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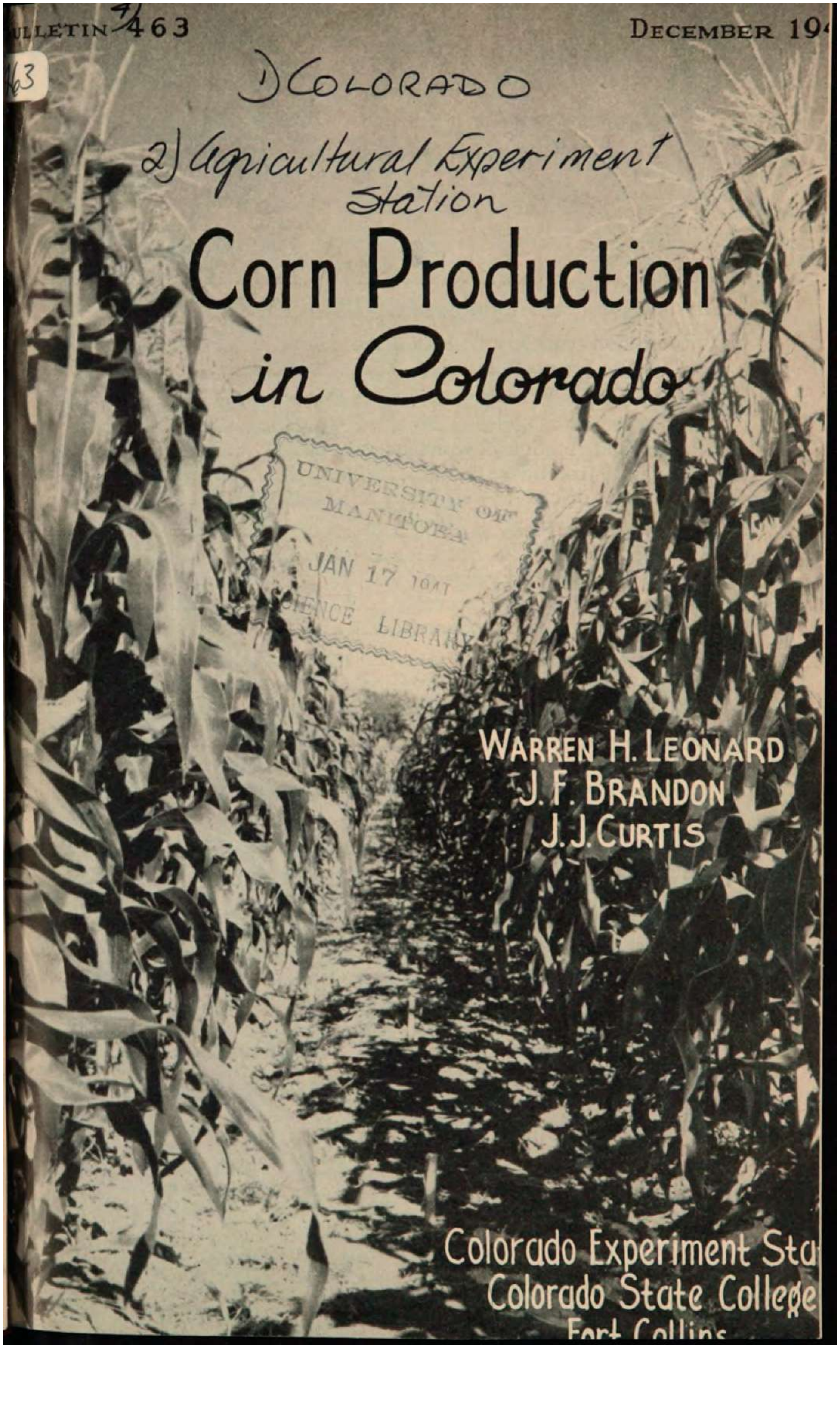

Corn Production in Colorado

WARREN H. LEONARD
J. F. BRANDON
J. J. CURTIS

Colorado Experiment Sta
Colorado State College
Fort Collins

CONTENTS

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WARREN H. LEONARD, J. F. BRANDON, AND J. J. CURTIS[1]

Introduction

CORN *(Zea mays* L.*)* has become one of the important Colorado crops in the past 25 years because of the culture of adapted varieties. In fact the Corn Belt has been extended literally to the foothills of the Rocky Mountains. For the 10-year period from 1927 to 1936 an average of 1.461,300 acres was grown in the State each year with an average annual production of 17,038,700 bushels.[2] The acreage distribution by counties for this period is shown in figure 1. The quantity produced varies considerably from year to year because of rainfall fluctuation and other variable climatic factors. From 85 to 90 percent of the acreage and 75 to 80 percent of the production is in the nonirrigated regions. The average yield per acre for the 10-year period from 1923 to 1932 was 32.2 bushels for irrigated and 11.6 bushels for nonirrigated corn.

It has been estimated that in normal years 85 percent of the corn crop is consumed on the farm where grown, while 15 percent is marketed. More corn is marketed in years of surplus, such as 1930, than in years of shortage. In seasons of low production a large quantity of corn is shipped into the State from the Corn Belt to meet local needs.

Many failures were experienced in the pioneer days by farmers who attempted to grow corn. These were too often the result of the importation of unadapted varieties. Experience and experimental results have indicated that many Corn Belt practices must be greatly modified for successful corn production in this State. An attempt will be made to point out the best accepted practices in Colorado at the present time.

[1]Associate agronomist, Colorado Experiment Station; associate agronomist, Division of Dry-Land Agriculture, Bureau of Plant Industry, U. S. Department of Agriculture, and superintendent of the U. S. Dry-Land Field Station near Akron, Colo.; and junior agronomist, Division of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, and cerealist at the Station. The United States Dry-Land Field Station, located in northeastern Colorado at an altitude of about 4,600 feet, is operated by the Division of Dry-Land Argiculture, in full cooperation with the Colorado Experiment Station. The cereal experiments at this station are under the care of a representative of the Division of Cereal Crops and Diseases, also in cooperation with the Colorado Experiment Station.

[2]*Colorado Agricultural Statistics, 1936*, Colorado State Planning Com. publication, pp. 15, 27, and 56.

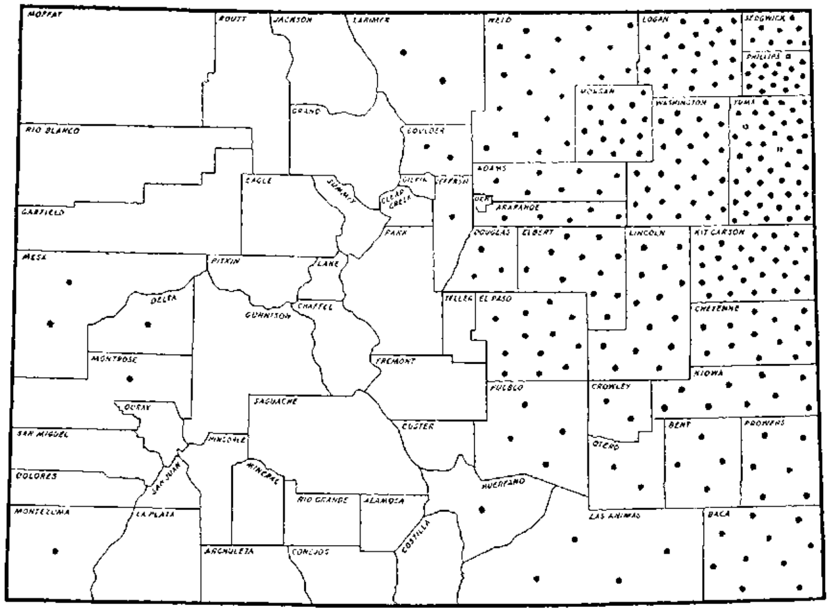

Figure 1.—Average acreage of corn in Colorado by counties for the 10-year period, 1926 to 1935, inclusive. Each dot represents 5,000 acres or major fraction thereof.

EARLY HISTORY OF CORN IN THE STATE

All the corn varieties now grown in the State were introduced, but the plant was grown here long before the advent of the white man. The ancient Cliff Dwellers grew corn in southwestern Colorado, as their habitations amply show (22).[3] Ears, cobs, husks, and articles woven from the latter, have been found in a good state of preservation in the Mesa Verde. Excavations in the Chimney Rock country in northern Larimer County have unearthed corn that probably dates back to the time of the post-Basket-Makers of 2,000 to 3,000 years ago.

Some corn, probably flint and flour types, appears to have been grown by the Plains Indians. The first varieties brought into the State by emigrants, in 1858, were the improved strains of the Corn Belt at that time. Two distinct types of corn were found in the State when agriculture started: the Mexican in the southern region, and the American varieties in the Pikes Peak area.

While corn was tried extensively in the early days of irrigation, many failures resulted through attempts to grow unadapted types brought in from the Corn Belt. These failed to mature grain in Colorado. It was soon learned that varieties or strains with tall stalks

[3]Numbers in parentheses refer to bibliography, page 36.

and large ears were undesirable for Colorado conditions. Corn remained an unimportant crop for a long period.

ENVIRONMENTAL CONDITIONS

The climatic and soil conditions are important in the adaptation of corn because it is a full-season crop. For maximum yield it is essential that a variety be grown that will utilize the entire frost-free season and produce mature corn.

Climatic Factors

The natural habitat of corn is a region of abundant moisture, high mean summer temperature, and a long frost-free season. The temperatures in Colorado are comparatively lower during the growing season than those found in the Corn Belt, especially the mean temperature. The seasons are comparatively short, being less than 150 days in most parts of the State. In some places the frost-free season averages only 90 days (fig. 2). Most of the corn is grown east of the mountains, but it can be produced in the warmer mountain valleys, particularly on the Western Slope. Conditions favorable to corn production are usually limited to elevations below 6,000 feet. It is seldom grown successfully when the normal rainfall is less than 14 inches, except under irrigation.

