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Title THE EFFECT OF SEEDING TIME ON THE HEADING AND YIELD OF WHEAT IN THE WILLAMETTE VALLEY

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Wheat is an important cereal crop in the Willamette Valley of Oregon and the stiff-strawed, high yielding winter varieties are the predominate types grown although spring varieties are not uncommon. Because of the mild, often open winters present in the Willamette, it is not unusual to be able to seed wheat almost every month from early fall until late spring.

The purpose of these studies was to determine the cold requirement and critical heading period of some important winter wheat varieties. The cold requirement and critical heading period was measured by determining the extent that each of the winter varieties would develop heads from various planting dates from late fall until early summer.

Results were obtained on the percentage of heading for each variety in the 1961-62 trial and for heading and yields in bushels per acre in the 1962-63 trial. The critical seeding date was

determined for each variety and a comparison was made between the two years.

The new winter wheat variety, Gaines, had the highest average yield from all dates of seeding for the winter varieties and Gaines likewise had the highest yield from the latest date of seeding in the spring.

There was more variation in the critical heading periods in 1961-62 than in 1962-63. Redmond showed the greatest variation between the two years. The critical period for yield was earlier than the critical period for heading.

The results also showed lack of agreement between the winter hardiness of the winter varieties and the critical heading period.

THE EFFECT OF SEEDING TIME ON THE HEADING AND YIELD OF WHEAT IN THE WILLAMETTE VALLEY

by

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INTRODUCTION

Wheat is grown on more of the world's acreage than any other cultivated crop. It is adapted to a wide range of soil and climate but is not extensively cultivated in regions having seasons of less than 90 days or having less than nine inches of rainfall, except under irrigation. The most favorable conditions for wheat production are areas with a cool, moderately moist growing season and a warm, dry harvest season. Such conditions are found in the interior of continents and in coastal regions with Mediterranean-type of climate.

In the Willamette Valley of Oregon, wheat is grown on some 100,000 acres with an annual production of over 3,000,000 bushels. Winter wheat varieties are the highest yielding and are the predominate types grown, but spring varieties are not uncommon. Because of the mild, often open winter present in the Willamette Valley, it is not uncommon to be able to seed wheat almost every month from early fall, through the winter months, and into the early summer. The question is often asked of agronomists, "How late can a winter wheat be planted and still obtain a satisfactory yield?"

The purpose of these experiments was to determine the extent to which the important winter wheat varieties grown in the Willamette

Valley would develop heads from various dates of planting from late fall until early summer. From these results it would also be possible to describe the cold requirement of the important wheat varieties and to develop recommendations on the best dates of seeding for wheat in the Willamette Valley.

REVIEW OF LITERATURE

Wheat varieties are commonly classified as winter intermediate or spring based on their habit of growth.

Bayles and Clark (1, p. 14-17) reported that the different classes for growth habit are not clear-cut as there is a more or less complete series or types from true winter to spring types. Because of this lack of distinction between types, this classification by habit of growth has gradually become less valuable for classification purposes; however, in some areas the separation of varieties for winter or spring growth habit is very important.

According to Bayles and Clark, winter wheat varieties generally must be planted in the fall if they are to develop heads. When planted in the spring, they usually remain prostrate and produce no culms or heads. The intermediate types retain a prostrate habit of growth when sown late in the spring but will head normally when sown early. Spring varieties will produce normal heads from either fall or spring plantings but are often winter-killed when seeded in the fall, except in areas with mild winters. When spring wheats are sown in the spring, their growth is usually erect; and culms and heads are produced during the early part of the growing season.

Time of planting studies have been made for almost every area where wheat is grown commercially, and in general, the best

seeding time is early enough in the season to permit maximum growth and development towards maturity before the advent of hot weather, drought, and disease.

Martin and Leonard (8, p. 453-516) cited that winter wheats fail to head when planted in the spring except when sown very early or under cool conditions. Early seeding of spring wheats usually resulted in the highest yields. Early sown spring wheats are more likely to avoid injury from unfavorable conditions and disease.

Maistrenko (7) mentioned that early sowing of spring cereal varieties is of great importance for producing mature and viable seed, and the earliest sowing dates of winter wheat gave the highest yield because winter wheat required cold treatment for vernalization.

Foote (5) reported that in the Willamette Valley of Oregon, the date of planting of winter wheat has been established by taking into consideration the availability of soil moisture, Hessian fly-free date, and the necessity of avoiding excessive fall growth. The optimum date of seeding is between October 15 - November 15. The optimum date for spring wheat is to seed as early as the soil can be prepared into a good seed bed. The critical seeding date for normal heading of varieties with a winter growth habit characteristic or the expression of the growth habit is affected by temperature, length of day and date of seeding.

Bayles and Martin (2, p. 483-500) reported on experiments conducted at the Sherman County Branch Experiment Station, Moro, Oregon, during 1923-24. They found that winter wheat could be sown as late as February 15 and still head and produce yields equal or better than the spring varieties.

According to Bayles and Martin, referring to studies of Adams with Kharkof winter wheat seeded in plots in the greenhouse at Ottawa, Canada at weekly intervals from March 5 to April 23, after which the plants were transplanted outside on May 15, they found that all plants sown in March headed and completed their life cycle.

Nuttonson (10, p. 330-337) stated that the date of sowing is determined by the climatic conditions of a given area. Time of sowing, as well as other field practices, is determined by physical, biological, and economic factors. The optimum dates of seeding in the major wheat regions in the United States varies for the different areas, but it appears that the mean daily temperature range between 50° and 60° F at the time of sowing is an important factor in the yield.

Montaruli (9) reported three years of experiments on the yields of eight wheat varieties and showed that the best period to increase grain yields and improve some commercial characteristics was by sowing in early November.

Watson, et al. (13, p. 1-22) mentioned the physiological causes

of variation in yield between autumn and spring sown wheat. The autumn sown varieties had greater leaf-area indices and dry weight, but smaller net assimilation rates than the spring varieties.

Woodward (16) stated that in experiments conducted in the western part of the United States on irrigated land, wheat when sown at three dates approximately a month apart during three years in all experiments the late seeding caused a depression in the yield.

Beutler and Foote (3) reported in a recent study that standard wheat varieties behave differently under various environment and treatment. They pointed out that some of the presently grown wheat varieties in the Pacific Northwest possess agronomic characteristics which will permit early fall seeding in the wheat growing areas of the Columbia Basin. Plants sown in April, in most cases, did not produce heads until the next season when they headed normally. Bayles and Martin also stated that the date on which wheat will head depends upon the variety, date of sowing, and seasonal factors. Every wheat variety which carries the genetic factors for winter-growth habit, if sown after a critical spring date characteristic for that variety, will not head during that season but will produce a prostrate excessive vegetative growth.

The flowering or heading of plants is greatly affected by the temperature. Winter wheat planted in the spring fails to produce

heads unless the germinating seed or growing plant are subjected to cold or cool conditions. The process of treating plants or seeds with low temperatures in order to induce flowering is called "vernalization."

Whyte (14, p. 1-37) prepared a comprehensive review of the literature and summarized the history of research on vernalization. According to Whyte, Gassner (1918) was one of the early chillers of grain, giving cereals in the laboratory the low temperature they would normally receive in the field after being sown. Gassner was primarily interested in temperature in the early stage of plant growth. He stated that the growing of winter plants at low temperatures induces increased winter hardiness and conditions them for flower formation. Whyte, referring to the studies of Tolmacev (1929), pointed out that winter cereals will not ear until a definite growth activity has been completed. Those conditions, for instance, low temperature, which stimulate the accumulation and preservation of the "products of disintegration," also stimulate fruit bearing. It was noted that the time required for the completion of some of the recognisable stages in the growth, such as seedling emergence, ear emergence, full flowering, etc., are completed more rapidly at higher temperatures than at lower temperatures.

Whyte (15, p. 87-96) reported that Purvis and Gregory (1937)

had postulated the existance of a flower-forming substance. The effect on the primordia varied according to the external factors which the plant was exposed to. It appears that during the vernalization of winter cereals that some of the flower-forming substance may be translocated and accumulated in all growing points of the shoots, and when critical concentration is reached, flower formation is induced.

Razumove (11, p. 101-118) mentioned that the length of the stage of vernalization in winter wheat is one of the most important physiological characteristics. Vernalization of the vegetative winter-type plants depends greatly on environmental conditions. Temperature conditions play an important role in the process of vernalization beside all factors which are influencing the synthesis of energy-storing substances in the plant and their distribution among the organs of the plants. The effect of the short day on the length of the vernalization stage is limited to the initial period of the process. The higher rate of vernalization under short day does not appear in all species and varieties responding to vernalization. It is more clear-cut in the winter-type varieties and failed to develop in the less winter-type species. In all species and varieties during their vegetation, long day, and particularly continuous light, promoted the completion of vernalization.

Ishihara (6) reported that vernalization is also directly perceived by the stem or bud, primary meristem, and proceeds at field temperatures above 5° C.

Foltin (4) cited the degree of change in the heredity of spring wheat when seeded in the autumn. These results which are highly controversial indicate that this change was dependent on the proper conditions prevailing during the interval of the effect and also the duration of that period.

MATERIALS AND METHODS

The experiments reported in this study were conducted during the years 1961-62 and 1962-63. The 1961-62 plantings were made on the East farm located in Linn County about a mile east of Corvallis, Oregon. The soil was a sandy phase of the Chehalis soil series. The 1962-63 experiments were made on the Beach Farm on a heavy phase of the Chehalis soil series.

Seven wheat varieties were used in these studies during the two years. The varieties used in each of the trials is given in Table 1.

Table 1. List of wheat varieties used in the time of planting studies.

Varieties	C.I. No.	Growth Habit	Experiments	
			1962	1963
Gaines	13448	Winter	X	X
Redmond (Alba)	13256	Winter	X	X
Druchamp	13723	Winter	X	X
Burt	12696	Winter	X	
Kharkof	1442	Winter		X
Marfed-Merit Sel. 28	13058	Spring	X	X
Zimmerman	7359	Spring	X	X

A brief description of each of the wheat varieties is as follows:

Gaines is a short-strawed, high yielding winter wheat variety. It is rated as being moderately winter hardy under the Pacific Northwest conditions. Gaines was released to growers in Oregon, Washington, and Idaho in 1961, and by 1963 it was the leading variety in the area.

