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WORK OF THE NORTHERN GREAT PLAINS FIELD STATION IN 1923

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INTRODUCTION

By J. M. Stephens, *Superintendent*

This bulletin gives the results of the investigations conducted in 1923 at the Northern Great Plains Field Station, which is located near Mandan, N. Dak., in the semiarid Great Plains area. The results that have been attained since the station was established in 1913 are summarized in presenting those of the current year.

The work at this station includes experimental field tests in the growth of trees, shrubs, fruits, vegetables, and field crops; cooperative shelter-belt investigations with farmers on the northern Great Plains; and a series of pasture experiments to study the management of native and cultivated grassland for grazing beef cattle.

The investigations are organized under four general projects: Arboriculture, horticulture, agronomy, and grazing. Each project is under the direct control of a scientifically trained investigator, working under the general supervision of the station superintendent and the agriculturist in charge of the Office of Dry-Land Agriculture Investigations, Bureau of Plant Industry.

The personnel of the station organization is as follows:

Administration: J. M. Stephens, Agriculturist and Superintendent; F. W. Mason, Senior Clerk; *Arboriculture:* Robert Wilson, Associate Agronomist in Charge; *Horticulture:* W. P. Baird, Associate Agronomist in Charge; T. K. Killand, Scientific Aid; *Agronomy:* J. T. Sarvis, Associate Agronomist in Charge; J. C. Thysell, Assistant Agronomist; J. C. Brinsmade, jr., Assistant Agronomist in Charge of Cooperative Cereal Investigations; *Grazing:* J. T. Sarvis, Associate Agronomist in Charge.

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J. H. Shepperd represents the North Dakota Agricultural Experiment Station in livestock problems in connection with the grazing experiments.

Figure 1 is a map of the station, showing the location and area of the several fields and pastures.

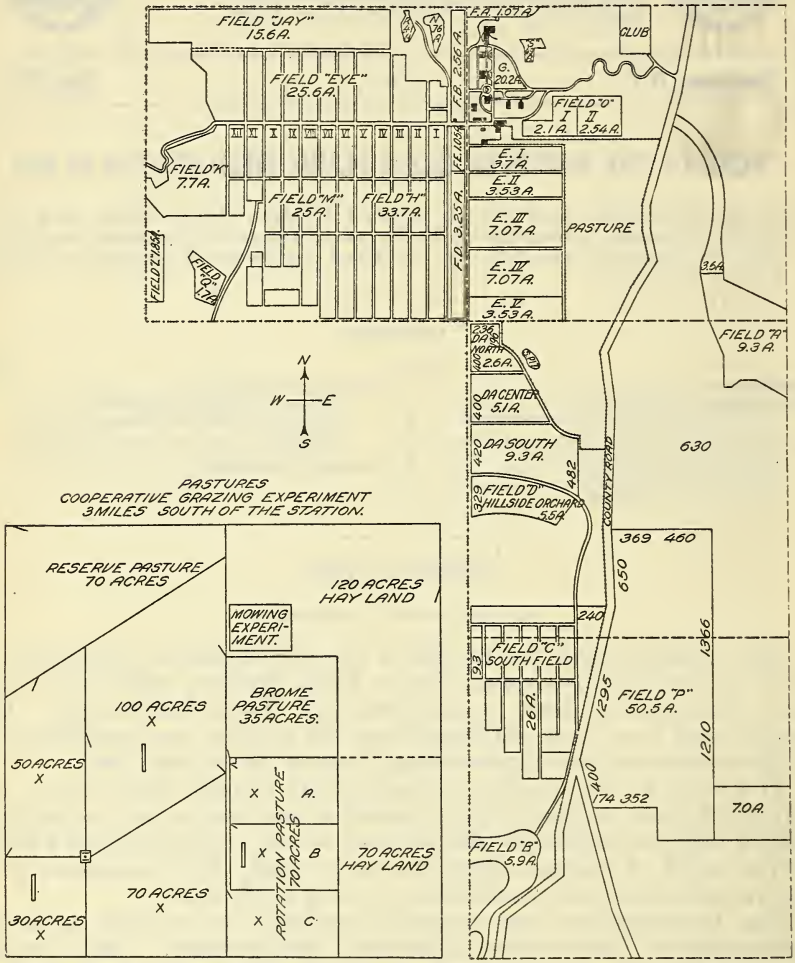

FIG. 1.—Diagram of the Northern Great Plains Field Station, Mandan, N. Dak., showing the location and area of the fields in 1923. The inset is drawn to a different scale and shows the arrangement of the pastures in the grazing experiment

ARBORICULTURAL INVESTIGATIONS

By ROBERT WILSON, *Associate Agronomist*

COOPERATIVE SHELTER-BELT DEMONSTRATIONS

The arboricultural investigations project was started in 1915 to stimulate interest in tree planting and in this way assist farmers in improving home surroundings. The station has entered into a cooperative arrangement with a limited number of farmers each

year in actual plantings of trees on their farms. The station operates a nursery for the production of planting stock, makes the planting plans after having inspected the land on which the trees are to be planted, and provides instructions for the planting and care of the trees. The farmer for his part agrees to plant and care for the trees in accordance with the plans and instructions given him. The number of plantings is limited to five in a county in one year.

