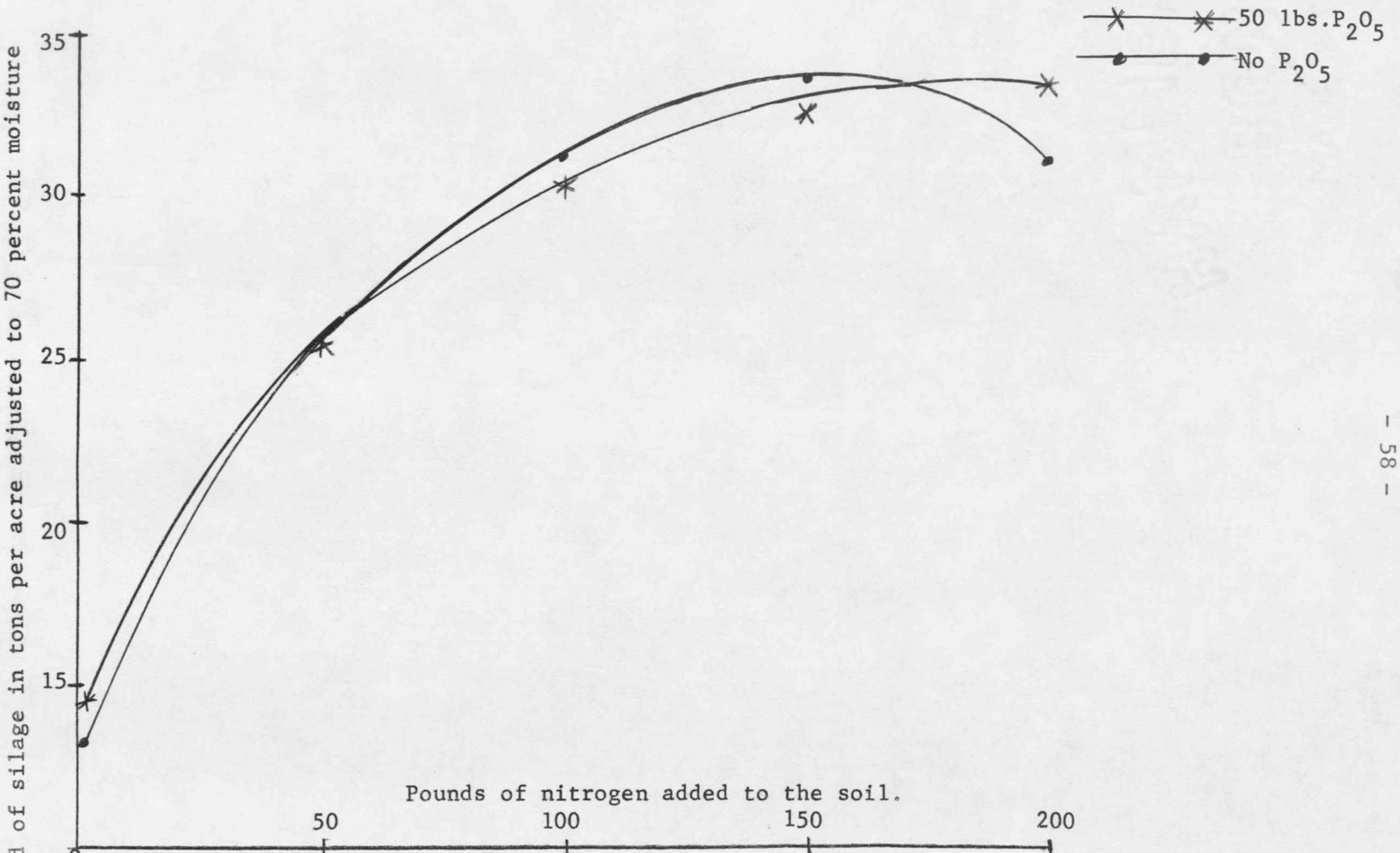

Figure 3. Plotted data for silage yield in tons per acre at 70 percent moisture of 105 day maturity rated corn variety and pounds of nitrogen and phosphorus (P_2O_5) fertilizer added to the soil. (Huntley, Montana, 1960)

The relationship of the pounds of phosphorus applied to the soil and the silage yield gave non-significant values for the combined data. This was true for the individual years at each location studied.

It was indicated by the data presented in figure 3 that phosphorus was needed when over 150 pounds of nitrogen was added to the soil. Up to this rate there was little difference in forage yields. Under the condition of this study, it was concluded that there was no change in yield by the addition of phosphorus unless nitrogen was also added at rates of 150 pounds per acre.