Redmond (Alba) is a tall, late maturing winter wheat variety introduced into western Oregon from Holland. Redmond is rated as a moderately winter hardy wheat.

Druchamp is a semi-tall winter wheat variety introduced into western Oregon from France. It has moderate winter hardiness.

Burt is a short-strawed, mid-season winter wheat variety with moderate winter hardiness under Pacific Northwest conditions. Burt was released to wheat growers in the Pacific Northwest in 1956, and it has been grown rather extensively since that time.

Kharkof is a mid-tall, mid-season, weak strawed winter wheat variety. Kharkof is identical to the original Turkey hard red winter wheat and is very winter hardy.

Zimmerman is a tall mid-season spring wheat grown to a limited extent in western Oregon. This variety often produces its best yields when planted in late winter.

Marfed-Merit Sel. 28 is a new mid-season spring wheat

variety currently being increased for distribution to growers in the Willamette Valley.

Plantings were made at weekly intervals during the winter and spring months in the 1962 experiment. In the 1963 experiment, plantings were made monthly during the fall months and then at weekly intervals during winter and spring. The planting dates for each year were as follows:

Table 2. Weekly planting dates during 1961-62 and 1962-63

1962		1962-63	
January	4	November	6
January	11	December	4
January	18		
January	25	January	4
		January	11
February	1	January	18
February	8	January	25
February	15		
February	22	February	1
		February	8
March	1	February	15
March	8	February	22
March	15		
March	22	March	1
March	29	March	8
		March	15
April	5	March	22
April	12	March	29
April	19		
		April	5
		April	12
		April	19
		April	26
		May	3
		May	10

Planting at each of the various dates was accomplished by opening a small furrow with a wheel-plow and distributing the seed evenly in each row by hand. Only when the soil was frozen was any difficulty experienced in making the plantings and covering the seed sufficiently for germination.

The plots planted in the 1962 experiments consisted of a single row 10 feet long and 18 inches between rows. Two replications of each of the six varieties were planted at each date. In the 1963 experiment, three replications of single row plots were used.

The seed for each plot was weighed and treated with a fungicide prior to seeding. The seeding rate was 90 pounds per acre.

The plots were kept free of weeds by hand weeding when necessary, and each experiment was given a uniform application of approximately 40 pounds of nitrogen during early spring.

In the 1961-62 experiment, counts were made on the total number of tillers and number of tillers with well-developed heads for each variety at the various dates of planting.

In the 1962-63 experiment, the dates of heading were obtained for each variety through all the dates of planting. Prior to harvesting, the total number of tillers and number of tillers with normal heads per unit area were counted on each date of planting for each variety. The plots were harvested by hand, and each plot was

threshed and cleaned prior to weighing. The yield was obtained in grams and converted to bushels per acre for each variety at each of the dates of planting.

EXPERIMENTAL RESULTS

1961-62 Experiment

In this study six wheat varieties were used to study the extent of heading from various dates of seeding from January 4 until April 19. The percent of heading of each variety at the various dates of seeding was obtained and the results are given in Table 3. These results are graphed and shown in Figure 1. The number of tillers and the number of tillers with well developed heads for each variety are given in Appendix Table 1. The daily maximum and minimum temperatures from a nearby weather station were obtained for the four months covered by these trials, and these are given in Appendix Table 2.

The percent of heading of the four winter wheat varieties was consistently high from the first date of planting on January 4 until the planting made on March 1. The heading percentages ranged from 75-96 percent for these dates of planting.

Druchamp had a high percentage of heading from the first date of planting through the March 15 planting. After this date the percentage of heading decreased at each date until the variety planted on April 19 produced no heads.

The percent of heading of Redmond declined rapidly after the

Table 3. Summary of the percentage of tillers with well developed heads from various dates of planting in 1961-62.

Planting Date	Winter Varieties					Spring Varieties		
	Druchamp	Redmond	Gaines	Burt	Average	Sel. 28	Zimmerman	Average
January 4	96	96	89	94	94	95	94	94
January 11	95	78	91	95	90	96	96	96
January 18	88	90	91	96	91	95	94	94
January 25	94	96	95	93	94	98	98	98
February 1	93	90	96	96	94	94	96	95
February 8	95	91	89	93	92	92	95	93
February 15	94	90	96	79	90	88	95	91
February 22	80	83	89	75	82	88	87	87
March 1	87	75	87	76	81	93	94	93
March 8	96	36	87	79	74	97	97	97
March 15	78	0	86	83	62	93	96	94
March 22	48	0	62	75	46	96	84	90
March 29	12	0	35	72	30	98	86	92
April 5	4	0	7	40	13	97	89	93
April 12	4	0	5	38	12	96	97	96
April 19	0	0	0	0	0	90	82	86

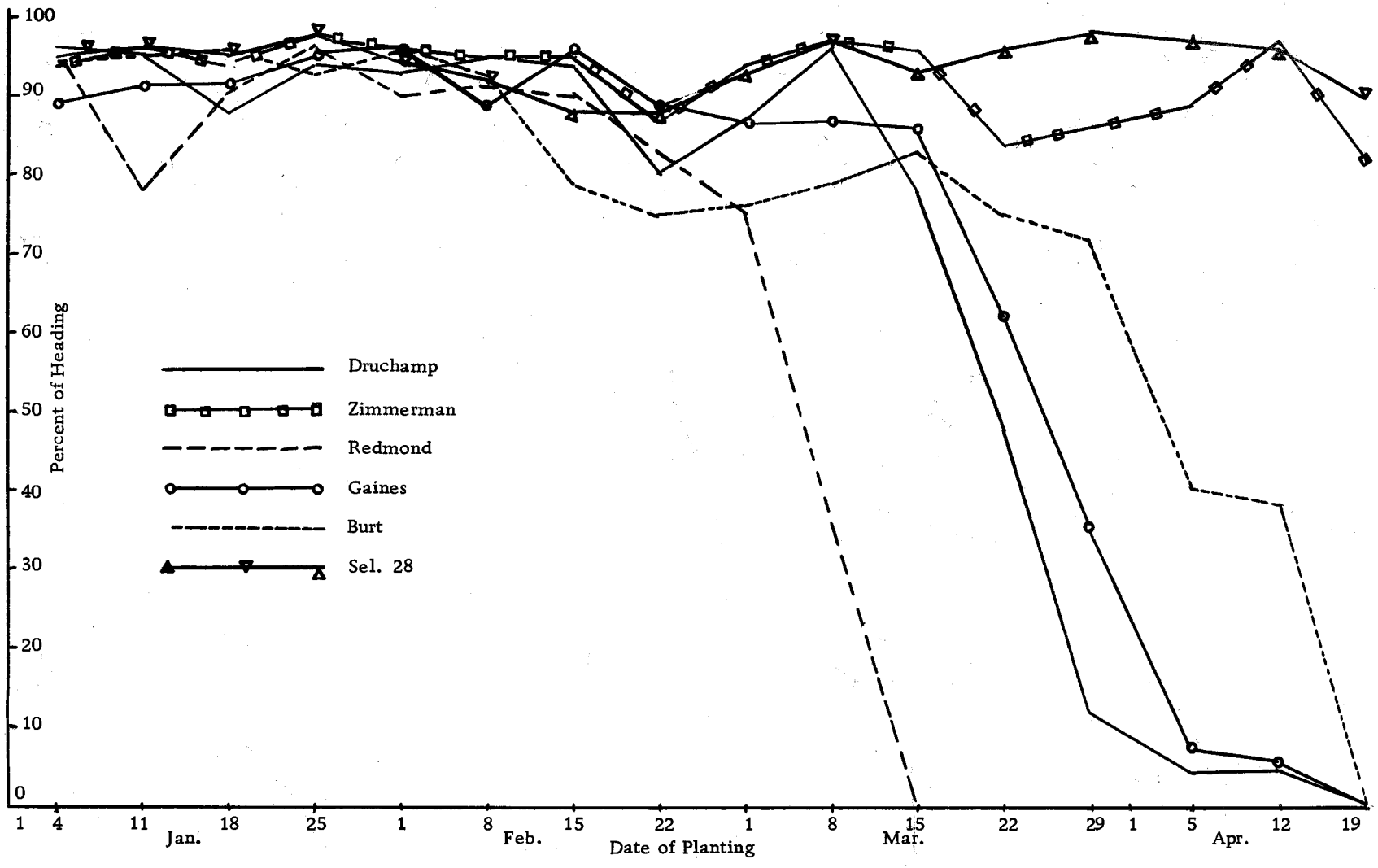

Figure 1. Percent of heading of six wheat varieties sown at weekly intervals during the season of 1961-62.

March 1 planting date. It did not head after the March 8 planting date.

The decrease in heading of the variety Gaines occurred at the March 22 planting date and continued until the variety did not head at the April 19 planting date.

Burt gave a high percentage of heading from the January 4 to the March 29 planting date, and then the heading decreased through the later planting dates. Burt did not head from the April 19 planting.

The spring wheat varieties headed well at all dates of seeding. There was little variation in amount of heading between Zimmerman and Sel. 28. The average percent of heading of spring wheat varieties was higher than in the winter wheats. Druchamp showed no difference in total number of tillers between the early and late date of planting, but the number of tillers with normal heads decreased during the late planting date. The total number of tillers and number of tillers with normal heads of Redmond, Gaines and Burt declined after the March 1 planting date. The average percentage of heading for the four winter and two spring wheat varieties are shown in Figure 2.