It is essential to the success of this project that only hardy stock of known origin be used. To insure this the nursery stock is produced from home-grown seeds and cuttings. In 1923 the Siberian pea-tree, Russian-olive, and Tatarian maple had excellent seed crops, and ample supplies were collected. It should be possible to produce from this seed crop enough seedlings of the Tatarian maple to give this species its first extensive test in 1926. The boxelder seed crop was poor, and only a part of the desired quantity of seed was collected. The seed crop of green ash, American elm, and Chinese elm failed entirely. The northwest poplar made an excellent growth of cutting stock, and an ample supply was obtained. Small quantities of seeds of pin cherry, chokecherry, and wild plum were also collected. Purchase was made of 5 pounds of seed of western yellow pine collected in the Black Hills near Rochford, S. Dak.

The quantities of stock produced in the station nursery in 1923 for use in cooperative shelter-belt plantings are given in Table 1.

TABLE 1.—*Quantities of nursery stock produced in 1923 for use in cooperative shelter-belt plantings*

Group and variety	Kind of stock	Number
Hardwoods:		
Northwest poplar	1-year rooted cuttings	47,770
Boxelder	1-year seedlings	28,265
Green ash	2-year seedlings	47,660
Siberian pea-tree	do	40,000
Russian-olive	1-year seedlings	5,217
Wild plum	2-year seedlings	1,000
Chokecherry	do	250
Tatarian maple	1-year seedlings	1,300
Black walnut	do	420
Total hardwoods		171,882
Conifers:		
Western yellow pine	2–2 transplants	2,098
Jack pine	do	4,571
Total conifers		6,669
Grand total of both hardwoods and conifers		178,551

The 40,000 Siberian pea-trees were obtained from Valley City, N. Dak., in exchange for cuttings of northwest poplar, as the seed planted at the station failed to germinate.

In 1923 there were 1,085 shelter-belt demonstrations in active cooperation. The distribution of these by States and years in which they were planted is shown in Table 2.

On January 1, 1924, there were 165 applications on file for plantings in 1924. The numbers from each State were: Montana, 50; North Dakota, 49; South Dakota, 50; and Wyoming, 16.

TABLE 2.—*Number of shelter-belt demonstrations in active cooperation in 1923, by the States and years in which they were planted*

Year	Number in each State				Total
	Montana	North Dakota	South Dakota	Wyoming	
1916	162	68	44	8	282
1917	54	28	18	3	103
1918	15	3	12	2	32
1919	49	41	18	1	109
1920	35	20	11	6	72
1921	48	25	11	3	87
1922	73	42	47	14	176
1923	80	73	50	21	224
Total	516	300	211	58	1,085

On the same date 106 applications for plantings in 1925 were on file. The numbers from each State were: Montana, 32; North Dakota, 34; South Dakota, 35; and Wyoming, 5.[1]

A total of 742 established shelter belts and sites for which applications for plantings had been made was inspected in 1923. This involved 16,248 miles of travel, 143 days' work, and an expense of $1,126.31. The cost was $7.88 a day, $1.52 an inspection, and 6.93 cents a mile. The expense as given includes subsistence of the inspectors, but does not include their salaries, which at $3.33 per day amounted to $476.19.

In view of the present crowded appearance of many of the older demonstration plantings that were set out with a distance of 4 by 8 feet, the spacing used in the 1923 plantings was increased to 6 by 10 feet. The width of the plantings varied from 2 to 10 rows. In a small number of plantings the inside row was chokecherry, but the following are typical combinations:

Ten-row plantings: Siberian pea-tree, green ash, northwest poplar, boxelder, northwest poplar, boxelder, northwest poplar, green ash, green ash, Russian-olive.

Eight-row plantings: Siberian pea-tree, boxelder, boxelder, northwest poplar, northwest poplar, green ash, green ash, Russian-olive.

Five-row plantings: Siberian pea-tree, boxelder, northwest poplar, green ash, wild plum.

Three-row plantings: Russian-olive, northwest poplar, Chinese elm.

The numbers of trees of the different kinds used in new plantings in 1923 are given in Table 3.

TABLE 3.—*Number of trees of each kind used in new cooperative shelter-belt plantings in 1923*

Kind of tree	Number	Kind of tree	Number
Northwest poplar	32,871	Chinese elm	1,012
Boxelder	20,087	Chokecherry	981
Green ash	33,043	Wild plum	5,158
Siberian pea-tree	35,380		
Russian-olive	13,934	Total	142,466

Seventy-four additional plantings of one to three rows of conifers were made on the inside of older hardwood plantings. These addi-

[1] Applications for plantings in 1925 were received until June 1, 1924, and the total number listed for inspection was 302.

tions required 8,919 Black Hills spruces and 305 jack pines. In replacements in the 1922 plantings 4,882 hardwoods and 3,350 conifers were used, making a total of 159,922 trees shipped to cooperating farmers. Since 1916 the following numbers of trees of all species have been used in the demonstration plantings in the States specified: Montana, 1,105,546; North Dakota, 463,212; South Dakota, 259,730; Wyoming, 97,457; total, 1,925,945.

A card on which to list the number of trees of each kind that died during the summer was sent in August to each cooperator. The percentage of living trees of each species of hardwood, as calculated from the reports received, is given in Table 4.

