Row spacing studies with cereal grains in Montana
by James L Krall

A THESIS Submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of Master of Science in Agronomy at Montana State College
Montana State University

Abstract:
Various problems associated with growing small grains in wide rows, such as cultivation, 2,4-D treatment, varietal response, seeding rates, and date of seeding, were studied at three location in Montana using winter wheat, spring wheat, oats, and barley.

The cultivation of 18, 24, and 30 inch spacings gave substantial increases in yield of winter wheat over the uncultivated 12-inch spacing at Moccasin, Experiments with 2,4-D and cultivation showed nearly identical yields. Applications of 2,4-D after two cultivations gave substantial increases in yield. Seeding rates have little effect on the yield of spring and winter wheat at the wide spacings, No increases in yield were obtained from spaced plantings of spring wheat, oats, and barley. Generally greater reductions in yield due to wide spacings were obtained with spring wheat compared to oats and barley. The reductions in yield of the spring sown grains were, not as great under dry land conditions as they were under irrigation. Comparison of two seeding dates with barley at Bozeman in 1950 indicated that ..wide spacings would respond the same. Trials conducted with half and. full rates of seeding of oats and barley at 6-inch spacings resulted in decreased yields of barley and nearly identical yields of oats.

Variety spacing trials, where several varieties of barley and oats were used, indicated that nursery tests could be grown at 12-inches when normal spacing of 6-inches are used for production. It was found by the analysis of three years of data for Glacier barley and Bridger oats that no years x spacings interactions occurred.

Significant increases in protein and test weights were obtained from wide row spacings and cultivations of winter wheat. No apparent increase in test weight was obtained from spring sown grains, At Havre, no significant increases in protein were found in spring wheat.

It was generally concluded that winter wheat and barley were better adapted to spaced conditions than oats or spring wheat. It was suggested that trials be conducted to study the following possibilities • increasing protein content of wheat by row spacing, possibilities of 2,4-D and cultivation as a method of production and place in crop rotations, ability of varieties under spaced conditions, and the effect of row spacing when used with a companion crop.

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ABSTRACT

Various problems associated with growing small grains in wide rows, such as cultivation, 2,4-D treatment, varietal response, seeding rates, and date of seeding, were studied at three locations in Montana using winter wheat, spring wheat, oats, and barley.

The cultivation of 18, 24, and 30 inch spacings gave substantial increases in yield of winter wheat over the uncultivated 12-inch spacing at Moccasin. Experiments with 2,4-D and cultivation showed nearly identical yields. Applications of 2,4-D after two cultivations gave substantial increases in yield. Seeding rates have little effect on the yield of spring and winter wheat at the wide spacings.

No increases in yield were obtained from spaced plantings of spring wheat, oats, and barley. Generally greater reductions in yield due to wide spacings were obtained with spring wheat compared to oats and barley. The reductions in yield of the spring sown grains were not as great under dry land conditions as they were under irrigation. Comparison of two seeding dates with barley at Bozeman in 1950 indicated that wide spacings would respond the same. Trials conducted with half and full rates of seeding of oats and barley at 6-inch spacings resulted in decreased yields of barley and nearly identical yields of oats.

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INTRODUCTION

Natures ability to space plants differently under varying climatic conditions makes it logical to assume that the methods now used for the production of cereal crops might be modified to obtain maximum plant growth. Such a modification could be wide row spacing and cultivation of the cereal grains. From observations made of border rows in plant breeding nurseries, where the plants remained green in spite of drought conditions, it is apparent the wide spacings might be of some practical value. Why small grain row cultivation was not practiced in the past is probably hinged on the fact that the horse drawn cultivator was a slow tedious process and was not too effective in controlling the weeds within the rows. However, with the advent of motorized equipment and chemical weed killers, such a practice now seems feasible.

Row spacing studies are of interest as the wide rows may have value in; increasing yield and quality of the cereal grains, controlling perennial and other 2,4-D resistant weeds, permitting better establishment of perennial crops when used as a method of companion crop seeding, facilitating rogueing of pure seed crops, determining the validity of 12-inch or wider rows in conducting variety trials, and use in rotation sequences, particularly in continuous cropping. It is the purpose of this thesis to study the various aspects of wide row spacing of cereal grains in order to determine what might be expected in the way of yield and quality as influenced by cultivation, seeding rate, varieties, date of planting, 2,4-D sprays, seasons, and locations.