The combined comparison of pounds of phosphorus added to the soil and the percent crude protein in the forage at harvest showed no relationship. Some individual years at some locations showed a positive relationship which was significant. The data indicated that at some location, Huntley, Sidney, and Columbus, phosphorus fertilization may be needed for the presence of high crude protein percentages.

From this study it was concluded that nitrogen and phosphorus fertilization was important to the production of high forage yields and high percentages of crude protein. Alexander (1) also supports this finding. In some cases, fertilization was not necessary such as in an alfalfa rotation program.

Table IV. Results of the analysis of the corn silage data from 1951 through 1963 at seven locations.

Relationship Tested and Location	N	Means X	Means Y	Correlation Coefficients r	Ave. r
Plant population (X) x silage yield (Y)					
Combined	911	22,673.07	17.80	.1100**	.2305**
Bozeman	106	42,328.47	15.34	.2154*	
Sidney	274	16,422.17	16.04	.3664**	
Huntley	395	20,086.23	18.79	.2059**	
Kalispell	57	27,570.53	22.21	.3730**	
Corvallis	24	18.597.50	17.84	.7115**	
Havre	25	32,670.00	17.16		
Columbus	30	30,000.00	21.77		
Maturity rating x silage yield.					
Combined	1030	105.86	19.75	.3278**	.4802**
Bozeman	198	106.85	16.44	.4267**	
Sidney	290	103.83	20.19	.5356**	
Huntley	333	103.88	22.99	.4319**	
Kalispell	142	108.19	15.61	.4161**	
Corvallis	12	104.83	23.41	.6355*	
Havre	25	106.16	17.16	.7110**	
Columbus	30	130.00	21.77		
Stage of maturity x silage yield					
Combined	495	6.44	16.42	-.0778	-.1278**
Bozeman	112	5.11	16.66	-.2564**	
Sidney	152	6.45	16.39	.0288	
Huntley	163	7.77	16.71	-.1973*	
Kalispell	56	5.27	15.80	-.4147**	
Corvallis	12	6.08	13.67	-.4113	
Tasseling date x silage yield					
Combined	405	31.22	17.19	.0891	
Bozeman	85	52.22	17.44	.0022	
Huntley	320	25.64	17.12	.2116**	

Table IV. Results of the analysis of the corn silage data from 1951 through 1963 at seven locations. (continued)

Relationship Tested and Location	N	Means X	Means Y	Correlation Coefficients r	Correlation Coefficients Ave. r
Plant height x silage yield					
Combined	435	93.93	18.28	.5496**	
Bozeman	36	78.81	15.64	.2199	
Sidney	49	82.16	14.23	.5757**	
Huntley	313	97.67	19.49	.4592**	
Corvallis	12	65.00	13.67	.7310**	
Havre	25	105.76	17.16	.7288**	
Planting date x silage yield					
Combined	1181	18.17	17.64	-.2737**	
Bozeman	159	22.57	15.58	-.1327	
Sidney	269	18.15	17.32	.1717**	
Huntley	495	15.14	18.94	-.2173**	
Kalispell	167	22.48	15.98	-.1548*	
Corvallis	36	22.00	15.71	-.6801**	
Havre	25	14.00	17.16		
Columbus	30	20.00	21.77		
Mean summer temperature x silage yield.					
Combined	1571	63.09	18.24	.2664**	
Bozeman	246	60.76	16.27	.4891**	
Sidney	464	63.44	18.10	.4339**	
Huntley	598	64.61	19.65	.0376	
Kalispell	208	59.79	16.49	-.1975**	
Havre	25	65.60	17.16		
Columbus	30	67.10	21.77		
Nitrogen fertilizer x silage yield					
Combined	150	127.91	23.53	.1318	
Bozeman	30	149.80	17.11	.4673**	
Sidney	30	100.20	25.71	.5452**	
Columbus	30	145.60	21.77	-.0402	
Huntley	60	121.97	26.55	.5098**	

Table IV. Results of the analysis of the corn silage data from 1951 through 1963 at seven locations. (continued)