Soil Conditions

In Colorado, the dry-land soils that most successfully produce corn are either sandy loams or light sandy loams, that is, "semihard lands."[4] These soils warm up earlier in the spring than the heavier or so-called "hard land" soils, a fact which permits corn to be planted earlier on them. A slightly later variety can be matured on the "semihard" soils. Because these soils are more "sponge-like" in their ability to absorb rainfall, they direct more of the summer precipitation into corn production.

The "hard lands" will produce fair yields in many seasons. Some yields compiled from dry-land experiments on "hard lands" (5) indicate that an annual precipitation of more than 20 inches will produce a high yield more than one-half the time. High yields of corn were rarely obtained at Akron on less than this amount of rainfall, although fair yields were produced about one-half the time with 17 to 20 inches of annual precipitation. Crop failures almost always occurred with less than 14 inches of annual rainfall. Observation

[4]"Hard land" is a local term used to designate soils of loam, silt loam, clay loam, and sandy clay loam topsoil textures. In their native state these soils are generally covered with short grasses. "Semihard land" likewise refers to soils of loamy sand to fine sandy loam topsoil textures. Such land generally supports a semitall native grass cover. Very fine sandy loam surfaces may be considered in some cases as "hard land", and in others as "semihard land."

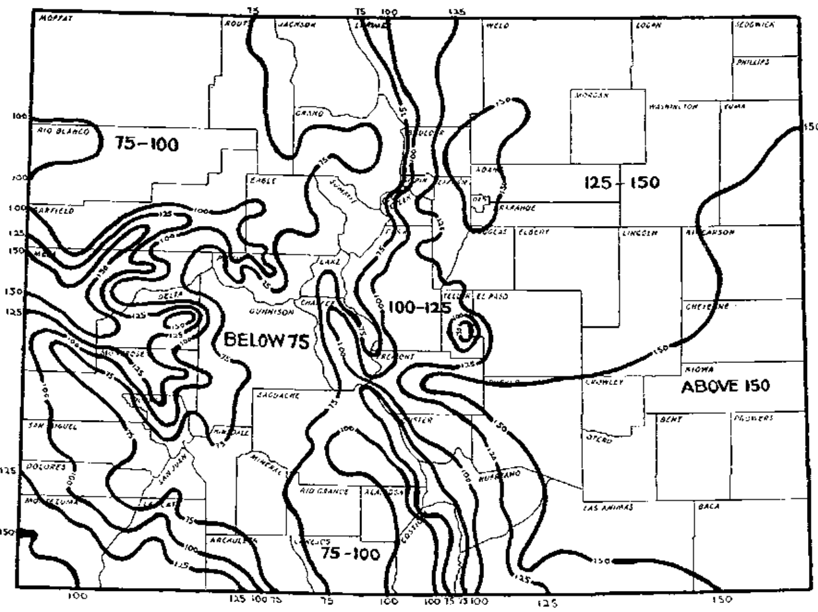

Figure 2.—Average number of days of frost-free season in Colorado.

has indicated that the corn crop is more frequently a failure on the "hard lands" than on the "semihard lands." It is well recognized that the "hard land" of the Akron station is not nearly so well adapted to corn as the more sandy lands in comparatively nearby localities.

Most Colorado soil types are suitable for corn production when ample soil moisture is available, especially under irrigation.

ROTATIONS FOR CORN

Crop rotation and cultural studies have been conducted under dry-land conditions at the U. S. Dry-Land Field Station near Akron over a long period of years (2). The practices followed for corn under irrigation have been deduced from the results of experiments in other states, as well as from general experience within this State.

Dry-Land Rotation Experiments

Dry-land experiments at Akron indicate that the highest yields were obtained from corn after fallow, the 30-year average yield being 17.5 bushels per acre. There were three practical failures to produce grain under this system, these being in 1931, 1932, and 1934 when the yields were 0.3, 2.4, and 2.3 bushels per acre, respectively. The next highest yields were obtained from plots planted continually to corn (corn after corn), but commercially the practice must be avoided when root worms, insect pests, or diseases become serious. From crop sequence studies with small grains, corn appears to follow either oats or barley better than spring or winter wheat. The results with different sequences are presented in table 1.

TABLE 1.—*Thirty-year average yields of corn for different crop sequences under dry-land conditions at Akron, 1909 to 1938.*

Previous crop or condition	Treatment: Fall plowed	Treatment: Spring plowed	Average
	Bushels per acre	Bushels per acre	Bushels per acre
Oats	10.5	10.5	10.5
Barley	...	11.0	11.0
Spring Wheat	9.3	9.8	9.6
Winter Wheat	9.2	10.2	9.7
Corn	12.6	13.1	12.8
Fallow	...	17.5	17.5

Thus it is indicated that corn may follow corn 2 or 3 years on the same land unless crop pests become troublesome. One of the problems in rotation practices is to convert the stubble land over into row-crop production. For a simple rotation, alternation of corn and a small grain has been practiced successfully on many dry-land farms. However, experience during drought periods indicates that a rotation of fallow, wheat, corn, and corn is more satisfactory. A simple 5-year rotation of fallow, winter wheat, corn, corn, and barley has been practiced by many dry-land farmers. This rotation may be modified by the substitution of row-produced feed crops, such as forage or dual-purpose sorghums, for a part of the corn in the third year or even for the barley in the fifth year.

Irrigated Rotations

Under irrigation the highest yields of corn have been obtained when it follows alfalfa, sweet clover, or some cultivated crop like sugar beets or potatoes. Farmers generally prefer to follow alfalfa with corn, this crop in turn being followed by sugar beets. Corn rotations should include a legume like alfalfa, red clover, sweet clover, or field peas. Results at Fort Collins (18) under irrigation indicate that it is hazardous to plant corn after corn because of possible injury by the Colorado corn root worm *(Diabrotica virgifera,* Lec.).

A 5-year crop rotation that may be followed is: Alfalfa, alfalfa, corn, sugar beets, and barley seeded to alfalfa. This rotation may be modified to meet local conditions.

Mixtures of Corn and Soybeans

Various mixtures of corn and soybeans were tested under irrigated conditions at Fort Collins (19) from 1923 to 1925. In planting such mixtures the beans are usually seeded at the same time and in the same rows with the corn. Special planter attachments consisting of separate boxes operated by an additional gear wheel may be used under farm conditions. A special pea attachment allows the corn and beans to be kept in separate boxes from which they are dropped together in the row or hill.

Some of the mixtures used in the 3-year experiment were planted with a corn planter, while others were hand-seeded. In all cases the rows were 3 feet apart, with the hills spaced 3 feet except where a double rate was used. The mixtures were as follows: (a) Corn and soybeans planted in the same hill by hand; (b) soybeans planted in hills between 3-foot corn hills; (c) corn and soybeans seeded in alternate rows with a planter; and (d) corn and soybeans planted in alternate 3-foot hills by hand. For comparison (e) corn and (f) soybeans were seeded in hills alone in the same experiment. The results are given in table 2.

TABLE 2.—*Yields of corn and soybean mixtures at Fort Collins, 1923 to 1925.*

Item		Yields in bushels per acre					
		2-year average*			3-year average		
		Corn	Soybeans	Total	Corn	Soybeans	Total
(a)	Corn and soybeans in same hill (hand-planted)	64.4	2.2	66.6	56.4	2.0	58.4
(b)	Soybeans planted between 3-foot corn hills.........	56.4	3.0	59.4	50.5	2.9	53.4
(c)	Corn and soybeans in hills in alternate rows (corn planter)	42.6	4.8	47.4	37.9	4.8	42.7
(d)	Corn and soybeans in alternate 3-foot hills (hand-planted)	48.0	3.3	51.3	44.1	3.2	47.3
(e)	Minnesota 13 corn alone..	74.0	..	74.0	..	..	...
(f)	Soybeans alone..........	..	19.0	19.0	..	18.4	18.4

*Yields for 1923 and 1925.

The corn retarded the growth of the soybeans, especially when planted in the same row or hill. A decided loss in yield resulted from all mixtures when compared with corn planted alone. The corn yields were also low when the number of hills per acre was reduced to accommodate the soybeans in alternate hill plantings. Soybeans alone far outyielded the crop grown with corn.

Further tests over a 2-year period were made to compare additional methods of seed drop with a planter. In one case the corn and soybeans were planted in hills, a pea attachment being used on the planter. Another mixture consisted of corn planted in 3-foot hills with the beans drilled at a comparable rate in the row. This method required two rounds with the planter, one for each crop. In still another combination corn and soybeans were mixed in the same box and seeded in hills by use of a bean planter plate. The results, while preliminary, indicate no benefit in yield of either corn or soybeans from any mixed plantings in the row.

Such mixed plantings should not be attempted on the dry lands where sufficient moisture is seldom obtained for corn alone.

CORN TYPES AND VARIETIES

Three general types of field corn are grown in Colorado, these being dent, flint, and flour corns. Dent corn is by far the most important commercially, both field varieties and hybrids being grown. Because of the great variation in climatic conditions within the State no one variety is suitable to all regions.

Adaptation

For adaptation of corn the inherited vegetative characteristics of the type grown should be suited to local environmental conditions. In general, open-pollinated corn that has been grown locally for a period of years has become adjusted to such conditions as moisture supply, temperature, and length of frost-free season. Locally adapted varieties have been shown by many experimental tests to outyield varieties brought in from other localities unless the climatic conditions in the two areas are similar.

A variety will yield its maximum in a locality when it makes full use of the average growing season. An early variety that matures short of a full season, or a late one that fails to mature, will yield less as an average than adapted local sorts. Adapted varieties may be said to be in equilibrium with the environmental conditions. Of all crops grown in Colorado, corn is the most sensitive to changes in the balance between growth habit and environment.