The average maximum and minimum daily temperatures for January, 1962, was 34.8° and 29.5° F; for February, 48.8° and 33.8° F; for March, 51.4° and 35.2° F; and for April, 62.5° and

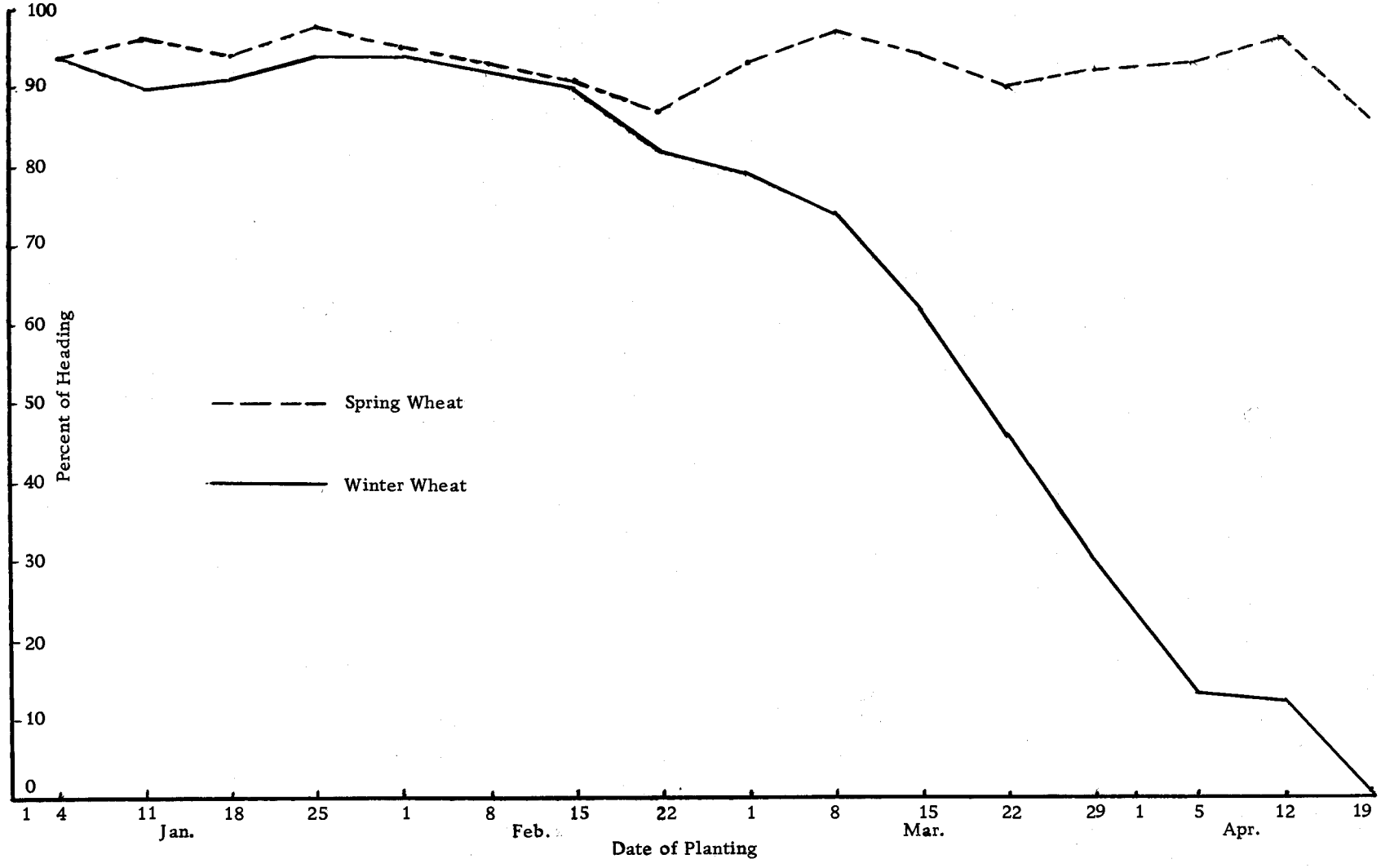

Figure 2. Average percent of heading of four winter and two spring wheat varieties sown at weekly intervals during the 1961-62 season.

40.6° F. The mean maximum daily temperature difference between January and February was 14.0° F; between February and March, 2.6° F; and between March and April, 11.1° F. The difference of the mean minimum between January and February was 4.3° F; between February and March, 1.4° F; and between March and April, 5.4° F. (12).

1962-63 Experiment

The trial conducted in 1962-63 included four winter and two spring wheat varieties. These were planted at 21 different dates of planting and, in addition to measuring the extent to which each variety produced heads, yields were also obtained from each plot. The yields obtained for each variety at each planting date are given in Appendix Table 3. The average yields for each variety and date of planting for the three replications are presented in Table 4, and these are presented in graph form in Figure 3. The extent to which each variety headed at the various dates of seeding is presented in Table 5 and Figure 4. The average date of heading for each variety is given in Table 6.

The yield of Kharkof was high from the first date of planting until the March 1 seeding date. The yield of Kharkof was, however, consistently lower than the yield of the other wheat varieties from

Table 4. Average yields in bushels per acre for four winter and two spring wheat varieties obtained from the 1962-63 experiment.

Planting Date**	Winter Varieties					Spring Varieties		
	Kharkof	Druchamp	Redmond	Gaines	Average	Sel. 28	Zimmerman	Average
November 6	58.7	98.6	112.1	86.0	88.8	83.3	86.5	84.9
January 4	84.6	74.4	82.1	79.3	80.1	77.2	78.9	78.0
January 11	66.5	72.2	82.1	100.9	80.4	100.2	71.6	85.9
January 18	78.4	81.3	88.7	77.5	81.5	100.4	66.8	83.6
January 25	70.2	81.3	87.2	95.9	83.6	94.5	88.0	91.2
February 1	54.4	83.7	70.4	84.4	73.2	91.9	72.3	81.7
February 8	55.2	71.8	77.4	89.6	73.5	86.6	72.8	79.7
February 15	64.8	77.7	69.0	77.9	72.3	98.0	71.7	84.8
February 22	48.4	58.5	56.8	76.2	60.0	67.6	60.2	63.9
March 1	55.8	40.6	50.8	70.9	54.5	69.6	56.5	63.0
March 8	40.2	33.0	21.4	54.9	37.4	68.5	39.5	54.0
March 15	46.9	40.6	41.9	59.3	47.2	62.2	52.5	57.3
March 22	33.8	38.8	33.5	42.2	37.1	54.2	39.8	47.0
March 29	19.6	24.3	15.0	38.0	24.2	38.6	26.0	32.3
April 5	11.3	15.0	4.9	32.1	15.8	46.4	42.2	44.3
April 12	4.6	0	0	0	1.1	25.6	17.3	21.4
April 19	0	0	0	0	0	16.3	9.1	12.7
April 26	0	0	0	0	0	16.9	7.4	12.1
May 3	0	0	0	0	0	12.4	5.1	8.7
May 10	0	0	0	0	0	*	*	

* Did not ripen for harvest.
** The yields from the December 4 planting date omitted from this table.

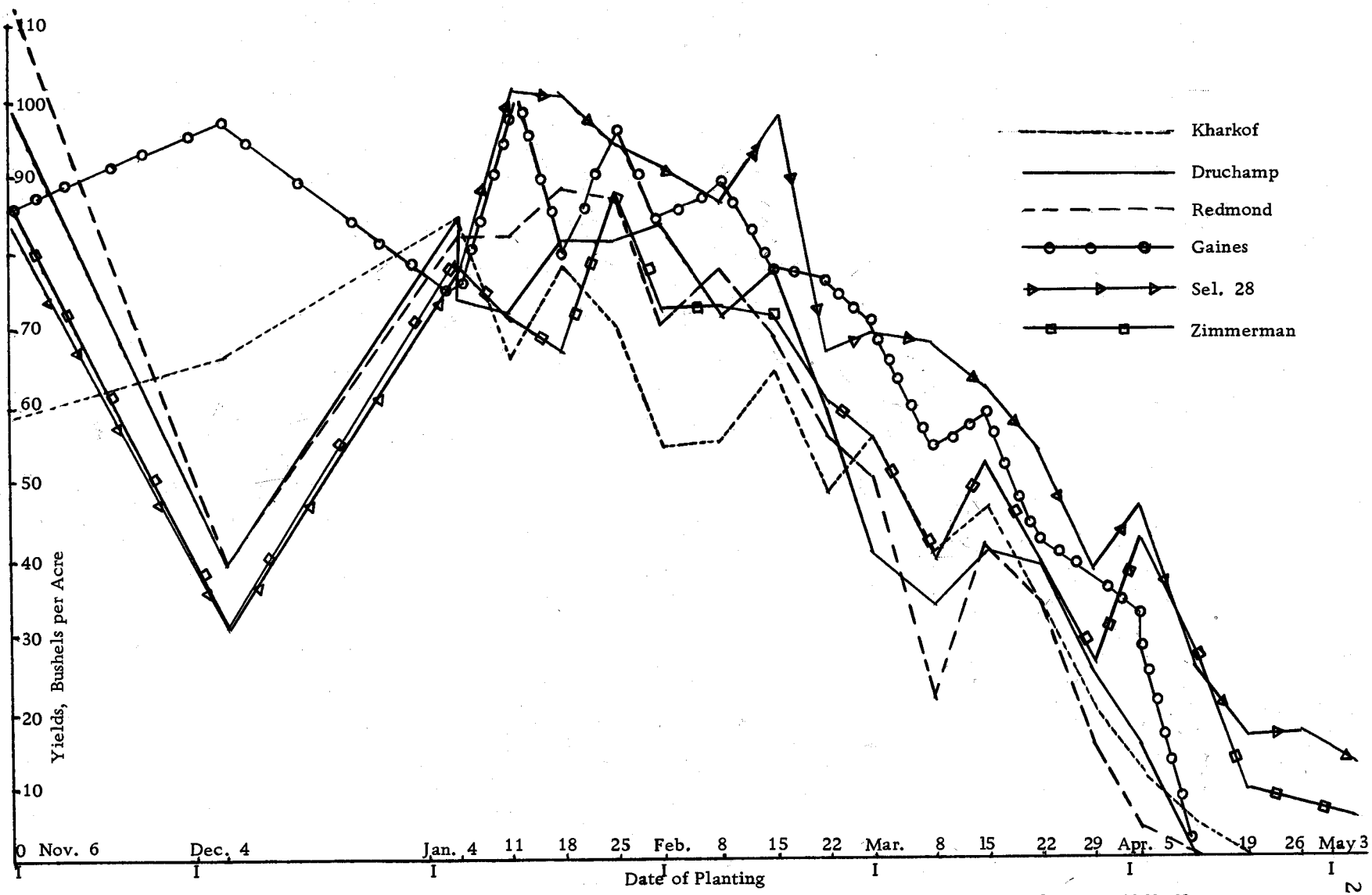

Figure 3. The average yields of four winter and two spring wheat varieties planted at various intervals during 1962-63.