Relationship Tested and Location	N	Mean X	Y	Correlation Coefficients r	Ave. r
Phosphorus fertilizer x silage yield.					
Combined	150	50.43	23.54	-.0101	
Bozeman	30	50.50	17.11	-.0771	
Sidney	30	50.33	25.71	.0564	
Huntley	60	50.42	26.55	-.0095	
Columbus	30	50.50	21.77	-.0594	
Plant population x moisture percentage.					
Combined	561	25,290.31	74.24	.2288**	
Bozeman	100	43,818.80	78.60	-.1335	
Sidney	135	15,472.74	76.78	.4453**	
Huntley	235	21,892.74	69.14	.0933	
Kalispell	12	34,112.00	73.72	.1191	
Corvallis	24	18,597.50	74.75	-.0245	
Havre	25	32,670.00	80.08		
Columbus	30	30,000.00	83.10		
Maturity rating x moisture percentage.					
Combined	884	105.95	76.44	.4112**	
Bozeman	198	106.85	78.73	.1686*	
Sidney	212	103.83	77.18	.4926**	
Huntley	297	103.29	71.25	.5883**	
Kalispell	110	109.07	82.46	-.0233	
Corvallis	12	104.83	74.67	.0685	
Havre	25	106.16	80.08	.7642**	
Columbus	30	130.00	83.10	.0132	
Stage of maturity x moisture percentage					
Combined	411	6.41	76.02	-.5400**	
Bozeman	108	5.00	78.53	-.6046**	
Sidney	104	6.31	75.20	-.4033**	
Huntley	163	7.77	74.24	-.5722**	
Kalispell	36	4.78	78.96	-.4194**	

Table IV. Results of the analysis of the corn silage data from 1951 through 1963 at seven locations. (continued).

Relationship Tested and Location	N	X	Y	r	Ave. r
Tasseling date x moisture percentage.					
Combined	251	34.62	73.15	.4970**	
Bozeman	85	52.22	77.68	.4098**	
Huntley	166	25.61	70.83	.1848*	
Plant height x moisture percentage.					
Combined	276	96.87	73.02	.2750**	
Bozeman	36	78.81	76.46	.2944	
Huntley	251	98.68	71.62	.4051**	
Havre	25	105.76	80.08	.4737*	
Planting date x moisture percentage					
Combined	838	18.49	76.58	.5577**	
Bozeman	153	22.24	79.94	.4474**	
Sidney	178	17.99	78.20	-.0196	
Huntley	326	16.03	71.29	.4600**	
Kalispell	114	22.18'	82.38	.8812**	
Corvallis	12	16.00	74.67		
Havre	25	14.00	80.08		
Columbus	30	20.00	83.10		
Mean summer temperature x moisture percentage.					
Combined	1108	63.27	76.31	-.2709**	
Bozeman	236	60.82	78.98	-.1452*	
Sidney	295	63.29	76.67	.0695	
Huntley	408	64.88	72.08	.3254**	
Kalispell	714	60.98	82.38	-.3728**	
Havre	25	65.60	80.08		
Columbus	30	67.10	83.10		

Table IV. Results of the analysis of the corn silage data from 1951 through 1963 at seven locations. (continued)

Relationship Tested and Location	N	Mean X	Mean Y	Correlation Coefficients r	Ave. r
Plant population x stage of maturity					
Combined	281	22,467.94	6.82	-.2214**	
Bozeman	36	43,560.00	5.67		
Sidney	134	17,361.34	6.41	.1350	
Huntley	99	20,298.67	7.94	-.0671	
Kalispell	12	34,112.00	5.67	-.2433	
Plant population x tasseling date.					
Combined	337	21,629.98	29.06	.6863**	
Bozeman	35	43,560.00	58.73		
Huntley	302	19,088.42	25.66	.4415**	
Plant population x plant height					
Combined	356	21,382.51	94.20	-.1685**	
Bozeman	36	43,560.00	78.81		
Sidney	49	14,935.00	82.16		
Huntley	246	18,274.19	97.68	.0743	
Havre	25	32,670.00	105.76		
Plant population x crude protein					
Combined	124	33,172.60	7.86	-.2702**	
Bozeman	44	37,546.77	7.47	-.4138**	
Huntley	38	30,315.79	6.81	-.1387	
Kalispell	12	34,112.00	7.34	-.3623	
Columbus	30	30,000.00	9.97		
Plant population x crude fiber					
Combined	34	41,570.65	22.94	.3707*	
Bozeman	14	53,718.43	24.92	.2982	
Huntley	8	31,500.00	15.88		
Kalispell	12	34,112.00	25.33	.6394	

Table IV. Results of the analysis of the corn silage data from 1951 through 1963 at seven locations. (continued)