Several small flint and dent varieties adapted to the College Farm (at Fort Collins) were grown in 1894 in comparison with large, late ones (11). The dent varieties, on the whole, were more productive than the flints. The large, late varieties failed to mature grain, but the differences in fodder yields were less with the dents than with the flints. All plots were harvested September 25. The yields are given in table 3.

TABLE 3.—*Yields of early and late varieties at Fort Collins, 1894.*

Type of corn	Varieties	Fodder per acre	Total dry matter	Shelled corn per acre
	Number	Tons	Tons	Bushels
Small flint	6	8.95	2.70	28.1
Large (late) flint	2	9.75	2.51	None
Small dent	6	10.95	3.60	36.9
Large (late) dent	8	13.51	3.38	None

A large Brazilian flour corn, which was included in the large dent group in this test, represented the extreme in lateness with no ears when killed by frost. As will be indicated later, experiments at the Akron Station show that the flint and flour varieties tend to be more productive on the dry lands than do the dent varieties.

That locally adapted varieties within the State vary widely in their vegetative characteristics as a result of adjustments to environment is shown by some data collected at Fort Collins in 1933.[5] Seed of varieties adapted locally for 5 years or more, as shown by records of the Seed Registration Service, were planted in a comparative test. The results are given in table 4.

TABLE 4.—*Plant characters in relation to adaptation in Colorado corn varieties at Fort Collins, 1933.*

Variety	Seed source each year	Plant* leaves	Nodes† per plant	Plant height	Grain weight per plant
		Number	Number	Feet	Grams
Hybrid	Fort Collins ...	12.1	10.0	7.4	199.4
Minnesota 13	Platteville	14.3	11.6	8.9	186.3
	Colorado Springs	14.4	12.0	8.7	211.5
	Masonville	14.8	12.1	8.7	195.0
	Penrose	14.4	11.9	8.8	198.4
	Sligo	13.7	11.0	8.5	168.7
	Pueblo	15.3	12.6	8.6	217.9
Logan Co. White	Iliff	15.0	11.8	8.4	215.5
Petty Yield More	Austin	16.9	14.1	10.0	254.5
Northwestern Dent	Craig	10.2	7.5	5.8	110.8
Talbot Yellow Dent	Austin	15.0	12.5	8.7	214.9
Iowa Silvermine	Pueblo	16.0	12.8	9.8	252.7
Reid Yellow Dent	McClave	17.6	14.5	10.1	236.2
	Pueblo	15.7	13.7	9.7	259.6

*Averages of 3 replications.
†Above the ground line.

The data indicate that the varieties with the greatest number of leaves, number of nodes, plant heights, and grain weights per plant are those adapted to the longer growing seasons in the State. Within the Minnesota 13 variety the strain from Pueblo is a slightly larger vegetative type than the ones adapted to areas with a shorter season.

A similar comparison is available for Minnesota 13 as shown in table 5. The Condon strain, seed of which was brought from Weld County each year, was compared with the same strain taken to Akron in 1928 and grown locally every year.

[5]These data were collected by D. G. Craig, former graduate student, Agronomy Department, Colorado State College.

TABLE 5.—*Adaptation of Minnesota 13 at Akron, 1928 to 1936.*

	Yield shelled corn in bushels per acre									8-yr.
	1928*	1929	1930	1931	1932	1933	1934	1935	1936	Aver.
Seed from Weld Co. each year	11.2	19.0	39.9	5.1	6.6	6.7	7.1	13.2	8.6	13.3
Seed from Akron each year	11.2	18.8	54.3	8.1	10.3	8.2	6.0	12.9	8.7	15.9
Akron White (check)	14.3	23.2	43.1	7.2	23.8	13.2	7.4	20.5	17.6	19.5

*Yield for 1928 not included in average.

The Minnesota 13 strain imported each year yielded appreciably less than the Akron White check. The Condon strain grown from local seed each year averaged 2.6 bushels more than when grown from seed brought in from Weld County each year.

A variety of corn grown in a given locality for many years, with the seed properly selected each season, is superior for that particular area. The opinion occasionally expressed that it is advisable to "change seed" every few years is erroneous. Such a procedure is justified only when another variety has proved to be better or when good home-grown seed is unavailable. The Colorado corn grower should exercise caution when he obtains seed from a distance greater than 25 miles from where he intends to plant it.

Yield Tests of Field Varieties[6]

The best adapted corn varieties have been determined by yield tests conducted under comparable conditions over a period of years. Many varieties have been introduced into Colorado over the past 50 years, but a large number have been found unsatisfactory from the yield standpoint. There has been a tendency in the past for the grower to import the large Corn Belt varieties, most of which have failed to mature in the shorter season in Colorado. These varieties are not grown to advantage until they have become well enough adapted through selection to mature in the average season.

Because of the existence of many locally adapted sorts in the State, the importation of field corn varieties now is seldom justified. Variety tests, which reflect adaptation, have been conducted on both irrigated land and dry land.

Variety Tests under Irrigation

In the early days before 1900 a large number of varieties were tested at the Experiment Station at Fort Collins over a 6-year period (9). These varied from the early Gehu flint, which ripened before frost and bore its ears less than 12 inches from the ground, to Giant Mexican June, which barely tasseled by harvest time. Gehu produced the most shelled corn per acre in these early tests. While many vari-

[6]Yield tests of hybrids among self-fertilized lines will be included in a separate bulletin.

eties were given a trial in the next 10 to 15 years, it was not until Minnesota 13 was introduced in 1916 that field corn became commercially important in the northern part of the State.

A yield test at Fort Collins conducted over a 5-year period indicates that locally adapted sorts, as for example, Colorado-grown Minnesota 13, outyield varieties from other regions. The data in table 6 indicate that Minnesota 13 (or Colorado 13) is satisfactory for northern Colorado irrigated lands. Golden Glow, while also well adapted, is not appreciably better than Minnesota 13.

TABLE 6.—*Relative yields of Minnesota 13 and other varieties at Fort Collins from 1925 to 1929.**

Variety	Seed source each year	Yield shelled corn in bushels per acre 1925	1926	1927	1928	1929	Averages 4 years	5 years
Minn. 13	Exp. Sta. (check)	78.7	69.2	73.8	60.0	67.0	70.4	69.7
	Platteville	84.0	74.0	75.8	63.2	68.8	74.3	73.2
	Eaton	75.1	72.1	75.9	71.4	71.2	73.6	73.1
Golden Glow	Experiment Station	85.0	69.3	79.9	68.1	68.5	75.6	74.2
Akron White	Akron Field Station	75.8	62.2	81.7	65.6	...	71.3	...
Reid Yellow Dent	....	79.5	51.8	71.7	58.4	...	65.4	...
Logan Co. White	Iliff	71.0	58.5	73.1	66.6	67.9	67.3	67.4

*Unpublished data supplied by D. W. Robertson, Colorado Experiment Station.

It should be noted that Reid Yellow Dent, an extremely late variety, yielded distinctly less than all strains of Minnesota 13. When moved only a short distance from the dry lands of eastern Colorado, Akron White failed to yield as much as locally adapted varieties. In recent years the Condon strain of Minnesota 13 has been used as a standard of comparison for northern Colorado conditions.

Dry-Land Variety Tests

Corn improvement was started at the Akron Field Station in 1917 when a strain of Swadley Dent was selected by the ear-to-row method and named Akron White (6, 7). This variety outyielded the parent Swadley variety materially the first few years. Over a later 11-year period it averaged 2.6 bushels per acre more than its parent. This is an excellent example of yield improvement by the ear-to-row method which was widely used in the early days.[7]

A large number of corn types, varieties, and strains were tested at Akron from 1922 to 1937. For the most part this test reflects the importance of locally adapted types as shown in table 7.

[7]Similar results probably could have been obtained with much less effort by good field selection.

TABLE 7.—*Corn varieties grown under dry-land conditions at Akron, 1922 to 1937.**

Type and variety	Seed source each year	Aver. yield per A.	Years grown	Yield Akron White for same period	Yield in pct. of Akron White
		Bushels	Number	Bushels	Percent
Dent Corn					
Akron White	Akron	15.4	16	...	100.0
Akron Yellow	Akron	14.2	16	15.4	92.2
Logan Co. White	Iliff	18.3	5	16.5	110.9
Minn. 13 (Condon Strain)	Platteville	11.3	10	17.3	65.3
Swadley (Vance Strain)	Akron	13.5	11	16.1	83.9
Bloody Butcher	Colby, Kans.	15.9	12	17.1	93.0
Substation White	N. Platte, Nebr.	18.0	12	17.1	105.3
Northwestern Dent	Akron	14.6	15	15.7	93.0
Flint Corn					
Australian White	N. Platte, Nebr.	17.2	14	15.1	113.9
Rainbow Flint	N. Platte, Nebr.	14.6	13	15.3	95.4
Flour Corn					
Blue Flour	....	17.3	14	15.1	114.6
Squaw Corn	....	24.5	6	21.4	114.5

*Yields expressed in bushels ear corn from 1922 to 1927, and in bushels shelled corn from 1928 to 1937, inclusive.

A large number of corn varieties from many different sources were tested at Akron from 1924 to 1937. Varieties tried and dropped since 1924, because they yielded less than Akron White or Akron Yellow, are as follows: Parson White Dent, Improved Calico, Colorado Yellow Dent, August 15, Improved Leaming, King of the Earliest, Disco 90-Day, Rhoeder Yellow Dent, Freed White, Silver King, Claridge U. S. 125, and Krug. These varieties were imported from other localities.

All factors considered, Akron White or some other locally adapted variety appears to be the most dependable under dry-land conditions similar to those found at Akron. Logan County White, a slightly later variety, has produced high yields for the short period tested. The white dents tended to outyield the yellow dents in this experiment. Colby Bloody Butcher appears to be too late for Akron, but may be suitable at lower elevations in the extreme eastern part of the State. As a market corn, its color is undesirable. Although commercially unimportant, the flint and flour varieties have yielded more than the dent varieties. White Australian Flint and Blue Flour have given the best results, but they are objectionable from the standpoint of the market. They are also difficult to husk.