Table 5. The average percentage of heading for four winter and two spring wheat varieties, obtained from the 1962-63 experiment.

Planting Date	Winter Varieties				Spring Varieties	
	Kharkof	Druchamp	Redmond	Gaines	Sel. 28	Zimmerman
November 6	94	96	87	92	90	95
December 4	94	91	88	93	93	90
January 4	93	87	82	81	89	89
January 11	92	86	84	87	92	92
January 18	88	89	85	89	95	92
January 25	86	84	78	85	83	87
February 1	91	84	86	83	92	87
February 8	82	86	82	87	92	90
February 15	89	85	79	78	92	92
February 22	90	88	88	88	89	89
March 1	84	83	74	92	91	92
March 8	78	86	85	84	89	77
March 15	88	82	78	88	90	87
March 22	79	78	75	88	89	88
March 29	29	58	8	67	88	83
April 5	13	26	0	55	88	92
April 12	9	1	0	16	90	88
April 19	9	0	0	0	79	84
April 26	0	0	0	0	77	75
May 3	0	0	0	0	78	72
May 10	0	0	0	0	69	68

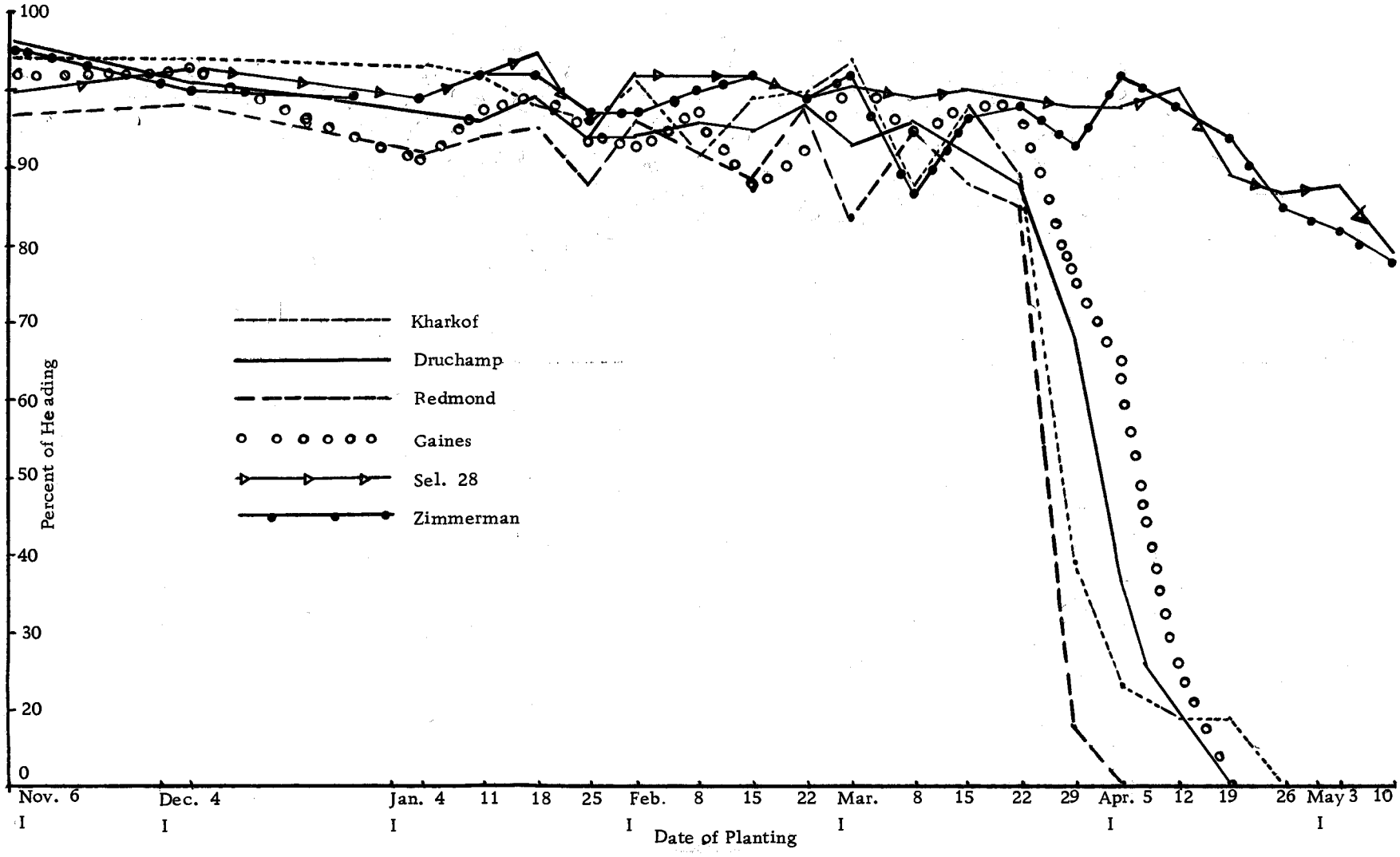

Figure 4. Average percentage of heading of four winter and two spring wheat varieties seeded at various intervals, 1962-63.

Table 6. Average date of heading for each of the four winter and two spring wheat varieties. in the 1962-63 experiment.

Planting Date	Winter Varieties				Spring Varieties	
	Kharkof	Druchamp	Redmond	Gaines	Sel. 28	Zimmerman
November 6	5-31	6-2	6-5	6-1	6-29	5-31
December 4	6-6	6-8	6-13	6-4	5-31	6-5
January 4	6-6	6-8	6-13	6-5	5-31	6-6
January 11	6-8	6-9	6-14	6-8	5-31	6-4
January 18	6-8	6-11	6-15	6-8	6-1	6-5
January 25	6-8	6-12	6-15	6-8	6-1	6-6
February 1	6-9	6-12	6-16	6-10	6-2	6-7
February 8	6-11	6-13	6-18	6-11	6-4	6-8
February 15	6-12	6-15	6-20	6-14	6-4	6-8
February 22	6-14	6-17	6-22	6-15	6-8	6-10
March 1	6-19	6-20	7-1	6-18	6-8	6-12
March 8	6-21	7-1	7-7	6-20	6-12	6-13
March 15	6-23	7-1	7-15	6-22	6-12	6-14
March 22	6-29	7-2	7-26	6-30	6-13	6-15
March 29	7-12	7-15	7-30	7-8	6-14	6-18
April 5	7-13	7-25	--	7-11	6-19	6-20
April 12	7-25	8-9	--	7-26	6-19	6-21
April 19	--	--	--	--	6-21	6-25
April 26	--	--	--	--	6-22	6-24
May 3	--	--	--	--	6-30	7-3
May 10	--	--	--	--	7-1	7-8

the January 25 planting until February 22. The average yield of Kharkof decreased at the later dates of planting and finally produced no yield at the April 19 seeding date.

Redmond had the highest yield of 112.1 bushels per acre on the November 6 planting date, and its yield was higher than 70 bushels per acre from the January 4 planting date until the February 8 date. Redmond did not produce any grain from the April 12 seeding date.

The average yield of Gaines was higher than 70 bushels per acre from the first date of planting through the March 1 planting date, but after this date the yield declined slightly until no yield was obtained from the April 12 planting date. The spring wheat varieties had high yields at all the dates of planting until May 3. The spring wheat varieties headed from the May 10 planting date but did not mature seed for harvesting. The average yield of Sel. 28 ranged from 12.4 - 100.4 bushels per acre.

The average yields of the spring wheat varieties, from the first date of planting until the January 4 planting date, was slightly less than the average yields of the winter wheat variesties. After the January 4 planting date until the May 3 planting date, the average of the spring wheat varieties was higher than that of the winter wheat varieties.

The percent of heading of Kharkof was high from the first date of seeding until the March 22 seeding date, then after that date the percentage of heading rapidly decreased. Kharkof did not head from the April 26 date of planting.

The percent of heading of Druchamp was high from the first date of planting until the March 22 planting date, and after this date of planting the percentage of heading declined.

Redmond headed normally up to the March 22 planting date, and its lowest amount of heading was eight percent from the March 29 date of seeding. Redmond produced no heads from the April 5 seeding date, while the other winter wheat varieties continued heading until the April 12 seeding date.

Gaines had a high percentage of heading from the first date of planting through the March 22 planting date. Gaines did not head from the April 19 seeding.

The spring wheat varieties headed at all dates of planting.

Kharkof headed on May 31 from the first planting date, November 6, and this interval from the date of seeding until the date of heading was 207 days. The last date of heading of Kharkof was on July 25, recorded from the April 12 planting date, and this interval was 105 days. The intervals between dates of heading for the various dates of seeding were approximately the same during

the early dates of planting. The date of heading of Druchamp was June 2, from the November 6 date of seeding, and the interval was 209 days. The last date of heading of Druchamp was August 7 from the April 12 planting date. This interval was 118 days. The results show that Druchamp headed slightly later than Kharkof.

Redmond was the latest winter wheat variety to head throughout the various dates of planting. The last date of heading of Redmond was on July 30 from the planting date of March 29. This interval was 123 days.

Gaines started heading on June 1 from the first date of seeding, and this interval was 208 days. The last date of heading of Gaines was July 26 from the April 12 planting date. This interval was 106 days.

Sel. 28 headed May 29 from the November 6 planting date. The interval was 205 days. The last date of heading of Sel. 28 was July 1 from the May 10 planting date. This interval was 53 days.