Relationship Tested and Location	N	Mean X	Mean Y	Correlation Coefficients r	Ave. r
Plant population x nitrogen free extract					
Combined	34	41,570.65	55.79	.3883*	
Bozeman	14	53,718.43	60.69	-.0213	
Huntley	8	31,500.00	41.69		
Kalispell	12	34,112.00	59.49	-.3340	
Maturity rating x stage of maturity					
Combined	312	104.69	6.05	-.6256**	
Bozeman	108	105.07	5.00	-.6416**	
Sidney	97	103.11	6.44	-.7141**	
Huntley	71	101.76	7.77	-.8269**	
Kalispell	36	113.53	4.78	-.4835**	
Maturity rating x plant height					
Combined	175	101.72	37.42	.5457**	
Bozeman	85	105.56	52.22	.5174**	
Huntley	90	98.09	23.43	.6574**	
Maturity rating x tasseling date.					
Combined	230	102.34	95.90	.5724**	
Bozeman	36	101.42	78.81	.4945**	
Huntley	169	101.98	98.08	.6807**	
Havre	25	106.16	105.76	.7049**	
Maturity rating x crude protein					
Combined	197	111.72	7.85	.2873**	-.1300
Bozeman	48	110.72	7.42	-.0891	
Sidney	26	111.15	9.13	-.1906	
Huntley	79	105.01	6.96	-.0315	
Kalispell	14	116.43	7.37	-.4190	
Columbus	30	130.00	9.99		

Table IV. Results of the analysis of the corn silage data from 1951 through 1963 at seven locations. (continued)

Relationship Tested and Location	N	Mean X	Y	Correlation Coefficients r	Ave. r
Maturity rating x crude fiber					
Combined	66	113.47	24.53	.1685	
Bozeman	18	110.72	23.89	.3072	
Sidney	5	118.00	23.60	.5417	
Huntley	29	112.96	24.62	.1489	
Kalispell	14	116.43	25.50	.1053	
Maturity rating x nitrogen free extract					
Combined	66	113.47	56.63	.0514	
Bozeman	18	110.72	62.10	-.3550	
Sidney	5	118.00	62.64	.0768	
Huntley	29	112.96	50.92	.1427	
Kalispell	14	116.43	59.30	.2603	
Tasseling date x stage of maturity					
Combined	199	35.19	6.78	-.6578**	
Bozeman	82	50.51	5.21	-.3778**	
Huntley	117	24.45	7.89	-.4319**	
Stage of maturity x plant height					
Combined	146	7.11	90.02	.1042	-.5809**
Bozeman	36	5.67	78.81	-.5792**	
Huntley	98	7.76	97.20	-.5921**	
Corvallis	12	6.08	65.00	-.6381*	
Stage of maturity x crude protein					
Combined	85	6.69	7.25	.0547	
Bozeman	20	6.05	7.12	.1146	
Sidney	18	6.72	7.27	.2873	
Huntley	35	7.40	7.27	.0321	
Kalispell	12	5.67	7.34	-.3225	

Table IV. Results of the analysis of the corn silage data from 1951 through 1963 at seven locations. (continued)

Relationship Tested and Location	N	Mean X	Y	Correlation Coefficients r	Ave. r
Stage of maturity x crude fiber					
Combined	85	6.69	22.78	-.3913**	
Bozeman	20	6.05	22.60	-.6433**	
Sidney	18	6.72	21.72	-.5734**	
Huntley	35	7.40	22.54	-.3594	
Kalispell	12	5.67	25.33	-.1249	
Stage of maturity x nitrogen free extract					
Combined	85	6.69	56.23	-.1470	.3541**
Bozeman	20	6.05	61.58	.3453	
Sidney	18	6.72	63.49	.5841**	
Huntley	35	7.40	48.32	.4392**	
Kalispell	12	5.67	59.49	.5166	
Planting date x stage of maturity					
Combined	340	17.73	6.34	-.2955**	.3541**
Bozeman	88	18.85	4.85	-.5056**	
Sidney	67	15.69	6.31	.2207	
Huntley	129	16.72	7.82	.1464	
Kalispell	56	20.71	5.29	.1294	
Mean summer temperature x stage of maturity					
Combined	483	63.09	6.45	.4171**	
Bozeman	112	60.95	5.11	-.1460	
Sidney	152	62.99	6.45	.1489	
Huntley	163	65.46	7.67	.1052	
Kalispell	56	60.75	5.27	-.5147**	

Table IV. Results of the analysis of the corn silage data from 1951 through 1963 at seven locations. (continued)