Significance of Variety Names

The results of corn variety tests in Colorado indicate that variety names mean less than those of almost any other crop. Because of its cross pollination, corn is maintained in an extremely heterozygous condition. As a result of selection, innumerable strains have been isolated within all of the important varieties. In fact it has often been shown in yield trials that there may be larger differences among strains within varieties than among the varieties themselves. In spite of these difficulties, variety names have some significance when used with reference to adapted strains.

The results with Northwestern Dent at Akron may be used to show the differences of strains within a variety. Seed of this variety, brought in each year from Minnesota and Wyoming, was compared with a locally adapted strain of the same name. The yields of the three strains are presented in table 8.

TABLE 8.—*Three differently adapted strains of Northwestern Dent grown at Akron, 1927 to 1932.*

Strain of Northwestern Dent	Yield shelled corn in bushels per acre							
	1927	1928	1929	1930	1931	1932	5-yr. Aver.	6-yr. Aver.
Local White Cap (Akron)	15.3	15.8	18.3	46.7	8.3	25.5	24.3	21.6
Crookston Strain (Minnesota)	7.7	9.1	9.2	23.2	...	4.5	10.7	...
Archer Strain (Wyoming)	9.0	7.1	6.5	27.9	2.2	12.8	12.7	10.9

The two out-of-state strains of Northwestern Dent yielded appreciably less than the locally adapted strain of that variety every year.

Description of Corn Varieties

Some of the more widely grown varieties found in Colorado will be described. It should be recognized that varietal characteristics vary with environmental conditions to a great extent, the region to which a variety is adapted being more important than the variety name. The descriptions apply to the varieties grown in the regions where they are adapted.

Minnesota 13

Probably Minnesota 13 is the most widely grown dent variety in the State, being particularly concentrated over an area that centers in Weld County. It is a yellow dent variety that requires approximately 120 days to mature at an altitude of 5,000 feet. Various locally adapted strains exist in the State. The variety has been field-selected by a grower near Platteville since 1922. The improved strains of Minnesota 13 were designated as Colorado 13 in 1930. Minnesota 13 is particularly adapted to northern and eastern Colorado but is grown in other areas where climatic conditions are similar.

Reid Yellow Dent

Locally adapted strains of Reid Yellow Dent are widely grown under irrigation in the Arkansas Valley. In Colorado this variety generally requires about 140 days to mature, and usually is found at altitudes below 4,500 feet. It is a large yellow dent with cylindrical ears and deep, rectangular kernels. The Ezra Moore strain is widely grown in the Rocky Ford area. Many of the local dry-land yellow strains trace back many years to Reid Yellow Dent.

Iowa Silvermine

Iowa Silvermine is adapted to about the same conditions as Reid Yellow Dent. It is a white dent corn that has been grown and improved by a grower near Pueblo for a number of years. This strain is the most widely grown white corn in southern Colorado. Most dry-land white strains also trace back many years to this variety.

Logan County White

Logan County White is a white dent corn grown to some extent in northeastern Colorado, both under irrigated and dry-land conditions. It is an adapted selection of either Iowa Silvermine or Rustler White Dent with about the same climatic requirements as Minnesota 13. A farmer near Iliff developed the variety.

Akron White

Akron White was originated at the Akron Field Station as a selection from Swadley Dent made in 1917 (6, 7). It is adapted to eastern Colorado dry-land conditions. Akron White has been described as being 5.5 to 7.0 feet in height, with medium to small ears. The kernels are white-capped yellow, medium to shallow in depth and dimple dented. It requires from 120 to 130 days to mature. Being rated commercially as mixed, and sometimes as Swadley, it has never met with much enthusiasm on the part of growers.

Other Dent Varieties

Many other named dent varieties are grown in Colorado, various strains being adapted to local areas. Crawford Yellow Dent is a mid-season type that has been grown to some extent in the Delta region where the frost-free season is longer than 120 days. As grown in this area, it is a medium, rough, yellow dent with large kernels. Recently it has met with some favor in the Platte Valley in the vicinity of Fort Morgan. Pride of the North and Akron Yellow are two other varieties that are occasionally grown under short-season conditions. Akron Yellow is an ear-to-row selected strain of Reid Yellow Dent. Swadley Dent is adapted to short-season, high-altitude conditions between 5,000 and 6,000 feet elevation, but it is not widely grown at present. It is one of the early Colorado varieties, grown near Denver since about 1882. Swadley was developed from a corn originally brought into the Clear Creek Valley by George C. Swadley in 1875. He brought several varieties from a mountain region in Pennsylvania. One of these, a 12-row dent selected after several years' trial, became the corn known as Swadley (22).

Several other dent varieties with more or less red kernels are grown under dry-land conditions, but their spread is limited by the market prejudice against colored kernels. These are Bloody Butcher (deep red kernels), Northwestern Dent (yellow-capped red kernels), and Calico (variegated kernels).

Flint and Flour Varieties

Flint corns as grown in Colorado are extremely early sorts, the best known variety being White Australian Flint. The stalks are generally very short, that is, 3.5 to 6.0 feet in height, with numerous suckers, their long and slender ears being borne very close to the soil surface. Along with Swadley it can be grown at higher altitudes than most varieties. Gehu Yellow Flint, also very early, is sometimes grown in the lower foothills of northern Colorado. It is practically necessary to grind flint corn to obtain the most economical use as feed.

Blue Flour corn is occasionally grown under dry-land conditions, being extremely early in maturity. It is also very reliable, being rated by some as the most drought-resistant among corn varieties. Its growth characteristics are very similar to those of White Australian Flint. The cobs are white, while the kernels are blue with rather soft texture. Types with bluish-black kernels are sometimes called "Squaw" corn. This term is loosely applied by many to include both flint and flour corns.

SEEDBED PREPARATION

The type of seedbed preparation depends upon the soil, the amount of precipitation (or irrigation), the previous crop on the land, susceptibility to wind erosion, and the method of planting. Practices under dry-land conditions may differ considerably from those under irrigation.

The Lister in Seedbed Preparation

Fall or early-spring listing has given excellent results in seedbed preparation on the dry lands.

Small Grain Stubble Land

When weeds are present, they can be controlled by listing in the early fall immediately after the previous small-grain crop has been removed. Delay in listing stubble land until early spring can be justified where the volunteer growth (weeds or small grains) is desired for pasture. Plant cover may also be left to reduce soil blowing as well as to catch a larger proportion of the winter snow.

A practice popular in the region is to "nose out" the old lister furrows in the spring and plant in them. This is recognized as a good practice on the dry lands as indicated in table 9. The bottoms of the furrows have an opportunity to become warm when planting is delayed for some time after the land has been listed. Previous cultivations, in the fall or spring, may be necessary for weed control to conserve the soil moisture for the use of crops. Fall cultivation may also serve for protection from soil blowing. When it promises to grow weeds, there is some indication (4) that stubble land managed in this way immediately after header or binder harvest may produce two-thirds as much per acre of some crops the next year as would fallow.

It is inadvisable to split the ridges of early fall or spring listed stubble land being planted to corn. The planter should be made to follow the old furrows even though the land has been practically leveled as a result of cultivation or wind erosion. Corn at Akron has produced low yields when the entire surface of stubble land is stirred at seeding time by ridge-splitting. Plowing under stubble and other debris in the spring appears to reduce corn yields to about the same extent. These data are presented in table 9.

TABLE 9.—*Different methods of listing versus spring moldboard plowing of barley stubble land at Akron, 1933 to 1938.*

Treatment of barley stubble land	Yield of corn in bushels per acre*						
	1933	1934	1935	1936	1937	1938	Average
Early spring listed: Ridges split	4.3	0.4	14.7	4.3	0.0	1.2	4.15
Early spring listed: Furrows "nosed out"	11.9	0.4	22.0	7.7	0.0	0.1	7.02
Spring plowed: Surface planted	5.1	0.0	13.5	5.6	0.8	1.1	4.35

*Yields for 1931 and 1932 omitted because of insect and rodent injury to some of the plots.

When the results are averaged for a 6-year period, 1933 to 1938, it is apparent that the yields from none of the cultural methods can be regarded as good. Conditions in a number of these years were very unfavorable for corn, the total annual precipitation being only 12.61 inches in 1934 and 11.35 inches in 1937. However, the results may be indicative of those that might be obtained under more favorable conditions as in 1935 when the annual precipitation was 19.09 inches. The plowed, surface-planted plots and the split-ridge listed plots averaged practically the same in yields for the 6-year period. The loss in yield from ridge-splitting, compared with the "nosed out" furrows, was 2.87 bushels per acre. The "nosed out" plots yielded decidedly more in 3 of the 6 years. About the same loss in yield is probable when stubble land is moldboard-plowed in the spring and surface planted. The damage that results appears to be dependent on the amount of debris turned under.

Corn Stubble Land

After a row crop has been removed, listing leaves the soil in a roughened condition to prevent wind erosion and also to catch snow. During 11 years of the period from 1909 to 1923 one of the two harvested corn stubble plots at the Akron Field Station was fall- and the other spring-listed (2). Both were planted to corn by "nosing out" the old furrows. As an average, the fall-listed land produced 2.5 bushels more corn per acre than the spring-listed land, a difference probably due to the greater amount of snow caught on the fall-listed corn stubble. Listing in the fall about one-half the time, and in the spring the remainder, produced a 30-year average yield of 12.1 bushels per acre. The plots that were moldboard-plowed in the spring and fall produced 13.1 and 12.6 bushels per acre, respectively. Because of the heavy soil, the corn planted with a lister failed to start growth as quickly as that which was surface-planted. Nevertheless, listing is the most economical of the three methods for the preparation of harvested corn stubble land for corn.