Zimmerman headed May 31 from the first date of planting. The interval was 207 days. The last date of heading of Zimmerman was July 8 from the May 10 planting date. The interval was 60 days.

Comparison of Heading for the Varieties Grown in 1961-62 and 1962-63

A comparison of the percentage of heading of Druchamp, Gaines, and Selection 28 for the two years of the study is given in

Figures 5 to 8. To assist in the possible interpretation of the effect of temperature upon the heading response of the varieties, the daily minimum temperatures for both years are included in each figure.

In both years the three winter wheat varieties had a high percentage of heading from all dates of planting until the critical date was reached. This critical date is considered to be the date of planting at which the heading begins to decrease rapidly. With the variety Druchamp, this critical date was at the March 15 planting in 1962 and March 22 in 1963. After both of these dates, heading decreased at the subsequent planting dates.

Gaines reached the critical date at March 15 in 1962 and March 22 in 1963. Both Druchamp and Gaines were similar in response.

There was, however, a wide difference in the critical dates for Redmond. In 1962 this period was at the March 1 date of planting and in 1963 almost a month later at March 22. This would be good evidence that Redmond was more sensitive to environmental change.

With Selection 28 the heading remained high at all dates of planting and no critical period was reached.

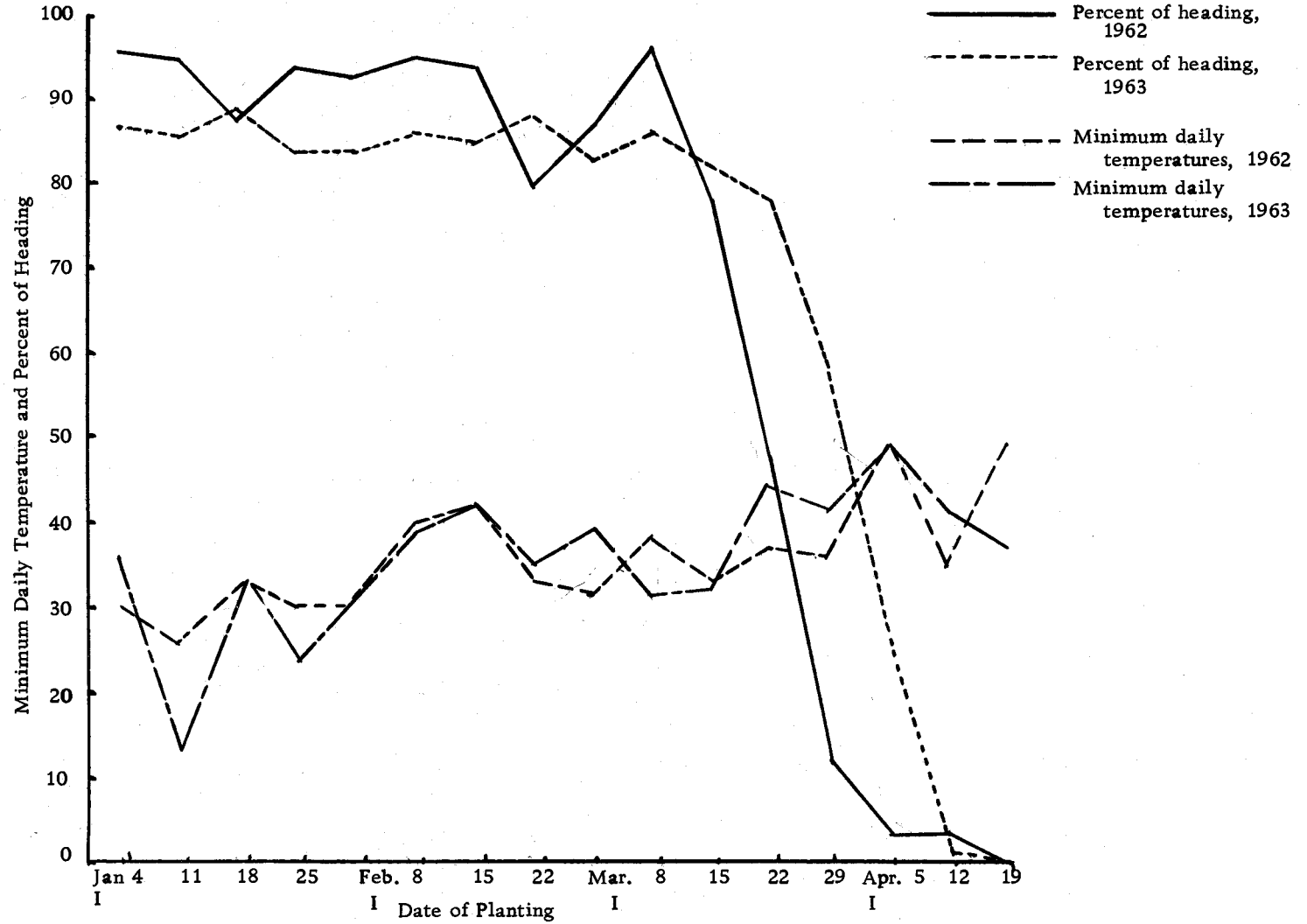

Figure 5. Percentage of heading of Druchamp planted at various intervals during the years 1961-62 and 1962-63.

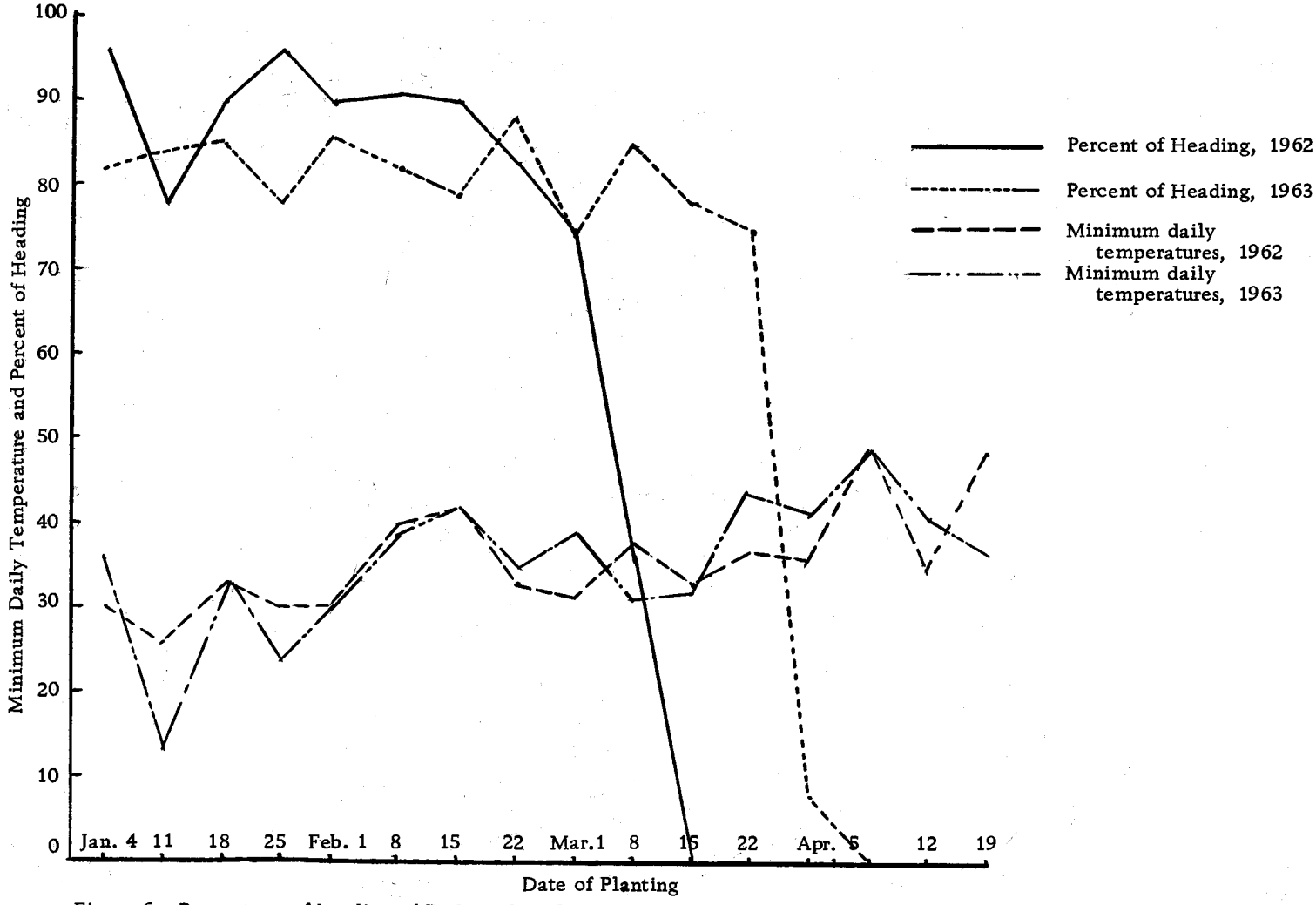

Figure 6. Percentage of heading of Redmond seeded at various intervals during the years 1961-62 and 1962-63.