LITERATURE REVIEWED

During the early development of the great plains agriculture the effect of row widths and rate of seeding on the yield of small grains was studied by several investigators to determine the best cultural practice for different soil and climatic conditions, (1), (8). It was generally considered that row spacing of 6 to 10 inches and rates of 50 to 60 pounds per acre would be most efficient.

In the early twenties considerable research was conducted to determine the relative merits of the wide spacing of the furrow drill. McKee and May (15), at the Judith Basin Branch Station, found that the 14-inch furrow drill produced a higher yield of winter wheat than the common 6-inch drill. Salmon at Kansas (18) found little difference in yield until spacing between the rows was greater than 12 to 14 inches. Over a three year period Kiesselbach, Anderson, and Lyness, at Nebraska, (11) found that lower yields of wheat were obtained in 14-inch rows as compared with 7-inch rows when the same quantity of seed was used. Stephans and McCall, in Oregon, (21) planted winter wheat in 7 and 14-inch rows and spring wheat in 4,6,8, and 12-inch spacings over a five year period. It was found that the 7-inch spacing produced the highest yield of winter wheat and the 4-inch spacing the highest yield of spring wheat.

Sprague, at New Jersey in 1931, (10) went into considerable detail in the spacing of barley in rows and within rows. It was found that barley yields were nearly alike as long as the plant populations were in reasonable limits. He concluded that; (1) Thickly populated areas draw from the soil

resources of neighboring sparsely populated areas. (2) Root zones were not confined to the vertical zones occupied by aerial portions. (3) Crops such as wheat, oats and rye were more capable in drawing soil resources from adjacent areas than barley.

Engledow, at Cambridge, (5), studied spacing of two spring wheat varieties in relation to the factors contributing to yield, namely, tillering, ear size, and kernel weight. It was found that as the individual plant spacing was increased from 2-inches on up to 18-inches the amount of tillering increased proportionately so that the final ear populations were nearly alike. Furthermore, it was found that the two varieties did not tiller alike at the closer spacings. The ear size and kernel weight increased as the distance increased. However, this was not reflected in the yield at the extreme spacing due to a slight decrease in number of ears. He concluded that the most efficient spacing was at the 12 to 14-inch or at the point where the ears per unit area, kernels per ear, and kernel size were at their maximum.

The cultivation of wheat has been tested by both cultivation of the rows and harrowing. It has been found that harrowing or rolling generally reduces yields (2), (6), (12). Montgomery, at Nebraska in 1899 (16), spaced oats in 24, 18, 12, and 6-inch rows. The results indicated that a reduction in yield was obtained from the 24-inch spacing cultivated four times. The 18-inch spacing yielded the same as the 6-inch check, and the 12 and 6-inch rows when cultivated produced higher yields. Champlin, at Saskatchewan (3), grew several crops in a double 36-inch row and triple 30-inch row as a

summer fallow substitute in Canada in the early twenties. The yields obtained from such a system of spacing were reduced. However, the following crop gave satisfactory yields. Cole and Hallsted at Kansas, 1922 (4) reported six year results from a single plot of intertilled wheat, where 30-inches were sown solid and 30-inches fallowed. Such a practice not only was difficult to maintain but produced lower yields than fall plowing. McClelland (14) studied the effect of border rows in Arkansas in 1934. He received a 26 per cent increase in yield of oats from 16-inch border rows over 8-inch rows.

Russel (17) discusses the merits of cultivation for weed control and stated quite emphatically that weeds are usually most harmful to the crop in the early stages and particularly the very early stages of growth. He suggested cultivation of row crops as soon as possible. Kiesselbach (10) stated that the development of the wheat spike was determined by favorable growing conditions in the early stages of growth.

The effect of row spacing on the yield of small grain nurse crops was determined by Harper (7) at several locations in Oklahoma. It was found that wide spacing was an insurance against loss of legume stands during drought periods. Yields of wheat were lowered by spacings up to 14-inches, however, oats and barley were about the same.