In spite of the fact that it is done late in the season, fall listing is preferable to spring listing. The use of the lister for seedbed preparation is confined almost entirely to dry-land conditions where the acreage to be covered is naturally large. Comparative results with different methods of seedbed preparation of harvested corn stubble land for corn are given in table 10.

TABLE 10.—*Different methods of seedbed preparation for continuous corn under dry-land conditions at Akron, 1909 to 1938.*

Previous treatment	Average yield per acre 1909 to 1938	1911 to 1922
	Bushels	Bushels
Spring plowed	13.1	16.0
Fall plowed	12.6	16.9
Subsoiled*	11.4	15.0
Listed	12.1	...
Spring listed and seeded	...	13.1
Fall listed and "nosed out"	...	15.4

*Fall plowed and subsoiled one-half the time, and merely plowed the remainder

The Moldboard Plow in Seedbed Preparation

Plowing as a method of seedbed preparation is not practiced as extensively now as it was 25 years ago. This has been due to experiments which indicate that the practice is unnecessary under some conditions. Since the principal advantage of plowing is for weed control, it usually involves a needless expense where a clean-cultivated row crop has occupied the land the previous year in a semiarid region. From table 9 it is apparent that plowing as a method of seedbed preparation for Plains stubble land is less satisfactory than the better listing method.

The results obtained at Akron on fields planted continually to corn indicate little difference for fall plowing over spring plowing (table 10). The 30-year average yield was 12.6 bushels per acre for fall-plowed land and 13.1 bushels for spring-plowed land.

Plowing as a seedbed preparation resulted in only a slight yield increase over listing which averaged 12.1 bushels per acre over the same 30 years. The average yields of corn after wheat and oats, subsequently fall- or spring-plowed, ranged from 9.6 to 10.5 bushels per acre (table 1). Distinct differences in yields due to fall or spring plowing stubble or harvested corn land were shown in some seasons, but the average difference for 30 years was small. However, the average date of fall plowing stubble land at Akron over this period was August 25. This was 26 days after the small-grain harvest, being too late to control adequately the weed growth on such lands. The lower cost of listing, as compared to plowing, makes it the preferable method of seedbed preparation for dry-land conditions.

Although experimental results are unavailable, general experience on irrigated lands indicates that it is unnecessary to plow as a preparation for corn grown after clean-cultivated crops such as sugar beets and potatoes. Often the land is merely disked and harrowed to place it in condition to plant. This appears to be a logical practice. Where corn follows crops like alfalfa, sweet clover, or pastures, it is necessary to plow the land. The field may be fall-plowed and left over winter in a roughened condition to catch snow and to prevent wind erosion. Alfalfa may be crowned in the fall, that is, plowed 3 or 4 inches deep, then replowed to a depth of 7 or 8 inches in the spring to insure that the plants are completely killed. Good results have been obtained with one plowing in the fall or spring to a depth of 7 or 8 inches.

PRACTICES IN PLANTING CORN

Two general methods of planting corn are followed in Colorado, namely, surface planting and listing. The rates depend upon moisture supply, while dates are influenced by the average time of the last spring frost, which varies in different parts of the State.

Methods of Planting

Listing is adapted to all types of soils under dry-land conditions (fig. 3). Two of the advantages of the lister are: (a) It can be made to cover large acreages adequately in a comparatively short time, and (b) the seed is planted in moist soil. Another reason commonly given is that spring growth of listed corn is slower than that of surface-planted corn. This tends to reduce the amount of succulent growth that may be severely injured by early drought.

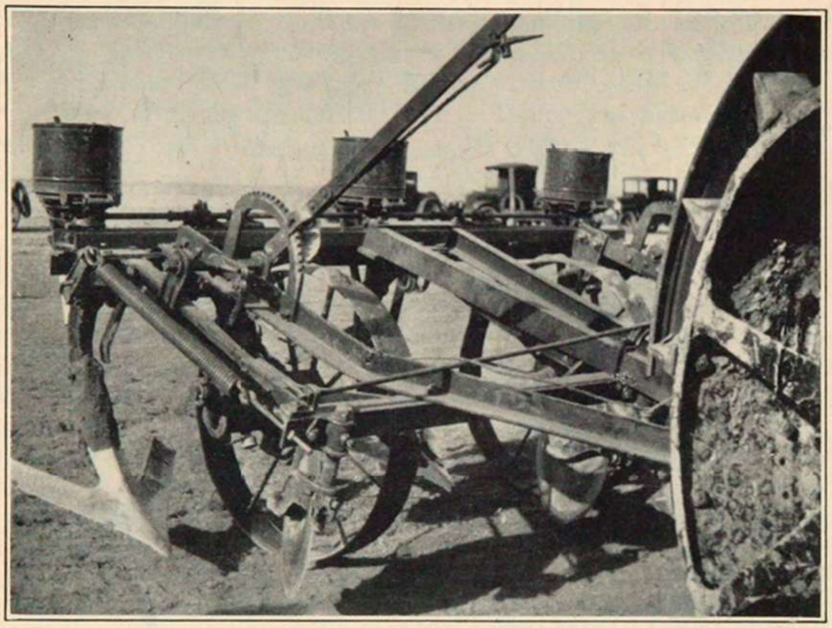

Figure 3.—Moldboard removed from lister and duckfoot shovels attached to plant corn in fall-listed furrows on "hard land."

Another advantage claimed by farmers, which is verified by recent experimental results, is that lister-planted corn withstands drought better on stubble lands. Furthermore, greater protection from late spring frosts generally has been observed for corn planted in furrows. Listed corn may be greatly retarded by cold, wet weather, but apparently not seriously. A common practice with the lister is to drop the subsoiler to the depth it is desired to plant, the seed being covered by the trailer wheels and a section of heavy chain. The grower should be careful that loose soil does not fall over the moldboard into the row because such soil may be infested with weed seeds. The use of disks to cover the corn also tends to throw soil with weed seeds into the row. Weeds in the row are difficult to eradicate.

Under irrigation a large part of the corn acreage is surface-planted. This permits better germination and more rapid growth in the early part of the season because the conditions for growth are more favorable near the surface than at the bottom of lister furrows.

Corn also may be planted in hills (checked) so that it can be cultivated at right angles, or it may be drilled in the row. In Colorado, corn is generally drilled in the row whether surface-planted or listed. In either case the seed should be planted deeply enough to place it in moist soil to insure immediate germination. A depth of 2 to 4 inches is generally sufficient.

Rates of Planting Corn

It is sometimes difficult to obtain the desired stand of corn because of the many factors beyond the control of the grower, which tend to reduce stands. The proper stand will be obtained more readily when seed of high germination is planted in a well-prepared seedbed. The rate of planting varies with the variety, soil fertility, and soil moisture likely to be available. A small early variety may be planted at a higher rate than a large late one, and higher rates can be used on fertile soils with plenty of moisture available throughout the growing season. It is general practice to plant corn more thickly under irrigated than under dry-land conditions.

Rates under Irrigation

Most corn under irrigation is surface-drilled in 36- or 42-inch rows, although some corn is planted in hills (checked). Tests were made at the Colorado Experiment Station (16) to ascertain the best rate of planting on highly fertile land with good water rights. Two varieties, Golden Glow and Pride of the North, were planted in 42-inch rows with the hills spaced 36 inches apart in the row. The data in table 11 indicate that 4 or 5 plants per hill result in significantly higher grain yields than the customary 3-plant rate used in much of the Corn Belt.[8]

Pride of the North, which is 3 to 4 days earlier than Golden Glow, gave the highest yield for both grain and fodder with five plants per hill. Golden Glow gave the best response with four plants, although the difference over the five-plant rate was small. Incidentally, some earlier work of the Experiment Station (9) between 1894 and 1898 showed that five plants per hill resulted in the highest grain yields.

TABLE 11.—*Average yields for corn planted in hills at Fort Collins, 1931 to 1933.*

Variety	Plants per hill	Average air-dry yields per acre: Shelled Corn		Fodder	
	Number	Bushels	Percent	Pounds	Percent
Pride of the North	3	76.6	100	7,299	100
	4	87.0	114	8,545	117
	5	90.1	118	8,641	118
Golden Glow	3	80.7	100	7,975	100
	4	86.8	107	8,620	108
	5	83.0	103	8,376	105
Difference for significance (5 percent point)		6.5		878	

Drill-planted corn was found to give the highest grain and fodder yields when the plants were 6 to 9 inches apart in the row. The data are given in table 12.

[8]The test was conducted for 4 years, but comparable data for the two varieties were available for only 3 years. The results for 3 years are included.

So long as the same number of plants is obtained per acre, it appears to make little difference whether corn is drilled or planted in hills.

TABLE 12.—*Average yields for drill-planted corn at Fort Collins, 1931 to 1933.*

Variety	Space between plants	3-year average yields per acre: Air-dry shelled corn		Air-dry fodder	
	Inches	Bushels	Percent	Pounds	Percent
Pride of the North	12	83.2	100	7,905	100
	9	91.3	110	8,620	109
	6	93.5	112	9,659	122
	3	79.3	95	9,899	125
Golden Glow	12	79.9	100	8,243	100
	9	86.2	108	8,854	107
	6	92.1	115	9,545	116
	3	69.3	87	8,553	104
Difference for significance (5 percent point)		6.5		878	

In further tests (15) the rate of planting was found to influence the protein content of shelled corn, the thinner rates resulting in the highest percentage. However, it is impractical to plant corn at 3 plants per hill or drill it so that they would be 12 inches apart in the row to increase the amount of protein because such an increase would be obtained at the expense of the yield per acre.

The amount of seed required to plant an acre of corn under irrigation varies from 8 to 10 pounds.