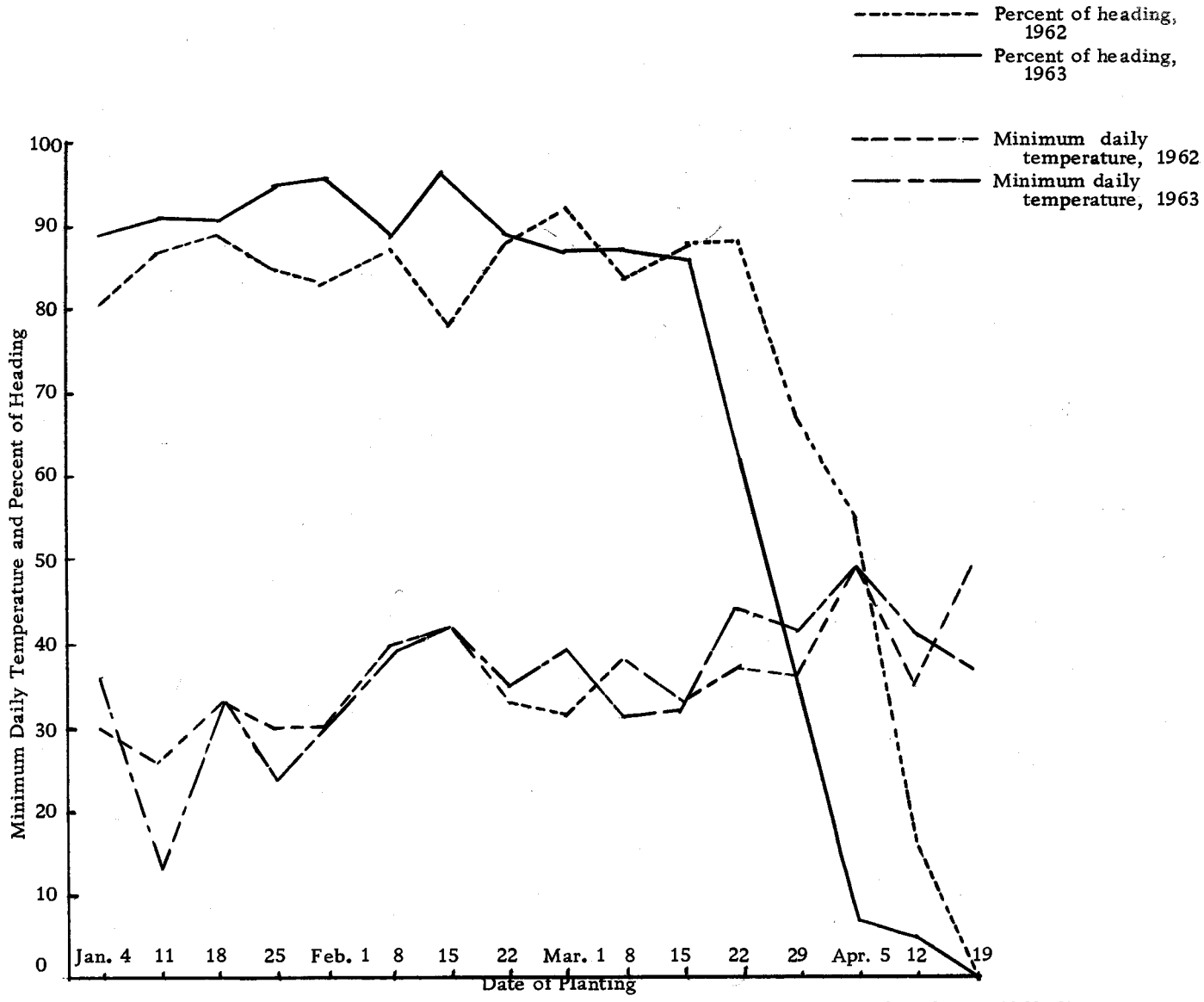

Figure 7. Percentage of heading of Gaines sown at various intervals during the season 1961-62 and 1962-63.

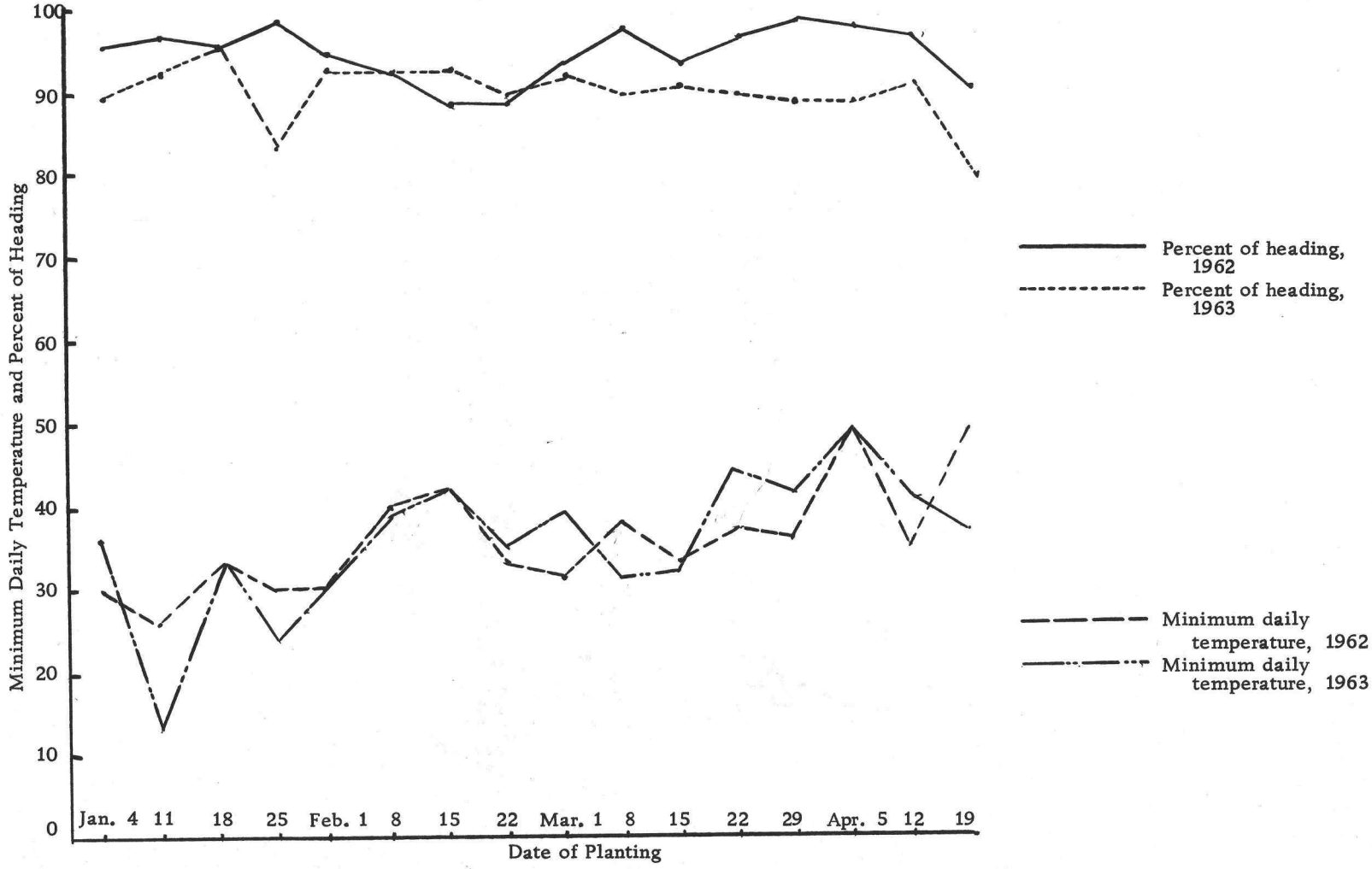

Figure 8. Percentage of heading of Sel. 28 sown at various intervals during the season 1961-62 and 1962-63.

DISCUSSION

The purpose of these studies was to determine the cold requirement and the critical heading period for several important winter wheat varieties grown in the Willamette Valley. In addition to determining the critical heading period, the yield results obtained for one year for the varieties seeded at various dates from late fall until late spring will be useful in developing time of planting recommendations and a more complete description of the growth habit of the varieties.

The yields in bushels per acre obtained from both the winter and spring varieties grown in the 1962-63 experiment were well above the average wheat yields in the Willamette Valley. The yields of the spring wheats from the late fall through the early spring planting dates ranged from 100 bushels to over 60 bushels per acre. The winter varieties ranged from 100 bushels to over 50 bushels for the same period. It has been the contention of some Willamette Valley wheat growers that the high yielding, stiff-strawed winter wheats would out-yield spring varieties from both fall and early spring seeding. The results from this one year study would not support this conclusion. However, it must be recognized that no winter-killing of the spring varieties was observed. If

winter killing of fall sown spring wheats occurred with any regularity, then it would be important to recognize this in planting recommendations.

Of the four winter wheats sown at the various dates of planting, Gaines gave the highest average yield for all dates, followed by Druchamp and then Redmond. Gaines also had the highest yield from the latest date of planting in the spring. It would appear from these results that Gaines will become an important winter wheat variety for the Willamette Valley as it produces high yields from both late fall and early spring seedings. The superiority of Gaines over the corresponding high yielding spring wheats from both fall and early spring seedings remains to be demonstrated in more reliable trials conducted at different locations and during additional years before definite recommendations should be made.

The critical heading period was determined for each of the winter wheat varieties for the two years of these experiments. The critical heading period used in this study is defined as the latest date of seeding in the spring that a winter wheat variety will produce a high percentage of heads. This is similar to the "critical seeding date" used by Bayles and Martin (2).

There was considerable more variation in the critical dates for the winter varieties grown in 1961-62 than in 1962-63. The

range of the four varieties in 1961-62 was nearly a month and only a week in 1962-63. When the two years are compared by using the varieties that were grown in both years, it is evident that the critical heading date was nearly a week earlier in 1961-62 (Table 7).

Table 7. Critical heading and yield periods for the winter wheat varieties grown in 1961-62 and 1962-63.

Variety	1961-62	1962-63	
	Heading	Heading	Yield
Kharkof	---	March 22	February 15
Druchamp	March 15	March 22	February 15
Redmond	March 1	March 22	February 15
Gaines	March 15	March 29	March 1
Burt	March 29	---	---

Redmond showed the greatest variety by year effect as the critical date was March 1 in 1961-62 and March 22 in 1962-63.

One of the possible explanations for this difference between years might be explained by the temperature difference following the critical planting dates between 1962 and 1963.

The mean minimum temperature recorded for the period from March 22 until March 31 and for the month of April in 1963 was 40.4° F and 38.9° F, respectively. This compares to a mean

minimum temperature for the same period for 1962 of 37.3° F and 40.6° F. It is difficult to explain the difference in heading between the two years on the basis of this rather small difference in minimum temperatures. However, it is recognized that mean temperatures do not accurately reflect the duration of a cold period that may be important or essential in the heading process of winter wheat.