Varietal interactions were found in barley, by Immer (9), when spaced planted 5-inches apart and in drill rows of 600 seeds per rod row.

MATERIALS AND METHODS

Central Montana Branch Station, Moccasin

Except for 1951, growing conditions were favorable for small grain production for the five year period in which these tests were conducted. The 43 year average seasonal precipitation (April 1st to September 30th) is 11.20 inches. During 1947, 1948, and 1950 above normal seasonal precipitations were recorded with 12.17, 13.51, and 12.59 inches, respectively. The below normal precipitation of 9.3 inches for 1949 was not reflected in yields because of the timely normal rainfall received in months of May and June. Low yields were obtained in 1951 as the seasonal rainfall recorded was only 8.52 inches. Due to drought conditions in the fall of 1948 poor germination of winter wheat occurred. However, by the 1st of May the following spring good stands were evident.

The first experiment to determine whether increase in yields could be obtained from wide row spacing and cultivation was started at Moccasin in 1947 with spring wheat. This test we conducted on fallowed ground using a row spacing of 6-inches for a check and cultivated spacings of 12, 18, 24, 30, and 36-inches. Each spacing was sown at 30, 40, 50, and 60 lbs. per acre. The experimental design was a modified split plot with two replications. The plot size was 18 by 80 feet. One cultivation was given with a corn cultivator when the wheat was from 4 to 6-inches high.

In 1948 experiments were started with winter wheat. The change from spring wheat was made primarily because weeds were not a serious problem in spring sown grains. Due to the difficulty encountered in the cultivation

of the narrow 12-inch spacing of spring wheat and due to the low yields obtained from the 30 and 36-inch row widths the following spacings were used for winter wheat from 1948 to 1951: (1.) 12-inch un-cultivated spacing as a check, (2.) 18-inch rows cultivated once in the fall and once in the spring, (3.) 24-inch rows with fall and spring cultivation, (4.) Two 6-inch rows spaced 30 inches apart with fall and spring cultivation. The same type of experimental design and plot size was used as with spring wheat except that the 30 lb. rate of seeding was dropped and a third replicate was added. Each year the grain was sown on fallowed ground.

Two varieties of winter wheat were used. Karmont was sown in the fall of 1947 and 1949, and Yogo in the fall of 1948 and 1950. The winter wheat was sown with a six foot single disk grain drill. The row spacings were obtained by covering the appropriate feeds in the drill. The winter wheat was cultivated during the middle of October and around the 1st of May with a duckfoot type row cultivator. The depth of cultivation was from 1 to 2 inches or just deep enough to control the weeds. In 1949 and 1951 the wheat plant population for each spacing was determined by counting at three locations the number of mature heads in a yard long row in each plot and then converting the data to heads per square foot. At harvest, sixteen feet of row was cut from the center of each plot and threshed in a Vogel Thresher. The threshed grain was then weighed in grams and later converted to bushels per acre. The grain of each treatment, from the three replicates, was bulked for test weight and protein determinations. The protein determinations were made by the Montana State Grain Laboratory, Bozeman, Montana.

During each of the five years heavy infestations of winter and summer annual weeds of the mustard and amaranth families occurred in all plots. No grassy weeds were observed.

During the period 1948 to 1951 several other aspects of wide row spacing of winter wheat were tested in conjunction with the experiment previously described. These tests were as follows:

1. A one year test conducted in 1948 to determine the effectiveness of fall and spring cultivation vs only spring cultivation. The method used was to divide each cultivated plot in half, one half being cultivated twice and the other half being cultivated once. Yield data were obtained from both halves.

2. A cultivation vs 2,4-D experiment was conducted from 1949 to 1951 to test the merits of cultivation as compared to chemical weed control. This test was a triplicated randomized block with the following treatments: (1) 12-inch uncultivated check, (2) 12-inch rows sprayed with 1/3 lb. of 2,4-D at tillering, (3) 24-inch rows sprayed with 1/3 lb. of 2,4-D at tillering, (4) 24-inch spacing cultivated in the fall and spring.

3. A cultivation plus 2,4-D experiment was conducted in 1951. This was accomplished by spraying a 16-foot swath with 1/3 lb. of 2,4-D per acre across the row spacings previously cultivated.