TABLE 4.—*Average percentage of stand of each kind of hardwood tree obtained by cooperators in 1923*

Kind of tree	Stand	Kind of tree	Stand
	Per cent		*Per cent*
Northwest poplar	93.2	Chokecherry	83.6
Boxelder	92.3	Chinese elm	79.0
Green ash	94.5	Wild plum	72.9
Siberian pea-tree	82.8		
Russian-olive	54.7	All species, weighted average	86.2

The percentages of stand for northwest poplar, boxelder, and green ash can be considered as fairly representative of what may be expected from good stock. The size and condition of the stock available for the other species doubtless had much to do with their comparatively poor showing. The Russian-olive developed considerable mold in winter storage, and the Siberian pea-tree and the wild plum were of smaller size than should ordinarily be used for this type of work. The reports for the conifer plantings showed stands of 63.9 per cent for Black Hills spruce and 20.5 per cent for jack pine. The Black Hills spruce was very good stock raised as transplants in the station nursery, while the jack pines were seedlings grown in northern Minnesota. The difference in stock probably accounts in part for the different showing. The experience thus far with conifers emphasizes the need of special care in obtaining thrifty stock and of using every precaution in shipping and planting to insure against injury from drying out.

TABLE 5.—*Average height in 1923 of willow, boxelder, green ash, and Siberian pea-tree planted in Montana, North Dakota, and South Dakota in 1919*

State	Average height of each species (feet)			
	Willow	Boxelder	Ash	Siberian pea-tree
Montana	5.5	7.8	5.1	5.2
North Dakota	6.2	7.8	5.2	----------
South Dakota	6.3	7.4	5.2	----------
Average	6.0	7.7	5.2	5.2

Nearly all the plantings set out in 1919 were inspected in 1923, and measurements were taken to determine the average height of each species. These heights determined by measurements made

on 34 plantings in Montana, 35 in North Dakota, and 13 in South Dakota are given in Table 5. No measurements were made in Wyoming.

EXPERIMENTAL TREE PLANTINGS

Experimental plantings of trees have been made at the station to test the adaptability of different species to prevailing climatic conditions and to compare the effects of different systems of species combinations, cultivation methods, and spacings on the growth of trees. These investigations began in 1914.

VARIETY AND SPECIES TESTING BLOCKS

This experiment is primarily for the purpose of testing the trees of different species or varieties or from different sources as to their ability to survive. It consists of blocks of 100 trees of each kind under trial. There are at present 94 of these blocks, consisting of 18 coniferous and 76 deciduous species or varieties of trees. The plantings vary from 1 to 9 years in age. The following species planted in 1922 have completely died out: Balsam fir (*Abies balsamea*), white fir (*Abies concolor*), beech (*Fagus americana*), largetooth aspen (*Populus grandidentata*), mossycup (bur) oak (*Quercus macrocarpa*), and red oak (*Q. rubra*). Most of these species probably are not adapted to the region, but it is by no means certain that with special methods of care and protection during the first season some of them might not succeed. Norway maple (*Acer platanoides*) planted in 1922 had practically a perfect stand in 1923, although a similar planting of the same species set out in 1915 was entirely dead at the end of the first year. Two species were added in 1923—*Catalpa bignonioides* and *C. speciosa*. The stand of these was practically perfect in the fall.

SHELTER-BELT COMBINATIONS

Belts of trees varying in width from 2 to 22 rows were planted in the years 1915, 1916, and 1917. The species are arranged in the different belts in various combinations and with variations of spacing distances, as follows: 4 by 4, 4 by 8, 2 by 8, and 6 by 12 feet. The following trees in these tests show noticeable losses or damage: Norway poplar, Carolina poplar, laurel-leaf willow, Russian golden willow, buffaloberry, and birch. Those that show a uniformly high number of survivals are boxelder, green ash, Siberian pea-tree, chokecherry, wild plum, northwest poplar, and Chinese elm. In a few combinations where the blocks are situated in low places and have the benefit of additional moisture through run-off from adjoining land both the willow and poplar are still maintaining a vigorous growth.

An interesting difference in behavior appears in two combinations, in one of which green ash and boxelder were planted in alternate rows, whereas in the other they were grouped in four adjoining rows of each. The ash has developed a much sturdier form of tree where it is grouped by itself than where alternated with the boxelder. This suggests the advisability, for ash at least, of grouping the species in adjoining rows rather than alternating it with other species. In all the plantings in which ash is alternated with boxelder the ash has been noticeably suppressed. The competition is not so pronounced where ash has been placed beside northwest poplar.

TESTS OF PRUNING, SPACING, AND METHODS OF CULTIVATION

Twelve belts of the same combination of trees were planted in 1918. Four of these belts are given clean cultivation and no pruning, but differ in the spacing distances used, as follows: 4 by 4, 4 by 8, 4 by 12, and 8 by 8 feet. Half of the remaining belts are spaced 4 by 4 feet and the other half 4 by 8 feet. One belt at each of these spacing distances is given clean cultivation and pruned moderately, one is given clean cultivation and pruned severely, one is mulched and not pruned, and the other is fenced off and neglected.

At the close of the sixth year of growth all the blocks spaced 4 by 4 feet show the effects of crowding, but in the blocks spaced 4 by 8 feet or wider there is no evidence of crowding. In the blocks that are given clean cultivation there is no noticeable difference between those that are not pruned and those that are moderately pruned. The bad effects of severe pruning and also of neglect are evident. The mulched blocks compare favorably with those that have received clean cultivation.

TABLE 6.—*Average heights in the fall of 1923 of four kinds of trees, each planted at two spacing distances*

Kind of tree	Year planted	Average height (feet)	
		Spaced 4 by 4 feet	Spaced 4 by 8 feet
Green ash	1918	6.4	7.5
Boxelder	1918	10.0	10.9
Sharpleaf willow	1918	8.2	8.4
Northwest poplar	1921	6.9	7.5

Eight 10-row blocks of approximately 260 trees of a single species each have been established. In four of these the trees are spaced 4 by 4 feet and in the other four they are 4 by 8 feet. Four kinds of trees were used, each kind filling one of the 4 by 4 and one of the 4 by 8 blocks. In all cases the trees in the blocks spaced 4 by 8 feet present the more vigorous appearance. Table 6 gives the average height at the end of the growth period in 1923 of the trees in each block.