The critical period for yield of the winter wheats is earlier than the date for heading (Table 7). This could be explained by the manner in which the yields and heading percentages were obtained. If the tiller of the winter wheat produced a head, it was recorded as headed even though the head may have been smaller and contained less kernels than those heads from plots seeded at different dates. From these results it would be important to measure the critical seeding date in terms of yield rather than heading.

The results from these trials demonstrated the apparent lack of agreement between the known winter hardiness of a winter wheat variety and the critical heading period. Kharkof was used in the 1962-63 trials because it is one of the most winter-hardy of the wheats. The critical heading period of Kharkof actually differed little from any of the less winter-hardy varieties. The exact winter-hardiness of Gaines is unknown but is believed to be more hardy than either Druchamp or Redmond, but yet its critical heading period was

later. While it may be considered that some of the same physiological processes operating in the wheat plant affect both the hardiness and the heading process, it would be difficult to separate the two.

One of the objectives of this study was to make an attempt to describe each of the winter wheat varieties in terms of its cold requirement or vernalization period. It was clearly demonstrated that both Selection 28 and Zimmerman were true spring wheats as they did not need a chilling period after planting to induce heading as both varieties had a high percentage of heading throughout all seeding dates.

It was found to be more difficult to describe the winter varieties. First, because even though the varieties are distinct types with many contrasting morphological characters they have very similar cold requirements for heading. These results were very surprising as it was thought that more differences between the varieties would exist for this character.

SUMMARY AND CONCLUSIONS

These studies were made to determine the cold requirement and critical heading period of several important winter wheat varieties grown in the Willamette Valley. Observations of the critical heading period are useful in developing time of planting recommendations and growth habit descriptions of the varieties. Four winter and two spring wheat varieties were seeded at weekly intervals from late in the fall through the winter months and until late in the spring during 1961-62 and 1962-63. The results of these experiments are summarized as follows:

1. In the 1962-63 trial, the yields of both the winter and spring wheats were high until the critical seeding date for the winter varieties was reached on March 22. The yields of the winter wheats decreased rapidly after this date until no grain was produced from the plantings after April 12. The yields of the spring varieties remained high from much later planting dates in the spring.

2. Gaines had the highest average yield from all dates of seeding and Gaines likewise gave the highest yield at the latest date of seeding of any of the winter varieties.

3. The critical heading period was determined for each winter variety in both years of the experiment. For the variety Druchamp, this was March 15 and March 22; for Redmond, March 1

and March 22; and for Gaines, March 15 and March 29. There was more variation between the varieties in 1961-62 than in 1962-63. The critical heading date was nearly a week earlier in 1961-62. Redmond showed the greatest variation between years.

4. The critical period for yield was earlier than the critical period for heading.

5. The results showed lack of agreement between the known winter hardiness of the winter varieties and the critical heading period. Kharkof, the most winter hardy of the varieties, headed at the same critical date as the moderately winter-hardy varieties.

Figure 9. The growth and extent of heading of the six wheat varieties from the November 6 planting date.

From left to right: Kharkof, Druchamp, Redmond, Gaines, Selection 28, and Zimmerman (photo taken July 31, 1963).

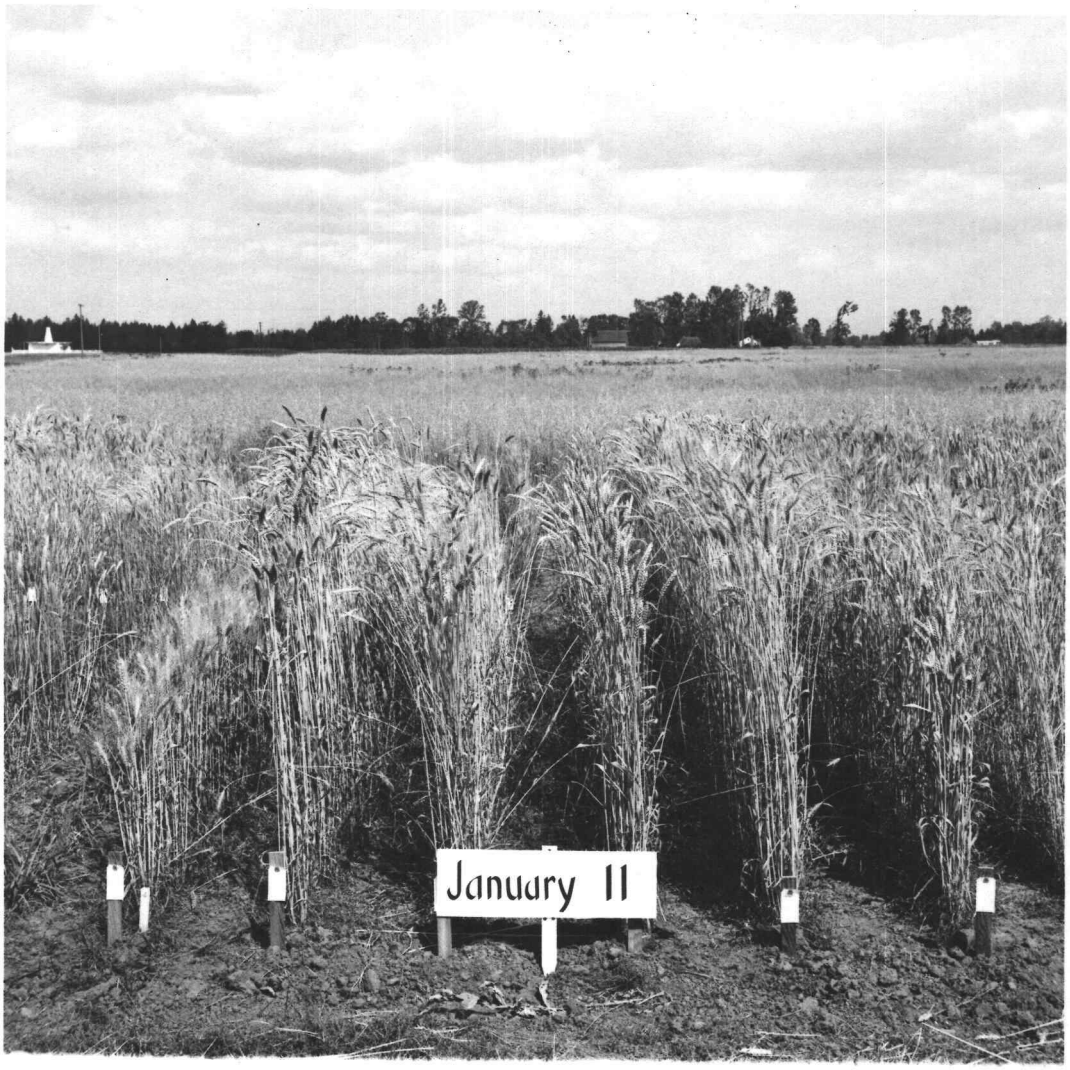

Figure 10. The growth and extent of heading of the six wheat varieties from the January 11 planting date.

From left to right: Gaines, Zimmerman, Kharkof, Redmond, Selection 28, and Druchamp (photo taken July 31, 1963).

Figure 11. The growth and extent of heading of the six wheat varieties from the March 29 planting date.

From left to right: Druchamp, Redmond, Selection 28, Gaines, Zimmerman, and Kharkof (photo taken July 31, 1963).

Figure 12. The growth and extent of heading of the six wheat varieties from the April 12 planting date.

From left to right: Selection 28, Kharkof, Gaines, Zimmerman, Druchamp, and Redmond (photo taken July 31, 1963).

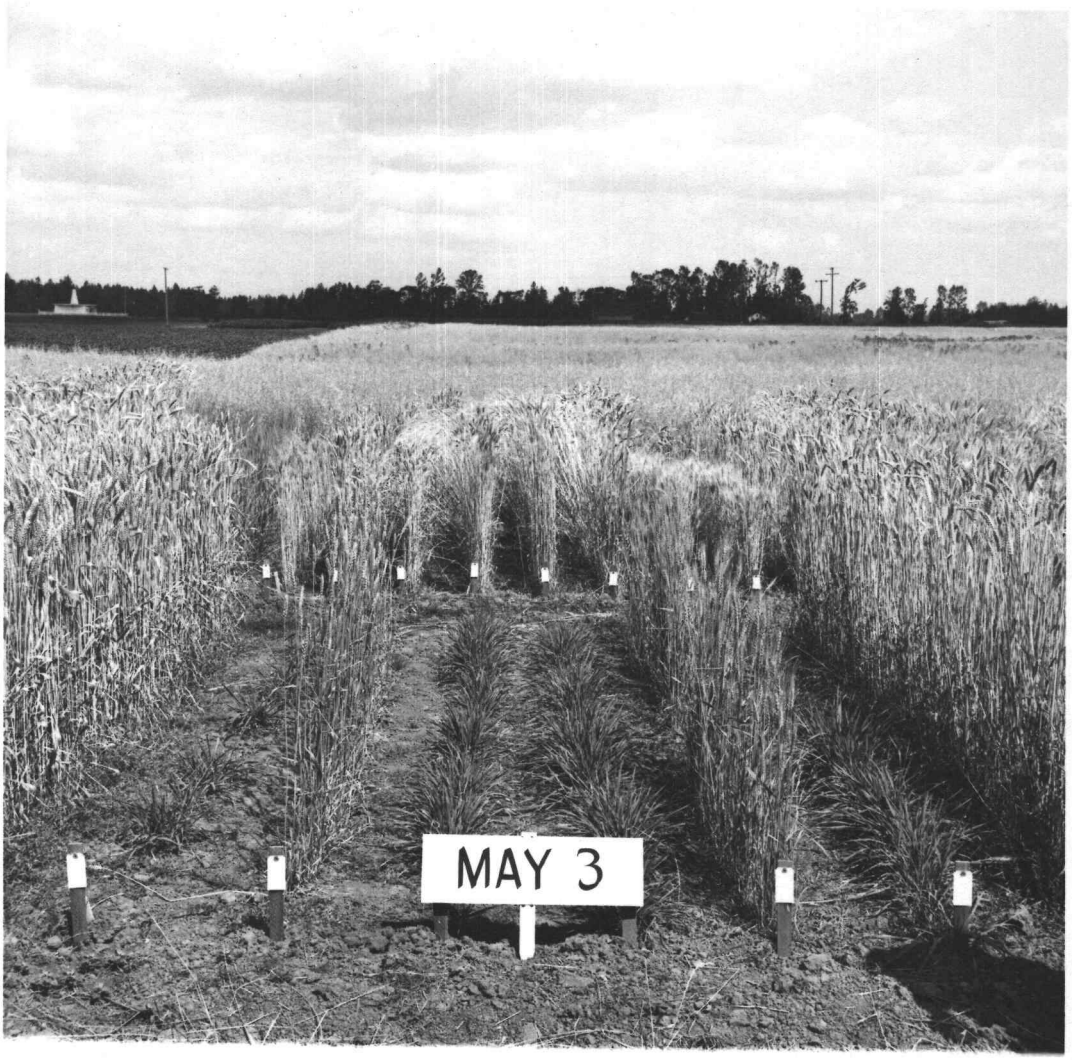

Figure 13. The growth and extent of heading of the six wheat varieties from the May 3 planting date.