Relationship Tested and Location	N	Mean X	Mean Y	Correlation Coefficients r	Ave. r
Tasseling date x plant height					
Combined	250	29.51	94.25	-.1235	.3210**
Bozeman	35	58.37	78.43	.4540**	
Huntley	215	24.81	96.83	.4712**	
Planting date x tasseling date					
Combined	367	15.17	31.20	.2694**	
Bozeman	65	18.23	56.89	-.0660	
Huntley	302	14.52	25.66	-.0086	
Mean summer temperature x tasseling date					
Combined	405	63.80	31.20	-.6464**	
Bozeman	85	61.50	52.22	-.2222*	
Huntley	320	64.40	25.64	-.2991**	
Planting date x plant height					
Combined	405	16.00	94.70	.1014**	
Bozeman	36	15.00	78.81		
Sidney	49	18.00	82.16		
Huntley	295	15.95	97.78	.1874**	
Havre	25	14.00	105.76		
Mean summer temperature x plant height					
Combined	423	64.41	94.75	.2349**	
Bozeman	36	60.80	78.81		
Sidney	49	64.60	82.16		
Huntley	313	64.70	97.67	.0764	
Havre	25	65.60	105.76		

Table IV. Results of the analysis of the corn silage data from 1951 through 1963 at seven locations. (continued)

Relationship Tested and Location	N	Mean X	Y	Correlation Coefficients r	Ave. r
Crude Protein x crude fiber					
Combined	196	7.36	23.28	.4880**	
Bozeman	48	6.92	24.17	-.3361*	
Sidney	43	6.68	22.70	-.5795**	
Huntley	90	7.89	22.67	.7018**	
Kalispell	15	7.47	25.73	.2911	
Crude protein x nitrogen free extract					
Combined	196	7.36	56.68	-.0107	
Bozeman	48	6.92	60.75	-.1193	
Sidney	43	6.68	63.11	.1541	
Huntley	90	7.89	51.08	.3348**	
Kalispell	15	7.47	58.79	-.7270**	
Plantings date x crude protein					
Combined	222	20.73	7.97	.2514**	.4970**
Bozeman	46	28.30	7.70	-.3793**	
Sidney	38	20.89	6.69	.6654**	
Huntley	93	17.84	8.06	.6351**	
Kalispell	15	16.40	7.47		
Columbus	30	20.00	9.97		
Nitrogen fertilizer x crude protein					
Combined	130	132.17	8.15	.4244**	
Bozeman	30	149.80	7.78	.9381**	
Sidney	20	100.20	9.53	.8844**	
Huntley	50	126.32	6.70	.6764**	
Columbus	30	145.60	10.00	.2776	

Table IV. Results of the analysis of the corn silage data from 1951 through 1963 at seven locations. (continued)

Relationship Tested and Location	N	Mean X	Y	Correlation Coefficients r	Ave. r
Phosphorus fertilizer x crute protein					
Combined	130	50.50	8.15	.0240	
Bozeman	30	50.50	7.70	.0175	
Sidney	20	50.50	9.57	.6910**	
Huntley	50	50.50	6.70	.0135	
Columbus	30	50.50	10.00	.4259*	
Crude fiber x nitrogen free extract					
Combined	195	23.28	56.68	-.1501*	
Bozeman	48	24.17	60.75	-.6758**	
Sidney	43	22.70	63.11	-.8095**	
Huntley	90	22.67	51.08	-.2127*	
Kalispell	15	25.73	58.79	-.8047**	
Planting date x crude fiber					
Combined	132	23.88	21.45	.5518**	
Bozeman	16	24.88	27.00		
Sidney	38	22.58	20.89	-.3995*	
Huntley	63	23.97	21.57	.7076**	
Kalispell	15	25.73	16.40	.2332	
Planting date x nitrogen free extract					
Combined	132	21.45	57.10	-.3386**	
Bozeman	16	27.00	60.01		
Sidney	38	20.89	63.17	-.3985**	
Huntley	63	21.57	52.30	-.5419**	
Kalispell	15	16.40	58.79	-.1114	

SUMMARY AND CONCLUSIONS

The corn silage data was collected from seven locations in Montana from 1951 through 1963. Simple correlations were calculated among factors related to corn silage production.

The analysis of the data indicated the following conclusions:

1. Forage yield was related to the maturity rating of the varieties grown, the plant population, pounds of nitrogen fertilizer applied, planting date, and the mean summer temperature. For high forage yields, early plantings of late maturing varieties should be made at high populations with adequate fertilization. Higher than average forage yield may be expected in years when the mean summer temperatures are higher than average.

2. Plant height, stage of maturity at harvest and tasseling date were directly related to the maturity rating of the varieties grown. Varieties with high maturity rating resulted in tall plants which tasseled late in the season, and were immature at harvest.