TABLE 7.—*Average height at the end of the sixth season of the trees in each row of two combinations of conifers, each with three spacing distances*

Combination and kind of tree	Row	Average height (feet)			Combination and kind of tree	Row	Average height (feet)		
		Spaced 2 by 4 feet	Spaced 4 by 4 feet	Spaced 4 by 8 feet			Spaced 2 by 4 feet	Spaced 4 by 4 feet	Spaced 4 by 8 feet
Combination No. 1:					Combination No. 2:				
Scotch pine	1	6.3	4.8	3.7	Black Hills spruce	1	3.5	3.7	3.1
Jack pine	2	7.9	7.6	7.1	Bull pine	2	3.2	2.6	2.3
Bull pine	3	3.2	3.1	3.2	Jack pine	3	6.4	7.4	6.9
Scotch pine	4	5.7	5.9	3.8	Scotch pine	4	4.3	3.7	3.5
Jack pine	5	7.6	7.3	8.6	Black Hills spruce	5	2.5	3.8	3.3
Bull pine	6	2.5	2.3	2.5					

Two combinations of conifers were planted in 1918, each with three spacings, as follows: 2 by 4, 4 by 4, and 4 by 8 feet. The length of the rows in each block is 100 feet. Table 7 shows the average height of the trees in each block at the end of the sixth season.

It appears that the close spacing has stimulated height growth in most of the species. The plantings are too young, however, to show any marked differences.

HORTICULTURAL INVESTIGATIONS

By W. P. Baird, *Associate Agronomist*, and T. K. Killand, *Scientific Aid*

The year 1923 was more successful from a horticultural standpoint than any previous year. More fruit was produced, the vegetables yielded well, and the appearance of ornamentals was satisfactory throughout the growing season. Thus the year's results as a whole are encouraging to those interested in horticultural development on the northern Great Plains.

As has been the case for several winters, there was but little injury to fruit or ornamental trees or shrubs during the winter of 1922–23. Where killing back occurred it was generally found in connection with a weakened condition of the plant from drought, mechanical injury, or some other cause. Practically all healthy and vigorous plants, even including such tender trees as sour cherries and pears, came through the winter without visible damage except that caused by rabbits.

POMOLOGICAL INVESTIGATIONS

Varietal tests, cultural experiments, fruit breeding, and cooperative tests with selected farmers constituted the pomological investigations for 1923.

VARIETAL TESTS

Varietal tests of apples, crabs, plums, currants, gooseberries, raspberries, strawberries, Juneberries, and sand cherries were in progress.

Apples and crabs.—A considerable quantity of apples and crabs was produced for the first time in 1923. A large loss was caused by the fruit being blown off the trees, and in most cases the crop was light. Hibernal, Oldenburg (*Duchess*), and Wealthy apples all started to bear. Transcendent, Virginia, Florence, Dolgo, and Silvia crabs produced fair crops.

Plums.—Late or midseason varieties of plums generally excelled the earlier varieties in yield and in the size and quality of the fruit, as they did in 1921. Varieties that did especially well in 1923, named in the order of ripening, were Opata, Compass, Sapa, Red Wing, "George," "Training School Special," Terry, Wolf, Surprise, Teton, and Emerald. Compass cherries yielded at the rate of more than 13 tons of fresh fruit to the acre and Teton plums almost as much. A number of new Minnesota selections were added to the variety orchard in 1923.

Currants.—Currants again demonstrated their reliability by yielding well. London Market, Red Cross, Pomona, and Red Dutch were the best yielders of the red varieties. The first-named variety yielded at the rate of about 2 quarts to the bush.

Gooseberries.—Low yields of gooseberries were the rule for 1923. Even the Carrie, which is generally prolific, made only a light crop.

Raspberries.—Herbert, King, and Sunbeam were the best yielders, while Latham produced the finest fruit. No variety yielded as much as a quart to the bush, but still this small fruit did considerably better than it does in most years.

Strawberries.—As is usually the case, strawberries were not a satisfactory crop under dry-land conditions. Duluth (Minnesota No. 1017), Bederarena and Minnehaha (Minnesota No. 935) were the best yielders. However, Duluth (the highest yielder) produced only about 10 quarts to 100 feet of row, and most varieties produced only 2 or 3 quarts. A new strawberry bed will be started in 1924.

Juneberries.—This fruit was a failure in 1923. The crop was light and birds ate most of the berries.

Sand cherries.—Although a little lacking in size, sand cherries were prolific and fairly satisfactory in 1923. The Sioux was the best variety tested.

CULTURAL EXPERIMENTS AND DEMONSTRATIONS

Fruit trees in the cultural experiments and demonstrations generally did well. Rabbits did a great deal of damage to apples and crabs, however, making it necessary to cut back many of the trees to within a few feet of the ground. Many trees were completely girdled just above the snow line, which amounted to a very severe pruning and promoted a rank growth of new wood from the remaining parts.

Hardiness experiment.—Clean cultivation, a cover crop, mulching with straw during the winter, and manuring are compared in this cultural test. As in past years, the different cultural treatments did not have very marked effects on either the hardiness of the trees or the yield and quality of the fruit. The two blocks receiving a straw mulch during the winter gave the highest average yields and the clean-cultivated blocks the lowest. Blocks on the west side of this experiment produced considerably more than blocks on the east side, regardless of the treatment. The trees in this experiment are spaced 8 by 12 feet, which is too close for the development of the best grade of fruit.