In 1951 spacing studies were conducted with eight barley varieties to determine if any variety x spacing interaction would occur. The barley was sown in 6 and 12-inch spacings. No cultivations were given, however, the plots were treated with 1/3 lb. of 2,4-D per acre when the barley was well tillered. The experimental design was a randomized block with three

replications. The plot size was 1/50 acre. Harvesting was accomplished by cutting a 7 foot swath from the center of the plot with a self-propelled combined.

A homogeneity of variance test as given by Snedecor (19) was run on the winter wheat data to determine if the 12-inch uncultivated spacing should be analyzed with the cultivated plots. It was found that the populations were alike so the data was analyzed by use of the analysis of variance and appropriate F-test as given by Leonard and Clark (13). The analysis of co-variance was used to study the relationship between yield, test weight, protein, and head populations.

North Montana Branch Station, Havre

A wide row spacing experiment with spring wheat was started at Havre in 1950. The test was conducted on dry land on an alternate fallow crop basis. The long time average seasonal precipitation for the station was 11.54 inches. The rainfall for 1950 was 1.17 inches above normal. However, a hot dry period during the latter part of July generally reduced yields. During 1951 the seasonal rainfall was 12.68 inches and the season was generally favorable for crop production.

The same experimental procedure was followed during each of the two years in which tests were conducted. Rescue spring wheat was sown with a common drill in rows spaced 6, 12, 18, 24, and 30 inches apart. All spacings were sown at rates of 20, 40, and 60 lbs. per acre. The design was a triplicated randomized block. The plots were 132 feet long and after the border rows were removed exactly 1/50 of an acre was left to harvest.

The row spacing plots were not cultivated. Instead, they were harrowed

to control small Russian thistles when the wheat was in the seedling stage. Later 4/10 of a pound per acre of 2,4-D was applied when the wheat was well tillered. Weeds were not a serious problem.

Harvesting was accomplished by a self-propelled combine. The harvested grain was weighed in pounds and later converted to bushels per acre. Test weight and protein determinations were made for each plot. The two years data were combined and analyzed by the appropriate statistical methods.

Montana Agricultural Experiment Station, Bozeman

Irrigated growing conditions were generally more favorable for crop production at Bozeman than under dry land conditions. Except in 1950 when late August rains delayed maturity and in 1951 when 3 weeks of hot weather in July caused premature ripening, crop conditions were ideal for the years that spacing experiments were conducted.

In addition to yield and quality of small grains when grown in wide row spacings, studies were made on other aspects of spacing such as: (1) The validity of testing small grain varieties in 12-inch rows when most farmers use a 6-inch drill for field production, (2) Date of seeding in relation to varieties and spacings, (3) The value of wide row spacings for nurse crops, (4) The possiblity of growing pure seed blocks in wide rows so rougeing would be less difficult.

The first test on row spacing was conducted in 1944 on dry land at Fort Ellis and under irrigation at Bozeman. During that year Compana and Glacier barley were grown in five randomized replications spaced at 6 and 12 inches to determine if any variety x spacing interaction would occur.

In 1947 row spacing studies were conducted with spring wheat and oats. The spring wheat test was similar to the 1947 Moccasin spring wheat experiment except that the seeding rates were increased to 45, 60, 75, and 90 lbs. per acre. In order to gain more precision, the oat experiment was sown as a latin square split plot design. Overland, Bridger, and Gopher were seeded in rows spaced 6, 12, 18, and 24 inches apart.

No spacing studies were conducted in 1948. To obtain information on spacing x crop interaction two varieties of oats, Bridger and Gopher, and one variety of spring wheat and barley, Thatcher and Glacier, were grown in separate latin square blocks in 1949. The spacings were slightly modified to include a 6-inch spacing which was sown at half the regular rate so as to gather more information on such a rate of seeding for companion crops.

In 1950, oat tests were continued on the same basis as the previous year except that V-R x Bannock (CI4283) was added. The barley experiment was modified to include three varieties, Glacier, Compana, and Titan. These three varieties were grown in a triplicated randomized block with the same spacings as used in 1949. In addition, Glacier and Compana were grown in a latin square split plot design using two dates of seeding in 6, 12, and 18 inch rows.