Rates under Dry-Land Conditions

Because of the normal shortage of moisture, fewer plants per unit area under dry-land conditions will result in maximum yields. An experiment at Akron (3) was conducted over a 12-year period from 1924 to 1935 to determine the response of corn to different spacings. The corn was thinned to 12, 18, 24, 30, and 36 inches between plants in 44-inch rows, and 12 inches in 88-inch rows, so far as possible.[9] The yields are given in table 13.

TABLE 13.—*Corn yields for different spacings under dry-land conditions at Akron, 1924 to 1935.*

Planned spacing	Distance between rows	Grain yields per acre	Stover yields per acre	Fodder yields (grain and stover)
Inches	Inches	Bushels	Pounds	Pounds
12	44	12.5	2,160	3,038
18		12.5	2,038	2,916
24		13.3	1,794	2,723
30		13.1	1,523	2,437
36		12.3	1,405	2,268
12	88	9.2	1,190	1,831

[9]The average spacings realized at the end of the 12-year period were 13.6, 18.9, 24.2, 30, 36, and 14.7 inches, respectively.

The highest 12-year average yield was 13.3 bushels per acre for the plants spaced 24 inches apart in 44-inch rows. This spacing is advocated for grain production under dry-land conditions similar to those at Akron. It is advisable to have corn thinner rather than thicker, because the 30-inch spacing produced 13.1 bushels per acre compared with 12.5 bushels for the 18-inch spacing. The double spaced or 88-inch row method failed to produce the highest grain yield in a single 1 of the 10 years when grain was produced. It is no more certain in dry years than the 36-inch spacing in the customary 44-inch rows. The yield was 28 percent less than the average for the five spacings in the 44-inch rows. Spacing plants from 12 to 18 inches apart in 44-inch rows is advised for silage production in the locality.

It has been estimated that 5 pounds of seed per acre will be enough to plant one kernel every 24 inches in 42-inch rows.

Dates for Planting Corn

The time to plant corn varies with the season and locality. The season becomes progressively shorter from the southern to the northern part of the State, as well as from the eastern boundary to the foothills. The season in the vicinity of Grand Junction on the Western Slope is similar to that in the Arkansas Valley. Under average conditions corn is usually planted in Colorado sometime between May 1 and 25, although it may be planted as early as April 20 in the Arkansas Valley and in regions with similar conditions. It is usually advisable to seed at about the same average spring date and risk a light frost rather than plant late with the subsequent risk of frost injury to immature corn in the fall.

Northern Colorado Irrigated Conditions

At Fort Collins (18) corn has been planted under irrigation at 10-day intervals from April 20 to June 10 with the results shown in table 14.

TABLE 14.—*Relation of date of planting to yield and quality of corn at Fort Collins. 1923 to 1929.*

Date planted	Yield shelled corn per acre*	Bushel weight	U. S. grade
	Bushels	Pounds	Number
April 20	53.3	57.8	1
May 1	51.3	56.8	1
May 10	49.2	55.2	1
May 20	45.7	54.0	2
May 30	41.2	51.6	3
June 10	30.9	45.4	6

*Average of 5 years except for April 20. No corn was planted on this date in 1929 because of adverse weather conditions. There were no data for 1925 and 1928.

In these experiments, which were conducted for 5 years, there was very little difference in yield for dates between April 20 and May 10 (fig. 4). However, there has been little to gain when corn was planted as early as April 20 because it usually emerged about the same time as that planted on May 1. Corn was not killed by frost, even when planted as early as April 20, in a single year from 1921 to 1929. The yields decreased rapidly for planting dates after May 20. The weight per measured bushel proved to be an index of maturity, the earlier planted corn being heavier than that planted after May 10. Corn planted May 20 or later failed to grade U. S. No. 1.

Dry-Land Conditions at Akron

Corn has been planted at 15-day intervals at the Akron Field Station from April 20 to June 20. The results for 8 years, given in table 15, indicate that May 20 is the most satisfactory time to plant corn in that vicinity. Although corn seeded June 5 produced the same yield in bushels per acre, the grain was generally less sound and lower in bushel weight. Since the corn was planted with a lister, that seeded earlier often gave poor stands because of cold soil together with unfavorable conditions for germination.

June 10 April 20 May 1

Figure 4.—Corn planted at different dates on the Colorado Experiment Station farm at Fort Collins. Picture taken about July 1.

TABLE 15.—*Relation of date of planting corn to yield under dry-land conditions at Akron, 1931 to 1938.*

Date planted	Yields air-dry shelled corn in bushels per acre 1931	1932	1933	1934	1935	1936	1937	1938	Average
April 20	4.9	9.6	9.4	3.8	11.6	7.9	4.6	17.6	8.7
May 5	4.7	19.0	8.7	2.8	17.4	7.4	5.9	19.4	10.7
May 20	8.0	24.5	9.4	6.6	18.8	17.1	6.5	13.4	13.0
June 5	12.8	22.3	10.9	5.2	17.5	19.8	3.9	11.2	13.0
June 20	7.8	16.7	7.3	6.7	16.2	16.8	3.8	10.8	10.8

CULTIVATION

While most corn growers recognize the necessity for cultivation or intertillage, they are not always aware of the reasons why it is beneficial. Experiments in other states have established the fact that the principal benefit of cultivation is from weed control, practically no advantage being gained by tillage beyond that necessary to kill weeds.

An additional advantage of cultivation on the dry lands is that it may leave the soil in a loosened, flocculent condition to take up water readily when it rains. The general practice of cultivation after a rain or irrigation in the early stages of growth appears to be necessary as a means of killing the small weeds that start naturally with the acquisition of surface soil moisture. The type of tillage implement used is dependent upon whether corn is surface-planted or listed.

The first cultivation of surface-planted corn can be made with the spike-toothed harrow. This is an effective way to kill small weeds, either before the corn comes up or after the plants are 3 or 4 inches high. Later cultivations may be made with the ordinary 4- or 6-shovel cultivator. Tillage should be just deep enough to kill the weeds. Unusually deep cultivation may cause unnecessary injury to corn plants by root pruning. Two or three cultivations are generally sufficient for weed control.

The harrow may be used also for the first cultivation of listed corn, after which the disk-type lister cultivator is suitable. In the first cultivation the soil is generally thrown away from the plants. When corn is cultivated the second time, the soil is thrown toward the plants. Later cultivations, when necessary, are generally made with the shovel-type cultivator.

IRRIGATION OF CORN

Corn is generally irrigated by the furrow method, water being run slowly down the cultivator furrows between the rows.

When only one irrigation is possible, the maximum grain yield will generally be obtained when water is applied at the tasseling stage. This is sometimes called the critical period of irrigation. It has been observed that droughty conditions at the tasseling stage tend to hasten the shedding of pollen but delay the emergence of silks. Thus the pollen may be shed before all the silks are fertilized. Later rain or irrigation will not repair the damage done at this stage. Under dry-land conditions moisture shortage at this stage may be disastrous.

General experience in Colorado indicates that two irrigations are usually sufficient to produce a corn crop, although three may be necessary on the more sandy soils. This observation was made by the Experiment Station as early as 1894 (12), as was the statement that irrigation can be withheld until the tassels begin to appear so long as growth has not been retarded.

Corn is very sensitive to overirrigation, a condition readily detected by a yellow appearance of the plants. The first irrigation is usually applied when the plants begin to joint, generally between June 20 and 30, while the second application is made when the plants begin to tassel. Adapted corn in Colorado usually tassels between July 20 and 30. Emergency conditions may require irrigation at other times. Corn needs water when the leaves roll during the day and fail to unroll by the next morning. Growth has practically ceased under such conditions and will be resumed only after a rain or irrigation. Application of water later in the season is inadvisable because it may delay the maturity of the crop. In northern Colorado the general practice has been to withhold water after August 15.

METHODS OF HARVEST

The general methods followed for the harvest of corn in Colorado are: (a) Cutting for silage, (b) cutting for fodder, and (c) husking the ears from the stalks in the field. An early account in 1894 showed that corn had potentialities as a feed crop when harvested for fodder. A yield of 5,539 pounds of dry matter per acre, equivalent to 3.5 tons of alfalfa hay, was cited in an Experiment Station report (10). In recent years a test (16) with the Golden Glow variety planted at the rate of 3, 4, and 5 kernels per hill resulted in yields of 8,433, 9,061, and 9,319 pounds of air-dry fodder per acre, respectively, as a 4-year average. When the seed was drilled, the same variety yielded 8,633, 9,448, 10,054, and 9,461 pounds of air-dry fodder per acre as a 4-year average for 12, 9, 6, and 3 inches between plants in the row, respectively. These data indicate that high forage yields are possible under irrigation.

Silage

Corn for silage should be cut when the ears are in the glazed stage. At that time the husks are usually brown while the leaves are still green. Immature corn may be used for silage, but it is likely to be rather acid (17). Dry corn fodder has been ensiled successfully where plenty of water has been added. On many farms the plants are cut with a corn binder, being hauled directly to the silage cutter. This applies particularly to farms with upright silos.

The most efficient machine is probably the combination cutter-harvester which harvests the stalks and cuts them into silage lengths in the field. The chopped material is delivered into a wagon, truck, or header-barge as the cutter moves down the row. These loads of silage may be delivered to a trench silo or to a blower for an upright silo (17). After the trench is filled, a 2-foot layer of straw is usually placed over the silage together with 8 to 10 inches of soil to seal it for later use. For storage over a number of years the trench cover should be up to the ground level.

Fodder

Corn is generally cut for fodder when the bottom leaves become dry. This is shortly after the ears have become glazed. After that time the grain will complete maturity in the shock satisfactorily. Fodder corn may be harvested by a binder or by a sled-cutter with heavy knives set at an angle on the front edge (13). Colorado experiments indicate that corn shocked and cured in the field loses from 25 to 85 percent of its value by loss of leaves, etc. One report (11) indicated that the losses in dry matter were 31 percent for fodder corn placed in large shocks, 43 percent in small shocks, and 55 percent where the plants were left on the ground. Many farmers in northern Colorado cut or shred corn fodder or stover[10] before it is used for feed in order to reduce the amount of waste. This may be done with a shredder, hammer mill, or silage cutter. Portable grinders that are taken from farm to farm are available in some localities.