Pruning experiment.—Apples and crabs in this experiment were damaged so severely by rabbits that all were removed and new trees planted. Some of the plum–sand-cherry hybrids started to bear fruit. The yields generally were highest on unpruned trees, but the fruit was largest and of a superior grade on the severely pruned trees.

The pruning experiment in the plum varietal orchard gave the usual results, a greater yield on unpruned trees but larger fruit on pruned trees. Severely pruned trees yielded about the same on an average as moderately pruned trees in 1923. The moderately pruned trees gave higher average yields in previous years.

The whitewashed trees in the pruning experiment were so severely damaged by rabbits that they all received the equivalent of a very severe pruning and produced little or no fruit. The salt in the whitewash probably attracted the rabbits.

Spacing experiment.—Trees in the spacing or planting systems experiment made a fair growth during the summer, and good stands prevail in the different blocks.

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Stock experiment.—Compass cherries on plums yielded decidedly more than Compass cherries on sand cherries in the old stock experiment. There was little difference in the grade of the fruit. Emerald plums in this experiment yielded about the same on both stocks, but the grade was a little better on the plum roots.

A new stock experiment was started in 1923, plums being tested on plum, sand cherry, and *Prunus armeniaca* roots. Stands were poor on the *P. armeniaca,* which does not seem to make a good union with either plums or sand cherries. A few pears on Juneberry and on *Pyrus baccata* roots were planted, but poor stands resulted, especially on the *P. baccata* roots.

Combination fruit patches.—The combination plantings made in 1918 and 1919 passed through a fairly successful year, but the trees are now too close for best results. Plums and crabs did well in both combinations, and a few of the apple and cherry trees are starting to bear. The combination planted in 1918 also produced some grapes, currants, and raspberries. The quality or grade of the raspberries was very poor. This fruit does not seem to have sufficient moisture when planted between the rows of tree fruits.

Coulee orchards.—The trees in the coulee orchards planted in 1920 continued to make a vigorous growth in 1923. They are planted 12 feet apart. There is evidence that this is too close, as it is already difficult to cultivate between them without breaking branches. The grade or quality of the plums grown in the coulee was good for some varieties, but for others not so good as in the plum varietal orchard, where the trees are set farther apart. The growth of all varieties in the coulee was much greater than that of the same varieties grown on the upland benches.

Hillside orchard.—The hillside orchard, where trees are planted in plowed strips between strips of sod south of the main field, presents a poorer appearance from year to year as more of the trees die or branches are broken. Individual trees here and there are doing very well, and some of the crabs bore good crops of fruit. A few of the Hibernal apple trees began to bear in 1923. In general, the trees appear weak and unthrifty in comparison with trees of the same variety and age planted in less exposed places. There does not appear to be any special benefit from the particular system of planting used in the hillside orchard.

FRUIT BREEDING

Work in fruit breeding continued along the same lines as in previous years. The crossing work in the greenhouse was confined to apples, crabs, plums, cherries, and gooseberries. A few grapes were grown in pots, but no crosses were made. The crossing work with apples and crabs was more successful than in any previous year, over 5,000 seeds being produced. More than 400 gooseberry seeds, 340 plum seeds, and 82 cherry seeds resulted from crosses between known parents. In the crossing work 81 combinations of varieties were used.

Seeds from crosses made in 1922 germinated fairly well in flats, and the seedlings will be grown in nursery rows in 1924.

Many seedlings in the south field bore fruit for the first time and considerable time was spent in making selections. Some promising crabs and apples were selected from the Wealthy seedling block, but

all the apple seedlings that have fruited seem to be somewhat lacking in size. Seedlings of plums, sand cherries, gooseberries, *Prunus tomentosa*, currants, and grapes were marked for selection purposes and notes taken on them. One seedling of the Sioux sand cherry seemed to be a natural cross between Sioux and some plum. It resembles the Compass cherry, but is earlier, larger, sweeter, and appears to be a promising new fruit. Some of the selections from the native flowering currant were very promising, and a number were propagated. Juneberries bore little or no fruit, and no selections were made.

HORTICULTURAL COOPERATORS

The first fruit trees were sent out to horticultural cooperators in the spring of 1923. Apples, crabs, and plums were the only fruits distributed, but it is planned to include small fruits in the future.

These cooperators were chosen from shelter-belt cooperators who had properly taken care of their plantings and who were interested in fruit growing. As more people applied for trees than could be supplied from the stock on hand, it was decided to limit distribution to one cooperator in each county. Trees were sent to 16 cooperators in Montana, 5 in North Dakota, 7 in South Dakota, and 3 in Wyoming.

The varieties sent out were those that had done best at the station. Two varieties of apples, 3 varieties of crabs, 20 varieties of plums, 4 varieties of plum–sand-cherry hybrids, 1 variety of sand cherry, and a number of wild-plum seedlings were distributed in 1923. In all, 80 apples, 122 crabs, 635 named plums, 180 plum–sand-cherry hybrids, 12 sand cherries, and 431 wild-plum seedlings were sent out.

About 80 per cent of the apples and crabs and 95 per cent of the plums were alive at the time of the summer inspection.

OLERICULTURAL INVESTIGATIONS

No new olericultural work was started in 1923. As in 1922, the work was carried on along three lines: Varietal tests of asparagus and potatoes, the 1-acre garden-vegetable test, and vegetable breeding.