3. The percent moisture in the forage at harvest was related to the plant population, maturity rating, planting date, and mean summer temperature. The percent moisture in the forage was increased by planting high maturity rated varieties, at high populations, late in the season. Lower than average mean summer temperature tended to increase percent

moisture.

4. The data indicated that as the percent crude protein increased the percent crude fiber also increased and the percent nitrogen free extract decreased.
5. The maturity rating of the varieties had no affect on the percent nitrogen free extract or crude fiber; however, as the maturity rating was increased the percent crude protein decreased.
6. The stage of maturity had no affect on the percentage of crude protein; however, plants that were mature contained a lower percent crude fiber and a higher percent nitrogen free extract than immature plants at harvest.
7. When the planting date was late in the season, the plants tasseled later were more immature and slightly taller at harvest.
8. When nitrogen fertilizer was added to the soil, the yield of forage was increased in most cases. The percent crude protein in the plants at harvest was increased by the addition of nitrogen fertilizer.
9. When phosphorus fertilizer was added to the soil, there was no increase in forage yield. In some cases the percent crude protein in the forage was increased when phosphorus was added.

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APPENDIX I

Coding of Data on IBM Cards

Column 1 - Experiment sorting column coded as follows:

0. Corn silage variety trials.
1. Plant population studies.
2. Fertilizer trials.
3. Maturity rating studies.
4. Planting date experiments.
5. Variety trials and Planting Date studies.
6. Fertilizer and maturity rating studies.
7. Maturity rating and planting date experiments.

Columns 2 and 3 - Year experiment was conducted.

Coded as the last two digits of the year. Example: 1955 coded as 55, 1956 coded as 56.

Column 4 - Location where experiment was conducted in Montana coded as follows:

0. Montana Agricultural Experiment Station, Bozeman.
1. Eastern Montana Branch Station, Sidney.
2. Huntley Branch Station, Huntley.
3. Central Montana Branch Station, Moccasin.
4. Northwestern Montana Branch Station, Kalispell.
5. Western Montana Branch Station, Corvallis.
6. Northern Montana Branch Station, Havre.
7. Columbus, Montana.

Column 5 - Experiment conducted under dryland condition or irrigation coded as follows:

0. Dryland

1. Irrigated

Columns 6, 7 and 8 - Variety of corn used in experiment coded as follows:

000 Dekalb 46

001 Pride PN 1

002 Nodakhybrid 208

003 Wisconsin 275A

004 Falconer

005 Pride B 2

006 Pride PN 4

007 Pride B 3A

008 Pioneer N

009 Wisconsin 255

010 Wisconsin 1602

011 Pride PXO 2

012 Montana 19 X 29

013 Wisconsin 279

014 Kingscrost KF

015 Pride D 1A

016 Pride PN 1A

017 Kingscrost KE 3

018 Pride PXO 3

019 Master F 32

020 Pride PXO 4

021 Nodakhybrid 301

022 Nodakhybrid 304

023 Wisconsin 240

024 Pride PN 2

025 Minnhybrid 802

026 (S 38 X S 64) (D X 49)