Grain

In the case of corn husked for grain the common practice is to allow it to stand in the field until thoroughly dried out. This is usually 2 to 8 weeks after growth has ceased, that is, after the plants either have dried up or have been killed by frost—sometime after October 15. High moisture in the ears makes the corn difficult to husk and may also cause it to heat in storage. Small fields are husked by hand, while some growers with large acreages favor the mechanical corn pickers which are available in 1-, 2-, and 3-row sizes.

MARKET GRADES FOR CORN

Corn that moves in commercial channels is generally graded under the federal grain standards. Corn is divided into the three color classes of yellow, white, and mixed. Yellow corn may include not more than 5 percent of corn of other colors, while white corn may

[10]Stover refers to the forage that remains after the ears are husked out.

contain not more than 2 percent of kernels of other colors. Mixed corn includes kernels of various colors. The grade requirements for each of these classes of corn are as follows:[11]

			Maximum limits of:		
Grade number	Minimum test weight per bushel	Moisture	Cracked corn and foreign material	Damaged kernels Total	Heat damaged
	Pounds	Percent	Percent	Percent	Percent
1	54	14.0	2	3	0.1
2	53	15.5	3	5	0.2
3	51	17.5	4	7	0.5
4	48	20.0	5	10	1.0
5	44	23.0	7	15	3.0
Sample	..				

Sample grade includes corn which fails to come within the requirements of the numerical grades. Corn that is sour, musty, or otherwise of distinctly low quality is placed in this grade. The main grading factors in Colorado corn are moisture content and damaged kernels.

SEED CORN

Quality in seed corn includes origin, variety, and viability. These are important considerations from the standpoint of the grower.

Longevity of Seed

There has been a general opinion among growers that seed corn loses most of its viability after being held in storage for even a single year. This may be true to some extent in the Corn Belt, but not under the dry climatic conditions in Colorado where it may retain its viability for a much longer period. Experiments were conducted at Fort Collins (20, 21) on the reduction in viability of corn stored in a dry room for as long as 15 years. Germination tests were made on this stored seed yearly. The results are shown in table 16.

TABLE 16.—*Percentage germination in corn stored at Fort Collins for several years.*

Years stored	Samples	Germination
Number	Number	Percent
1	2	92.0
5	3	87.0
10	6	69.6
15	1	36.0

It was found that yellow dent corn germinated well for the first 6 years, but dropped off rapidly between the ninth and tenth years, and again between the twelfth and thirteenth years. These

[11]Handbook of Official Grain Standards of the United States, Bureau of Agricultural Economics, U. S. Department of Agriculture, 1937.

data indicate that the corn grower may save a seed supply from good years sufficient for 2 or even more years without a serious reduction in germination. This practice is particularly justifiable for late varieties that may be frosted in the field enough to impair germination in occasional seasons.

Bushel Weight in Relation to Maturity

Bushel weight has been found to be an index of maturity in shelled corn, a fact that may prove advantageous to the grower as a means of detecting immature seed. The yields in table 14 show that corn planted after May 10 dropped progressively in bushel weight, being much more immature at harvest than that planted at the earlier dates (18).

Immature corn may be an indication of an unadapted variety. Bushel weight determinations were made at Fort Collins over a 3-year period (14) on individual ears of corn harvested at 10-day intervals from August 22 to October 1. The corn was air-dried for 6 months before the bushel weights were taken. The results in table 17 show that the bushel weight of Golden Glow progressively increased as it became more nearly mature at the time of harvest. When harvested after maturity in the field (about Sept. 11) there was little change in bushel weight.

TABLE 17.—*Bushel weights of Golden Glow corn harvested at 10-day intervals.*

Date harvested	Mean weight per measured bushel 1931	1932	1933	Average	U. S. grade
	Pounds	Pounds	Pounds	Pounds	Number
August 22	49.8	*	47.0	48.4	4
September 1	54.4	53.7	52.6	53.6	2
September 11	58.0	56.2	57.1	57.1	1
September 21	59.4	57.6	58.1	58.4	1
October 1	59.3	58.4	59.4	59.0	1

*Insufficient corn for individual ear determinations.

Mature corn, harvested September 11 or later, weighed well over 54 pounds, the minimum requirement for U. S. No. 1 corn. The immature corn harvested August 22 was graded U. S. No. 4 because of the low bushel weight. The seed buyer should suspect the maturity of corn at harvest time when the bushel weight falls below 54 pounds.

Germination Tests

It is advisable to test seed corn for germination before it is planted because it is impossible to ascertain viability by the appearance of the ear. The field is a poor place to test seed corn for germination.

Mature corn which has been harvested before frost, stored in a dry, well-ventilated room, and protected from freezing temperatures until it has dried down to 15 percent moisture, usually will have high viability. An ear-by-ear test probably is unnecessary under such conditions. As a precautionary measure, the grower may remove one kernel from each of 100 or 200 ears selected at random for a general germination test in a modified "ragdoll" tester. An ear-by-ear test is advisable when less than 90 percent of the kernels in the general test are viable.

A modified "ragdoll" tester large enough to germinate 10 seed ears can be made with paper towels of an extra good grade. A satisfactory size is 10 by 15 inches, three towels being necessary for one "ragdoll." Lines 1 inch apart are usually drawn crosswise with an indelible pencil, the spaces being numbered from 1 to 10. The marked towel and a blank towel are then moistened and placed on a piece of wax paper[12] approximately the same size. The ears are numbered to correspond to the spaces on the towel. Five kernels are removed from each ear, placed germ side down on the paper in the numbered column that corresponds to the ear number and covered with the third towel after it has been moistened. The "ragdoll" is then rolled and tied, after which it is kept at room temperature for 6 to 8 days. When the doll is unrolled, seeds should be regarded as germinated when they show a plumule (shoot) and radicle (root). The modified "ragdoll" method is illustrated in figure 5.

[12]The use of paper towels and the wax paper has been suggested by Anna M. Lute of the Colorado State Seed Laboratory. The wax paper serves as a means of retaining the moisture in the doll.

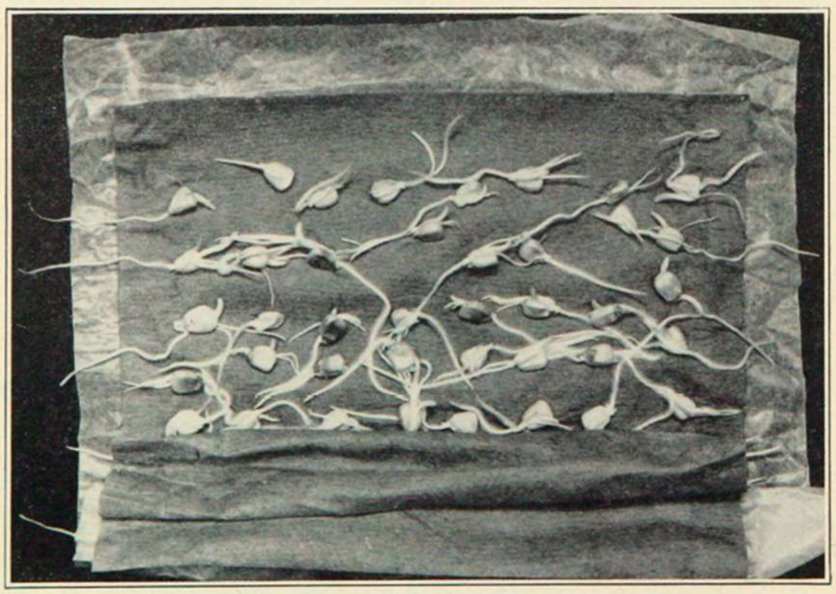

Figure 5.—Modified "ragdoll" used in testing germination of corn.

INSECT PESTS AND DISEASES

The most serious corn disease in Colorado is smut, *Ustilago zeae,* (Beckm.) Ung. In fact the most serious losses from corn smut in the country occur in the semiarid portion of the Great Plains area. Galls incident to this disease develop on any of the above-ground parts of the plant and may become several inches in diameter. In the earlier stages the galls are white or gray, but become black as the season advances. When mature, they rupture to release a dense powdery mass of black spores. Studies made in Colorado (8) indicate that the prevalence of corn smut is influenced by environmental conditions. Some data on smut in relation to seasonal conditions are given in table 18.

TABLE 18.—*Smut-infection percentages and precipitation and temperature records at Akron, 1920 to 1923.*

Year	Plants observed	Smutted plants	Precipitation May	Precipitation June	Precipitation July	Precipitation Aug.	Mean Temperature May	Mean Temperature June	Mean Temperature July	Mean Temperature Aug.
	Number	Percent	In.	In.	In.	In.	°F.	°F.	°F.	°F.
1920	12,461	11.86	1.78	4.89	4.72	1.45	54	62	71	67
1921	16,754	25.50	0.50	1.06	2.25	1.55	56	68	74	72
1922	17,645	18.54	3.62	1.43	3.24	1.24	56	69	71	75
1923	8,477	4.24	4.94	2.17	3.62	0.75	54	66	73	69

The percentages of smut were found to vary in different years, but the greatest amount of smut occurred in dry seasons. Scant precipitation in May and June, followed by moderate rainfall and comparatively high temperatures, seemed to favor the disease. Such conditions prevailed in 1921. Moderate amounts of precipitation throughout the season, accompanied by high temperatures in July and August, as observed in 1922, seemed to favor moderate infection. A rather heavy precipitation in the early part of the season, followed by scant rainfall and low temperatures in the later summer, was not conducive to heavy infection. Since the spores live over from one year to another in the soil, control by seed treatment is impossible. There is no satisfactory control for the disease. Adapted varieties in general tend to be more resistant than unadapted sorts, but no highly resistant field varieties are available at the present time.