VARIETAL TESTS

Asparagus.—The year 1923 was the most successful one since the asparagus bed was planted in 1914. The plants came through the winter without injury. Cutting began May 3 and continued until June 11. The heaviest yielding variety was Reading Giant, with a total of 55 pounds from 400 feet of row. No winter mulching is practiced. No rust or other disease has been observed.

Potatoes.—In the varietal tests of potatoes the source of seed continued to have a marked effect on yields. Potatoes from seed grown at the station for a number of years yielded decidedly less than those grown from seed of the same varieties obtained from outside sources in 1922. This is probably owing to the presence of degeneration diseases in the station seed stock. Irish Cobbler ranked first in 1923, with a yield of 238 bushels to the acre; Pinkeye was second, with a yield of 184 bushels; and Early Ohio was third, with a yield of 175 bushels.

Spacing tests and selection work were carried on with potatoes in 1923. The varieties employed in both of these experiments were

Early Ohio, Irish Cobbler, and Pinkeye. Three distances in the row were tested in the spacing experiments—14, 20, and 28 inches. Early Ohio and Pinkeye gave the highest yield with the 14-inch spacing, whereas Irish Cobbler yielded best with the 20-inch spacing.

In the experiment by the tuber-unit method of selection marked variations in yield and growth from the different tubers were observed, and a number of further selections were made. It is hardly expected to improve varieties by this method, as bud sports are not common in potatoes; but it should be of interest to determine whether the high yielding qualities of a variety may be maintained over a period of years by such selection.

ACRE GARDEN

The yields from nearly all vegetables in this experiment were very good. Indications are that an area of 1 acre produces an abundance of vegetables for the needs of an average farm. Exceptional yields were obtained from onions, cucumbers, sweet corn, eggplant, and wax beans; but the yields from cabbages and cauliflower were relatively low.

VEGETABLE BREEDING

Tomatoes.—Tomato breeding was continued on about the same scale as in previous years. Approximately six-sevenths of an acre is occupied by this project. From 55 to 110 plants of each of 85 selections were planted. A good stand was obtained; and, as nearly all first blossoms set fruit, a fairly comprehensive idea of the earliness of the selections was obtained. Unfortunately, the yield and quality were so badly impaired by hot and dry weather later in the season that complete data were not procured. About 75 selections for quality, yield, and earliness were again made from the most promising strains.

Sweet corn.—The area of land occupied by this project is the same as that of tomato breeding, these crops being rotated with each other. Half of the area was planted to separate ear selections made within the most promising strains the previous season. Blocks of five 20-foot rows were planted from each ear. The other selections were mixed together and planted in bulk in the remainder of the area. A great many variations in earliness and size of ear were shown. The yield was improved, and a large percentage of plants bore two to three ears per stalk. A large number of ears were again selected, emphasis being laid on earliness as well as yield. Only ears that were in the roasting stage 72 days from the date of planting were selected.

ORNAMENTAL HORTICULTURE

The work in ornamental horticulture included experiments with hedges, varietal tests of ornamental shrubs and roses in the field, and landscape work on the grounds of the station. The latter included informal plantings of trees, shrubs, and perennial flowers; semiformal bedding work with cannas, geraniums, and other bedding plants; and lawn investigations.

HEDGES

No new species were added to the hedge plantings. All existing hedges of various species and varieties came through the winter in good condition and made excellent growth during the season. The deciduous-tree hedges are becoming difficult to keep under control. It seems that this class of material is not very desirable for ordinary work, as the hedges take up too much space for average grounds.

VARIETAL TESTS OF ORNAMENTAL SHRUBS AND ROSES

Testing work had been discontinued since 1918, but as it seemed desirable to test some semihardy species, giving a little protection in the winter, a small beginning was again made in the spring of 1922. The species tested included a few hybrid-perpetual and hybrid-Rugosa rose varieties, Hydrangea, Philadelphus, Syringa (French lilacs), Tamarix, Euonymus, and Sambucus species. The roses were covered entirely with soil and mulched, and the other shrubs were hilled up a little with soil, then mulched around the base. Some winterkilling occurred, but all species were alive in the spring of 1923 and made a good growth during the season. The roses, especially the Rugosa hybrids, grew almost rampantly and bloomed well during the summer and until late in the fall.

LANDSCAPE WORK

Very little new landscape work on the grounds was done in 1923. One new group of evergreens was planted south of the entrance gate. Ground has been broken for several new plantings to be made in the future. All existing plantings on the grounds made excellent growth during the last few years and especially so during the season of 1923. The bedding work again was successful, cannas and geraniums both thriving during the hot season. Very little work other than watering in the driest part of the summer is needed to keep the beds in good condition.

The lawns received three irrigations during the season and appeared greatly benefited. Bluegrass lawn mixtures are not very successful here unless some water is applied during the driest period. The bromegrass lawns are improving each year and should be recommended where watering is not possible.

AGRONOMIC INVESTIGATIONS

By J. T. Sarvis, *Associate Agronomist*, and J. C. Thysell, *Assistant Agronomist*

The agronomic investigations include rotation and tillage experiments with the ordinary field crops as conducted by the Office of Dry-Land Agriculture Investigations, and variety testing, date of seeding, and plant breeding, as conducted by other offices of the Bureau of Plant Industry which cooperate at this station.

The first annual report of this station presented the details of the agronomic work for the period from 1914 to 1922, inclusive.[2] This bulletin summarizes briefly the results obtained in 1923 and also those for the period from 1914 to 1923, inclusive.