027 Dekalb 56

028 Wisconsin 355

029 Paynes White Dent

030 Pioneer K

031 Gehu

032 Jacques 853J

033 Dekalb 43

034 Funks G-18

035 Dekalb 58

036 Dekalb 58

037 Wisconsin 270

038 Haapala 359

039 Funks G-35

040 Kingscrost 2003

041 Jacques Sib-bred 1

042 Kingscrost 2002

043 Dekalb 41

044 Pride PNO

045 Master X 13

046 Funks G-68

047 Master X 23

048 Dekalb 55

049 Wisconsin 335

050 Dekalb 65

051 Pride PX 71

052 Kingscrost 2010

053 Kingscrost KC 3

054 Pride PN 21

055 Master F 21

056 Pride B 25A

057 Kingscrost Northern King

058 Dekalb 63

059 Jacques 957JA

060 Dekalb 62

061 Kingscrost KE 1

062 Pride PN 16A

063 Pride PX 70

064 Pride XGF 1

065 Master X 41A

066 Dekalb 67

067 Kingscrost KB 4

068 Pfister 33

069 Pfister 44

070 Funks 49143

071 Pfister 28

072 Funks 35715

073 Dekalb 44

074 Pfister 32

075 Pfister 57

076 Pride PX 12

077 Idahybrid 330

078 Magills Nodak 306

079 Idahybrid 216

080 Kingscrost KC 6

081 Magills Synthetic

082 Magills Nodak 305

083 Pride PN 3

084 Magills Nodak 302

085 Mexican June

086 Dekalb 1051

087 P.A.G. 485

088 Funks G-44

089 Dekalb 222

090 Magills W 642

091 Dekalb 253

092 Dekalb 414

093 P.A.G. 57

094 Funks G-20

095 P.A.G. 62

096 Idahybrid 544

097 P.A.G. 55

098 Dekalb 251

099 Funks G-35A

100 P.A.G. 32

101 Magills Nodak 502

102 P.A.G. 33

103 Dekalb 66

104 Dekalb 59

105 Dekalb 423

106 Kingscrost KW 5

107 Kingscrost M 2

108 P.A.G. 43

109 Kingscrost KA 3

110 Magills UM 164

111 Dekalb 444

112 Haapala Sweet Dent 60

113 Haapala Sweet Dent 50

114 Dekalb 640

115 Dekalb 633

116 Dekalb 3 X 4

117 Magills W 642

118 Kingscrost KT 6

119 Jacques Kow Salad 3

120 P.A.G. 44

121 Jacques Hy Sugar Silage Corn

122 Magills W 475

123 Jacques Kow Salad 950J

124 Jacques Kow Salad 1005J

125 Kingscrost KS 2

126 Northern King

127 Jacques Kow Salad 1R

128 A.E.S. 201

129 Montana 102

130 Montana 101

131 Dekalb 3 X 2

132 Kingscrost KN 2

133 Montana 201

134 Jacques Sib-bred 1F

135 Northwestern Dent

136 A.E.S. 101

137 Funks G-2

138 P.A.G. 58

139 Jacques Sib-bred 1E

140 Dekalb 61

141 Funks G-26

142 Idahybrid 680

143 P.A.G. 26

144 P.A.G. 323

145 Dekalb 50

146 Haapala Sweet Dent 70

147 Pride 75

148 Pfister 55

149 Jacques 12085

150 Pride 44-5

151 Pride 63

152 Kingscrost Exp. 2080

153 Dekalb 35

154 P.A.G. 28

155 Kingscrost Exp. 2070

156 Rainbow Flint

157 Pride 15

158 Nodahhybrid 307

159 Pride 11

160 Haapala Sweet Dent 40

161 Dekalb 42

162 Multicross

163 Nodakhybrid 403

164 Funks 94074

165 P.A.G. 434

166 H.S. 50

167 Funks 94110

168 Dekalb 238

169 P.A.G. 418

170 Agsco Smorgasbord M-59-201

171 Dekalb 441

172 Dekalb 57

173 Kingscrost KE 444

174 Minnhybrid 611

175 Kingscrost KE 475

176 Agsco Multicross 90

177 Pride 7

178 Pride B1

179 Pride 5

180 Dekalb 29

181 Agsco Hybrid 82-M59-7A

182 Agsco Hybrid 75

183 Morden 77

184 Corn Teosinte

185 Dekalb 45

186 Agsco Hybrid 80-M 59-5

187 Agsco Multicross 75

188 Dekalb 650A

189 Jacques 1205J

190 Dekalb 440

191 Haapala 230

192 Haapala 320

193 P.A.G. 24

194 P.A.G. 45

195 Pride 22

196 Pride 26

197 Kingscrost KM 539

198 Kingscrost KM 558

199 Agsco Smorgasbord H-60-201

200 Dekalb 415A

201 Jacques 1220A

202 Jacques 1108A

203 Dekalb B 116

204 Bozeman Composite

205 Dekalb 886

206 P.A.G. 70

207 Standard 401

208 Dekalb 856

209 Dekalb 30

210 Dekalb 40

211 Pfister 62

212 Dekalb 409

213 Pfister 43

294 Wisconsin 253

215 Pride PA

216 A.E.S. 203

217 A.E.S. 202

218 Minnhybrid 803

219 Minnhybrid 804

220 Wisconsin 273

221 Pride 21

222 Magill 902

223 Wisconsin 475

224 Minnesota 415

225 Dekalb 893

226 Dekalb 661

227 (2059 X 2061) (D X 49)

228 (2069 X 2051) (2059 X 2061)

229 Magill 813

230 (J X L) (I X M) - 51

231 (M X N) (A X E) - 51

232 (A X E) (B X G) - 51

233 Western Hybrid 88

234 (2059 X 2061) (J X H)

235 (2069 X 2054) (2059 X 2061)

236 Haapala 27

237 (2254 X 2249) (J X H)

238 (2254 X 2249) (2251 X 2257)

239 (2248 X 2249) (2251 X 2257)

240 (2069 X 2054) (D X 49)