Recently there has been some indication that ear-rot organisms carried on the seed may reduce field stands in the early spring because of seedling blight. Some of these organisms may be soil borne. In many instances demonstrations on farms[13] in various counties of the State have indicated that improved stands and, as a consequence, increased yields may be expected as a result of seedling blight control by seed treatment with organic mercury compounds. The results of 23 farm tests in 1937 indicate an average increase in stand of 20.0 percent, while the same number of tests in 1938 showed an average

[13]Unpublished data obtained through the courtesy of W. J. Henderson, Extension Plant Pathologist, Colorado Extension Service.

stand increase of 16.1 percent. Increased stands, where they exceed the optimum, occasionally may decrease yields under dry-land conditions. Corn growers may find it desirable to treat their seed as a precautionary measure, since the treatment is inexpensive. The organic mercury dusts are usually applied to the seed in a barrel mixer at the rate of 2 ounces per bushel. The mixer should be rotated for 2 or 3 minutes to insure that the seeds are thoroughly coated with the disinfectant.

The Colorado corn root worm may be a serious pest, particularly under irrigation, where corn follows corn on the same field (18). This worm is a small white larva about one-half inch long when fully grown. It feeds on the roots and may practically destroy them. Corn infested by this pest is very likely to lodge badly. Insect damage increased as the date of planting was delayed. This insect can be controlled successfully by crop rotation. Corn should not appear on the same land more than 1 year in succession in corn root worm infested areas (fig. 6).

CORN IMPROVEMENT

Field selection is regarded as the most effective method for the improvement of an open-pollinated variety. Tests in other states indicate that the ear-to-row method, widely practiced a few years ago, has failed to increase yields when applied over a period of years. Recently the production of hybrids by crosses among inbred lines has resulted in improved corn yields.

Figure 6.—A field of corn after corn at Fort Collins, showing western corn root worm damage.

Field Selection

Selection of mature ears, together with their removal from the field before frost, is the most important reason for field selection. It allows the grower to select seed from plants at the time corn should be mature for the locality. Field selections are usually made on the average date of the first fall frost, which varies from September 15 to 30 in most Colorado corn regions (fig. 7).

It is well known that corn is extremely heterozygous, that is, there may be all ranges of maturity represented in an ordinary field. Some plants are too early while others may be too late for the locality. The grower usually selects ears that mature at the proper time on vigorous plants free from suckers. He should avoid the selection of ears that ripen too early for the locality because such a practice will eventually result in a strain that makes use of only a part of the available season. The grower should disregard fine score-card points for the individual ears since close selection tends broadly to inbreed the variety with consequent reduction in yield. Mature ears in the field commonly contain 30 to 40 percent moisture. When laid out to dry they should be placed so as not to touch each other.

That field selection is effective in the improvement of an open-pollinated field variety was early recognized in Fort Collins tests (1). This statement was made in 1887 in Bulletin 2 of the Colorado Experiment Station: "By judicious selection of the first ears that ripen, the period of maturity has been materially shortened."

Hybrids Among Inbred Lines

Hybrid corn has attracted a great deal of attention in the last 4 or 5 years. For purposes of clarity, hybrid corn should be defined as the first-generation cross between strains that involve inbred lines, that is, true-breeding lines developed by several successive generations of self-pollination. Yield tests of various hybrids in commercial production have been conducted in Colorado since 1937. The results indicate that some hybrids are adapted to different Colorado conditions, being higher in yield than locally adapted open-pollinated varieties.

On the basis of a 3-year test at Fort Collins, Minhybrid 301 and Minhybrid 403 appear to be adapted to the heavier irrigated soils of northern Colorado. Minhybrid 301 yielded 9.0 percent more, and Minhybrid 403 about 7.4 percent more grain per acre than the Condon strain of Minnesota 13 as a 3-year average for 1937 to 1939. Minhybrid 301 is objectionable to some growers because it suckers profusely. Among several new hybrids included in 1938 for the first time, Wisconsin 570 offers promise in this region. It is 2 or 3 days later than Minnesota 13 but yielded 10.2 percent more in the 2 years tested.

Several hybrids, slightly late for grain production at Fort Collins, appear to be adapted to lower altitudes on the sandier soils. This applies particularly in southern Weld County and in the Platte Valley in the Fort Morgan area. These hybrids are Funk G-19, Iowa 939, and Wisconsin 696. These hybrids, and others of similar maturity, may be grown on the sandier soils in the Greeley area when the grower wants to chance a long season, and especially where he intends to use the crop for silage.

Figure 7.—Field selection of field corn.

The yield trials at the Rocky Ford Substation, which is representative of the lower Arkansas Valley, indicate that both Funk hybrid G-212 and Iowealth hybrid AQ will outyield the Ezra Moore strain of Reid Yellow Dent, an adapted field variety grown in that area. Funk G-212 yielded 59.5 percent more grain than the Reid strain, while Iowealth AQ yielded 51.1 percent more as a 3-year average. Pfister 360A, grown only for 2 years, has averaged 44.8 percent more in yield than Reid Yellow Dent. These hybrids require about the same relative time for maturity as Reid Yellow Dent under Rocky Ford conditions. They are recommended for irrigated conditions at altitudes below 4,500 feet where the frost-free season averages 145 days or more. For a slightly shorter frost-free season than that found at Rocky Ford, Funk G-19, Iowa 939, Kingscrost FB, and National 116 may be grown. When these are grown in a region for the first time, the farmer is advised to put in small plantings of 1 to 5 acres.

While tests have been conducted at Akron from 1937 to 1939, no hybrid can be recommended at the present time as superior to the best locally adapted field varieties for dry-land conditions.

The use of corn hybrids allows the grower to utilize the hybrid vigor of the first generation (F_1). Seed saved from a hybrid corn crop will result in loss in vigor in the next crop. This loss may reduce the yield to as little as two-thirds that of an adapted field variety. The grower must produce or purchase new hybrid seed each year.

SUMMARY

1. Corn production has shown a material increase in Colorado during the past 25 years because of the use of adapted varieties.

2. Corn is adapted locally to frost-free seasons of 90 to more than 140 days in various parts of the State. It is seldom successful above 6,000 feet elevation, or on dry land where the rainfall is less than 14 inches per year. Under dry-land conditions corn is usually more productive on the sandier soil types, that is, semihard lands.

3. Corn may be grown continually under dry-land conditions, but it is preferably grown in long-term rotations. Corn after corn under irrigation may be subject to damage by corn root worms.

4. There is no benefit to either the corn or soybeans when the two crops are grown in mixtures. Corn-soybean mixtures are not recommended for either irrigated or dry-land conditions.

5. The dent varieties are the most widely grown in the State, the flint and flour varieties being of minor importance. The latter are among the best yielders under dry-land conditions.

6. Seed of locally adapted varieties is preferable, it being hazardous to plant seed grown more than 25 miles away, especially when outside the altitude belt.

7. Among dent varieties, locally adapted strains of Minnesota 13 are widely grown where the frost-free season averages from 110 to 130 days, while Reid Yellow Dent is widely grown where the season is longer than 120 days. Logan County White and locally adapted sorts are most suitable for dry-land conditions in eastern Colorado.

8. Fall or early spring listing has given excellent results in seedbed preparation on the dry lands. Subsoiling is inadvisable. Plowing followed by surface-planting is sometimes practiced on the so-called "hard lands," but listing is considered better and more economical. Under irrigation it is often unnecessary to plow after a clean-cultivated crop.

9. Corn may be planted at a higher rate under irrigated than under dry-land conditions. Four or five plants per hill have resulted in higher yields than lesser rates. Drill-planted corn has given the highest grain yields when the plants are spaced 6 to 9 inches apart in the row. Under dry-land conditions the highest grain yields are generally obtained when the plants are 24 to 30 inches apart in 44-inch rows. For silage production the plants may be spaced 12 to 18 inches apart.

10. Corn is usually planted in Colorado during the month of May, but it is possible to plant it as early as April 20 in the warmer regions of the State. Under northern Colorado irrigated conditions the best time to plant corn appears to be from May 1 to 10. At the Akron Field Station May 15 to 25 is the recommended time to plant.

11. Corn should be cultivated frequently enough to control the weeds.

12. It has been the general practice to irrigate corn two or three times. The critical period of irrigation is at the tasseling stage.

13. Seed corn may be kept in storage for several years without serious loss of vitality. It has been found to germinate well at Fort Collins for the first 6 years of air-dry storage.

14. Bushel weight may be an important index of maturity of seed corn. Maturity of seed should be suspected when the bushel weight is less than 54 pounds.

15. The modified "ragdoll" is a satisfactory device for making a germination test.

16. Corn smut, the most serious corn disease, cannot be controlled by seed treatment. Adapted varieties in general tend to be more resistant than unadapted sorts, but no highly resistant varieties are available at the present time.

17. Ear-rot organisms, either seed- or soil-borne, may reduce field stands in the early spring under some conditions. Seed treatment with organic mercury dusts will result in improved stands when these organisms are present.

18. Field selection is the most effective means of improving an open-pollinated variety.

19. Improved corn yields may be obtained by the production of hybrids through crosses of inbred lines. These will be effective where the soil moisture is sufficient to take advantage of greater yield capacity. Several corn hybrids show promise under irrigated conditions. In northern Colorado, Minhybrid 403, Wisconsin 570, and Minhybrid 301 deserve trial. In the Arkansas Valley, Funk hybrid G-212 and Iowealth AQ have yielded high in 3-year tests. Hybrids have not shown as much promise under dry-land conditions at Akron as have locally adapted field varieties.

20. Seed saved from a hybrid corn crop will generally result in loss in yield when planted the next season. New hybrid seed must be obtained each year.

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NOTES

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