[2] Stephens, J. M., and others. Report of the Northern Great Plains Field Station for the 10-year period, 1913–1922, inclusive. U. S. Dept. Agr. Bul. 1301, 80 pp., illus. 1925.

The season of 1923 was not so favorable for small grains as that of 1922. The corn crop, however, was the largest that has been produced since the station was started in 1914.

The precipitation for 1923 was 14.41 inches, as compared with 17.35 inches during 1922 and 16.98 inches, the 49-year average for this section. The rainfall during May and June was below the average, but that for July was above it and was mainly responsible for the large corn crop.

ROTATION AND TILLAGE EXPERIMENTS

The rotation and tillage experiments were started in 1914, when all crops were seeded on land uniform in cultural treatment. The rotations, therefore, have been in operation for the period from 1915 to 1923, inclusive. They occupy the six series of plats constituting the field designated "H" in Figure 1 but commonly known as the main field. Some of them are duplicated on a heavier soil in field "C," commonly known as the south field. The yields reported in this bulletin are those from the main field and are higher than those on the heavier soil in the south field.

The principal crops grown in the rotations are spring wheat, oats, corn, and barley. Other crops appear in certain rotations, but their use is much more limited. The same varieties are used in all rotations and are those considered well adapted to this area. The varieties are Kubanka (durum) spring wheat, Sixty-Day oats (from 1914 to 1922, inclusive) and Victory oats (in 1923), Northwestern Dent corn, and Hannchen barley. The tillage methods followed are spring plowing, fall plowing, disked corn ground, summer fallow, subsoiling, and listing. The different crops are grown following various crops and tillage methods in rotations varying in length from two to six years. Crops are also grown continuously on the same land with different tillage methods.

YIELDS OF DIFFERENT CROPS

The average yield of a crop serves as a reliable index of its possibilities for this area. The average yield is based upon all plats and tillage methods for the crop under consideration and includes all methods from good to poor. The yields following different tillage methods are of most value and importance in determining the possibilities of increasing the average yields.

In considering the yields of small grains the results on disked corn ground are presented, as this is considered the best preparation for small grain in this area.

Wheat.—The 9-year average acre yield of wheat following all methods is 15.8 bushels, as compared with an average yield of 12 bushels in 1923. The average acre yield on disked corn ground was 15.3 bushels for the 9-year period and 12.1 bushels in 1923. Although the yields from summer-fallowed land exceed those from disked corn about 5 bushels to the acre for the 9-year average, the latter is considered the better method. In the case of fallow the land is used two years for the production of one crop. When corn takes the place of fallow, a crop of corn is obtained in addition to the crop of wheat. Corn is a valuable and important feed crop in this area.

Oats.—The average yield of oats for the 9-year period was 33.7 bushels per acre, as compared with 25.4 bushels in 1923. On disked

corn ground the yield averaged 33.1 bushels for nine years and 22.8 bushels in 1923. The yield on summer fallow usually averages about 15 bushels per acre higher than the yield on disked corn ground, but the increase is not enough to overcome the loss resulting from using the land two years to produce one crop.

Barley.—The 9-year average yield of barley was 21.5 bushels per acre. In 1923 the average yield was 18.1 bushels. The 9-year average yield on summer fallow was 30.2 bushels per acre and on disked corn ground 23.5 bushels. The yields by all methods in 1923 were less than the 9-year averages.

Flax.—This crop was grown on old land in the rotations. The average yield was low, as wilt reduced the yields on some short rotations during the period they were under trial. A wilt-resistant variety is now grown in all rotations but was not used during the earlier years. The average yield of flax for 1923 following sod crops and corn was 11.9 bushels per acre.

Corn.—The 9-year average yield of ear corn was 28.1 bushels per acre, as compared with 49.4 bushels in 1923. The season was exceptionally favorable for the production of corn by all tillage methods. The 9-year average yield on spring plowing was 28.9 bushels per acre, as compared with 26 bushels on fall plowing. During seasons of ample rainfall the difference in yield between spring plowing and fall plowing is small.

COOPERATIVE CEREAL AND FORAGE-CROP INVESTIGATIONS

Corn.—Varietal tests of corn are conducted in cooperation with the Office of Cereal Investigations. A number of different varieties are grown each year. Gehu Flint and Dakota White Flint are the best varieties among the flints grown. Northwestern Dent and Payne White Dent are the leading dent varieties at the present time. The season of 1923 was so favorable for corn that some varieties that do not usually mature produced good crops.

Forage crops.—The experiments with forage crops are now conducted in cooperation with the Office of Forage-Crop Investigations. The crops that are under trial are alfalfa, sweetclover, bromegrass, wheatgrasses, millets, sorghums, Sudan grass, corn, sunflowers, peas, and root crops. A detailed report giving the yields of these different crops may be found in a previous publication of this station.[3]

Alfalfa seeded along a small coulee at the station has yielded well since 1918, the year it was seeded. In 1923 it produced nearly 4 tons of good hay per acre in the best area. Sorgo and millet produced on the average approximately 2 tons of feed per acre. The early amber varieties of sorgo are best adapted to this area.

CONCLUSIONS FROM AGRONOMIC INVESTIGATIONS

The highest yields of the small grains—wheat, oats, and barley—are obtained on summer fallow; but their growth in rotation with corn is considered more desirable, because they are produced with less labor and there is in addition a crop of corn.

The highest yield of corn is produced on fallow, but the increase over the yield on either fall or spring plowing following a crop is not enough to make the use of fallow advisable. The average difference

[3] See footnote 2.

in the yield of corn on fall plowing and that on spring plowing is not great. Spring plowing will usually produce higher yields during seasons of drought.