241 (2251 X 2257) (J X H)

242 (S 38 X S 64) (J X H)

243 Haapala 356

244 Haapala 309

245 Jacques 907

246 United Hybrid U 22

247 Jacques 956J

248 Jacques 803

249 Nodakhybrid 201

250 (S 38 X S 64) (9 X M 13)

251 (4 V X S 64) (9 X M 13)

252 Wisconsin 1616

253 Occident Topcross 22

254 Western Hybrid 85

255 Wisconsin 1613

256 Western Hybrid 90

257 (2069 X 2054) (J X H)

258 Golden Jewel Sweet Corn

259 (J X P) (K X Q)-52

260 (A X E) (G X H)-52

261 (I X J) (K X Q)-52

262 (A X B) (G X H)

263 Dekalb 1024

264 Haapala Sweet Dent (Early)

265 Haapala Sweet Dent (late)

266 Dekalb 239

267 Jacques Kow Salad 1A

268 Wisconsin 335A

269 Magill 950

270 Searles Seed Co.

271 Wisconsin 353

272 Wisconsin 313

273 Wisconsin 435

274 Pride C 3

275 CB 2310

276 Dixie 18

277 Pride N 21

278 Standard 401

279 P.A.G. SX 29

280 Kingscrost KT 652

281 Kingscrost KT 632

282 Dekalb 831

283 Kingscrost KE 449

284 Kingscrost KE 497

285 Minnhybrid 305

286 Dekalb XL 50

287 Carl Ross

288 Dekalb XL 361

289 P.A.G. SX 49

290 Dekalb XL 45

291 P.A.G. 38

292 Kingscrost KE 435

293 Dekalb XL 15

294 Dekalb 36

295 Kingscrost KE 411

296 P.A.G. Si Chow 35-30G-71-336

297 P.A.G. Si Chow I. 1036

298 Pride 29

299 P.A.G. 5 X 29

300 G X R High Sugar

301 Wisconsin 273

302 Funks G-40A

303 Magill 828

Columns 9, 10, and 11 - Silage yields in tons per acre adjusted to 70 percent moisture. Values are recorded to 1 decimal place. Example: 19.9 or 17.5 tons per acre.

Columns 12, 13, and 14 - Moisture percentage of fodder at time of harvest for silage. Recorded to 1 decimal place. Example: 79.1 or 80.7 percent moisture.

Columns 15, 16, 17, 18, and 19 - Population in plants per acre.
Example: 13,500 plants per acre.

Columns 20, 21, and 22 - Maturity rating of the variety grown.
Example: 110 day maturity corn.

Columns 23 - Stage of maturity of the corn plant when harvested. Coded as follows:

0 Pre tasseling

1 Tasseling

2 Ears forming

3 Silk emerging

4 Pollen shedding

5 Kernels forming

6 Milk

7 Dough

8 Early Dent

9 Well dented

Columns 24 and 25 - Tasseling date of the corn. Coded as follows:

0 - 30 July 1 through July 31.

31 - 62 August 1 through August 31.

62 - 92 September 1 through September 30.

Columns 26, 27, and 28 - Corn plant height at harvest recorded as height in inches. Example: 112 inches.

Columns 29, 30, and 31 - Crude protein in corn forage at harvest recorded as percent of dry matter to 1 decimal place. Example: 08.3 percent crude protein.

Columns 32 and 33 - Digestable protein in corn forage at harvest recorded to 1 decimal place. Example: 6.1 percent digestable protein.

Columns 34 and 35 - Crude fiber in corn forage at harvest recorded as percent of dry matter. Example: 27 percent crude fiber.

Columns 36, 37, and 38 - Nitrogen free extract in forage at harvest recorded as percent dry matter to 1 decimal place. Example: 61.4 percent nitrogen free extract.

Columns 39 and 40 - Total digestable nutrients in forage at harvest recorded as percent dry matter. Example: 73 percent total digestable nutrients.

Columns 41 and 42 - Planting date of the corn recorded as follows:

1 - 31 May 1 through May 31.

Columns 43, 44, and 45 - Mean temperature. This was determined as the average of the four months: May, June, July and August recorded in degrees Fahrenheit to 1 decimal place at the individual locations. Example: 51.2° at Bozeman.

Columns 46, 47 and 48 - Pounds of Nitrogen fertilizer added to the experimental plot recorded in pound per acre. Example: 150 lbs. per acre.

Columns 49, 50 and 51 - Pounds of phosphorus (P_2O_5) fertilizer added to the experimental plot recorded in pounds per acre. Example: 080 lbs. per acre.