During 1951 the oat and barley tests were continued. The varieties of oats were changed to include Bridger, Mission, and Clinton x Overland[2] (CI6611). In the barley test the latin square design was changed to a triplicated randomized block and the 24-inch spacing dropped for Titan and Compana. The 24-inch spacing was maintained with Glacier so that a three

year comparison could be made with one variety.

The general experimental procedure at Bozeman was to plant rod rows with a nursery planter. The plot size varied with the width of spacing so that there would always be a border row on each side and two border rows on the 6-inch spaced plots. Except for the 6-inch spacings, all plots were cultivated once with a wheel hoe. Weeds were not a factor in any spacing. At harvest 16-feet of the center row of each plot, except for 6-inch spacing when two were cut, was cut by hand and threshed with a Vogel thresher. The grain was weighed in grams and converted to bushels per acre. Test weights were obtained.

The data for each of the yearly tests were analyzed by use of the analysis of variance and appropriate F test. Three years data for Bridger oats and Glacier barley were taken out of the yearly test an analyzed for year x spacing interaction. The 1949 data for oats, barley, and spring wheat were tested for crop x spacing interaction.

EXPERIMENTAL RESULTS

Winter Wheat

The winter wheat data presented are from the tests conducted at Moccasin from 1948 to 1951. The detailed data collected are reported in the appendix A, Table I. For the continuous four year spacing and cultivation study, the data for yield and test weight are based on four years results. The data for protein and head populations are for the years 1949 and 1950.

Yields obtained

The annual average yield obtained from the four spacings along with the seasonal precipitation for the 1948-51 period is presented in Fig. 1.

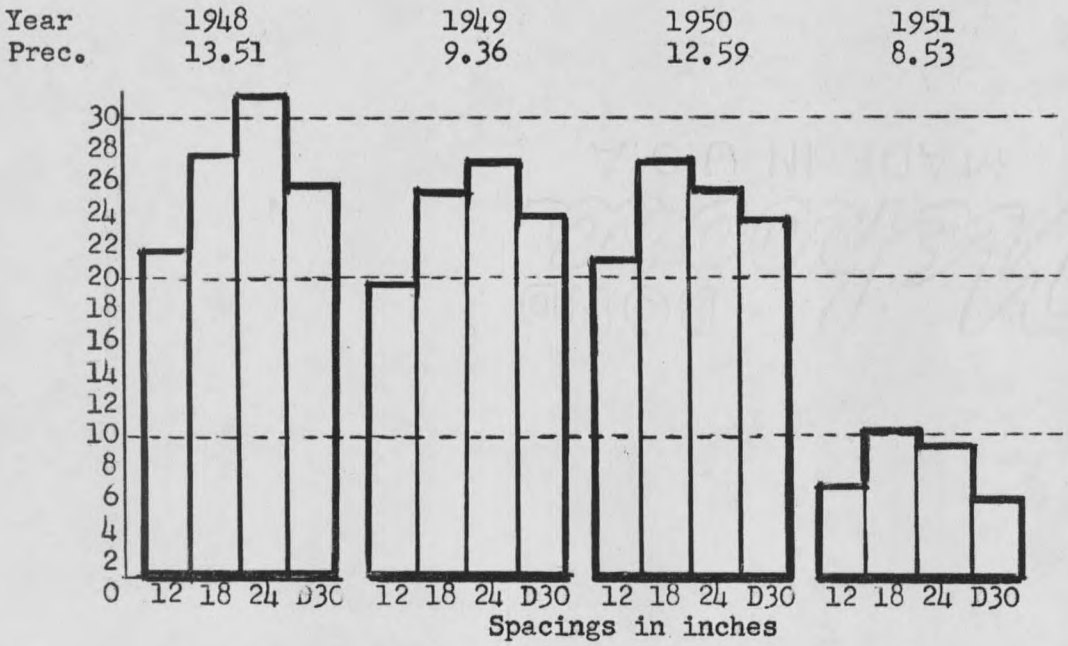

Figure 1. Annual average yield in bushels per acre obtained from spaced plantings of winter wheat, showing yield of 12-inch spacing and 18, 24, and 30 inch spacing cultivated twice, Moccasin, 1948 to 1951.