Gehu Flint, Dakota White Flint, Northwestern Dent, and Payne White Dent are good varieties of corn for this area.

Alfalfa, millets, and sorgo produce fairly well in this area and are of much value for forage.

GRAZING INVESTIGATIONS

By J. T. Sarvis, *Associate Agronomist*

The grazing experiments conducted in cooperation with the North Dakota Agricultural College, represented by Prof. J. H. Shepperd, completed their ninth year in 1923. During the season of 1915 an area of 250 acres was grazed with 53 head of 2-year-old steers. In the fall of 1915 the 250 acres were divided into four pastures of 100, 70, 50, and 30 acres, respectively. These four pastures are operated under a system of continuous grazing. In 1917 a pasture to be grazed under a deferred and rotation grazing system was added. This pasture of 70 acres was divided into three equal parts and grazed for the first time in 1918. In 1921 a cultivated pasture of bromegrass was added. It was cut for hay in 1922 and grazed for the first time in 1923.

The four continuously grazed pastures are each grazed with 10 head of 2-year-old steers. The rotation pasture is now grazed with 16 head of 2-year-old steers, but in 1918 and 1919 only 10 were used. The bromegrass pasture was grazed with 16 head of 2-year-old steers in 1923. The period of grazing for each season has been 150 days, or five months.

The four pastures under continuous grazing have been grazed for eight full seasons, the rotation pasture for six full seasons, and the bromegrass pasture for one.

The season of 1923 was not entirely favorable to the production of native vegetation. The rainfall during April and May was below normal, and the vegetation did not get start enough to make a maximum growth.

Table 8.—*Average gains per head and per acre made by 2-year-old steers in each pasture at Mandan, N. Dak., in 1923, and for the years they have been grazed during the period from 1916 to 1923, inclusive*

Pasture	Kind of pasture	System of grazing	Number of years grazed	Number of steers	Days grazed	Average gain for season (pounds)	
						Per head	Per acre
In 1923:							
100 acres	Native	Continuous		10	150	281.0	28.1
70 acres	do	do		10	150	291.5	41.6
50 acres	do	do		10	150	212.5	42.5
30 acres	do	do		10	115	150.5	50.2
70 acres	do	Rotation		16	150	250.6	57.3
35 acres	Bromegrass	Continuous		16	140	167.2	76.4
For period:							
100 acres	Native	do	8	10	150	293.2	29.3
70 acres	do	do	8	10	150	299.8	42.8
50 acres	do	do	8	10	148	248.4	49.7
30 acres	do	do	8	10	[1] 113	177.8	59.3
70 acres	do	Rotation	6	14	149	272.6	54.5

[1] Cattle are removed from their pasture when they become short of feed.

Flies and mosquitoes were worse during July than they have been since the experiment started. The gains of the cattle during July were the lowest that have been obtained for that month. The total gains for the season were slightly below normal.

Table 8 gives the average gains of the cattle for 1923 and for the period from 1916 to 1923, inclusive.

The botanical studies in connection with the experiments were conducted along the same general lines as during previous years. The number of plants of pasture sage (*Artemisia frigida*) per unit area in the 30-acre pasture has increased about tenfold. This increase has been caused by overgrazing. The individual plants are also more robust in this pasture than in any of the others. There has been an increase in the number of plants of this sage in the 50-acre pasture and slight or no increase in the other pastures. Cattle do not like pasture sage, and they lose weight although a large quantity of it is available for grazing.

The results of the grazing investigations for the period from 1916 to 1921, inclusive, are given in more detail in another publication.[4]

The following general conclusions based upon the gains of the cattle and the general condition of the pastures are drawn from the results of the grazing experiment to date:

The 100-acre pasture, which is grazed at the rate of one steer to 10 acres, provides more land than is necessary to allow the maximum gain per head. The pasture is annually undergrazed.

The 70-acre pasture, which is grazed at the rate of one steer to 7 acres, provides approximately the area of land required to produce the maximum gain per head. This pasture is grazed as heavily as it should be for a system of continuous grazing. The vegetation, however, is not utilized so completely as it can be with a different system of grazing.

The 50-acre pasture, which is grazed at the rate of one steer to 5 acres, does not provide enough feed to produce a maximum gain per head during a period of five months. It is overgrazed, and this fact is shown by the decreased gains of the cattle and the increase of pasture sage.

The 30-acre pasture, which is grazed at the rate of one steer to 3 acres, is too small to provide enough feed for the cattle for a period of five months. This pasture is severely overgrazed. The effect of overgrazing is shown by the marked decrease in the gain per head of the cattle as compared with the other pastures and the increase in the number and size of the plants of pasture sage.

The 70-acre rotation pasture, which is grazed by a system of deferred and rotation grazing at the rate of one steer to 4.4 acres, provides enough feed to allow the cattle to make gains about 10 per cent below the maximum gains obtained in any of the other pastures. This system of grazing affords the maximum utilization of the vegetation without serious injury to it from overgrazing.

The 35-acre bromegrass pasture, which was grazed at the rate of one steer to 2.2 acres in 1923, did not provide enough feed to allow the cattle to make good gains. It was grazed too heavily for the season.

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[4] Sarvis, J. T. Effects of different systems and intensities of grazing upon the native vegetation at the Northern Great Plains Field Station. U. S. Dept. Agr. Bul. 1170, 45 pp., illus. 1923.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE

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This bulletin is a contribution from

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