From left to right: Redmond, Zimmerman, Gaines, Kharkof, Selection 28, Druchamp.

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Appendix Table 1. Number of tillers and the number of tillers with normal heads per unit area.

Planting Date	Winter Varieties								Spring Varieties			
	Druchamp		Redmond		Burt		Gaines		Sel. 28		Zimmerman	
	Tillers											
1962	No. headed	Total	No. headed	Total	No. headed	Total	No. headed	Total	No. headed	Total	No. headed	Total
January 4	104	108	135	140	137	146	181	204	227	238	156	166
January 11	99	104	99	126	127	133	133	146	175	183	135	140
January 18	69	78	104	115	113	118	125	137	215	225	107	114
January 25	119	127	104	108	115	123	182	191	229	234	133	136
February 1	112	120	101	111	133	139	185	192	197	209	113	117
February 8	108	114	95	104	143	154	113	126	195	212	144	152
February 15	108	115	122	135	90	113	140	145	121	138	119	125
February 22	97	121	96	115	45	60	139	156	152	173	91	104
March 1	99	113	76	102	57	75	130	150	163	175	122	130
March 8	102	106	28	78	72	91	131	150	193	198	123	127
March 15	89	114	1	150	71	85	121	141	165	178	109	113
March 22	23	48	0	34	47	62	52	83	102	106	43	51
March 29	20	159	0	180	65	90	30	86	148	151	89	103
April 5	7	158	0	70	31	76	8	107	139	143	102	114
April 12	5	113	0	95	25	65	4	75	125	130	78	80
April 19	0	108	0	93	0	37	0	61	104	115	64	78

Appendix Table 2. The daily maximum and minimum temperatures.

Day of Month	November 1962		December 1962	
	Max.	Min.	Max.	Min.
1	64	39	53	30
2	67	36	50	33
3	64	36	44	39
4	62	40	50	39
5	59	42	55	35
6	60	38	52	38
7	57	37	58	42
8	58	38	48	37
9	54	49	43	38
10	58	46	41	37
11	54	47	43	35
12	56	40	47	30
13	55	39	43	33
14	55	33	45	40
15	45	37	56	40
16	51	37	57	41
17	52	37	50	44
18	49	42	52	38
19	52	45	47	41
20	58	50	52	43
21	58	42	48	41
22	52	42	45	41
23	51	32	43	37
24	45	33	42	29
25	55	45	40	24
26	57	45	40	20
27	50	39	39	24
28	47	29	41	36
29	37	31	46	33
30	50	34	45	36
31			51	39
Average	54.4	39.3	47.3	35.9

Appendix Table 2 (continued) Daily Temperature

Day of Month	1962 January Max.	Min.	1963 Max.	Min.
1	45	32	55	36
2	38	34	49	44
3	55	36	52	44
4	51	30	54	36
5	43	31	42	31
6	46	37	37	34
7	57	44	48	25
8	60	43	35	29
9	51	38	38	30
10	50	32	45	28
11	43	26	35	13
12	40	27	25	13
13	40	28	30	13
14	41	29	35	18
15	42	30	44	32
16	48	29	46	30
17	45	33	42	32
18	42	33	44	33
19	35	24	45	25
20	35	16	38	22
21	26	14	41	20
22	30	12	43	26
23	32	11	47	25
24	34	18	48	22
25	37	30	42	24
26	52	37	48	28
27	51	40	42	20
28	55	32	43	25
29	47	30	34	22
30	43	28	28	23
31	44	29	31	25
Averages	34.8	29.5	41.5	26.7

Appendix Table 2 (continued) Daily Temperature

Day of Month	1962 February Max.	Min.	1963 Max.	Min.
1	49	30	49	30
2	53	30	51	37
3	59	33	59	47
4	50	32	59	45
5	49	35	60	40
6	45	39	51	41
7	51	40	61	38
8	53	40	54	39
9	54	41	61	41
10	47	42	63	47
11	53	36	64	30
12	45	36	61	32
13	47	38	56	34
14	49	41	55	36
15	55	42	55	42
16	59	45	54	39
17	51	42	55	37
18	49	36	50	41
19	51	33	55	49
20	50	34	57	46
21	53	27	54	40
22	50	33	55	35
23	47	35	56	33
24	46	24	56	36
25	36	21	53	39
26	37	17	59	45
27	37	18	55	35
28	40	26	52	37
Averages	48.8	33.8	56.1	39.0

Appendix Table 2 (continued) Daily Temperature

Day of Month	1962 March Max.	1962 March Min.	1963 March Max.	1963 March Min.
1	42	31	51	39
2	42	30	51	39
3	38	30	49	29
4	45	34	49	28
5	52	42	54	34
6	51	42	60	29
7	57	39	57	30
8	55	38	60	31
9	48	29	61	28
10	47	30	56	35
11	43	32	55	41
12	47	28	52	29
13	50	28	53	26
14	57	29	52	30
15	60	33	48	32
16	55	37	48	36
17	59	32	49	29
18	61	32	53	32
19	56	40	50	40
20	48	41	59	40
21	50	38	66	40
22	45	37	62	44
23	47	37	52	44
24	48	40	51	33
25	51	41	53	41
26	52	44	57	41
27	49	41	58	38
28	50	33	54	42
29	59	36	48	41
30	66	33	47	42
31	64	34	52	38
Averages	51.4	35.2	53.8	35.5

Appendix Table 2 (continued) Daily Temperature

Day of Month	1962 April Max.	1962 April Min.	1963 April Max.	1963 April Min.
1	67	40	49	32
2	52	43	52	30
3	56	32	55	37
4	62	41	56	47
5	60	49	62	49
6	64	50	59	45
7	62	47	58	44
8	59	47	52	40
9	58	45	55	39
10	56	30	53	35
11	56	35	58	33
12	66	35	63	41
13	75	42	50	41
14	72	45	66	49
15	72	44	60	34
16	61	38	44	34
17	69	38	48	36
18	70	38	48	41
19	78	49	46	37
20	58	35	45	34
21	53	47	42	35
22	66	38	52	33
23	72	38	56	38
24	73	44	58	39
25	59	35	48	43
26	59	38	58	45
27	57	47	56	34
28	52	38	55	34
29	53	37	70	47
30	58	33	65	41
Averages	62.5	40.6	54.6	38.9

Appendix Table 2 (continued) Daily Temperature

Day of Month	May 1963	
	Max.	Min.
1	55	40
2	51	44
3	53	35
4	58	40
5	55	43
6	53	45
7	50	44
8	58	44
9	62	42
10	58	37
11	60	45
12	59	42
13	61	36
14	68	39
15	73	46
16	66	44
17	71	44
18	82	44
19	84	46
20	88	58
21	92	49
22	73	54
23	66	44
24	69	46
25	67	43
26	68	39
27	68	39
28	73	45
29	82	42
30	77	47
31	68	52
Averages	66.7	43.8

Appendix Table 3. The yields for each wheat variety and date of planting for the three replications, experiment 1962-63.

Planting Date	Winter Varieties																Spring Varieties							
	Kharkof				Druchamp				Redmond				Gaines				Sel. 28				Zimmerman			
	R_1	R_2	R_3	Av.	R_1	R_2	R_3	Av.	R_1	R_2	R_3	Av.	R_1	R_2	R_3	Av.	R_1	R_2	R_3	Av.	R_1	R_2	R_3	Av.
November 6	60.2	56.0	60.0	58.7	87.8	98.0	100.0	98.6	136.4	97.2	102.6	112.1	94.0	84.8	79.2	86.0	90.2	70.6	89.2	83.3	86.6	97.0	76.0	86.5
December 4	70.0	95.8	34.0	66.6	50.0	46.4	20.6	39.0	52.6	58.6	7.2	39.5	108.8	114.4	68.4	97.2	41.8	48.2	1.4	30.5	40.8	29.0	21.8	30.5
January 4	74.8	114.8	64.4	84.6	90.2	67.4	65.8	74.4	83.8	88.8	73.6	82.1	74.2	88.4	75.4	79.3	60.8	81.6	89.2	77.2	78.8	88.0	70.0	78.9
January 11	76.0	73.0	50.6	66.5	77.4	74.0	65.4	72.2	78.8	96.2	71.2	82.1	119.8	96.6	86.4	100.9	91.4	81.2	128.2	100.2	74.2	69.0	-	71.6
January 18	69.6	88.4	77.2	78.4	75.6	94.4	73.8	81.3	117.4	76.0	72.8	88.7	72.0	-	83.0	77.5	92.2	99.2	110.0	100.4	65.4	73.2	61.8	66.8
January 25	72.2	71.6	66.8	70.2	81.4	82.6	79.8	81.3	86.2	83.4	92.0	87.2	96.2	103.4	88.0	95.9	91.4	105.4	86.8	94.5	96.4	86.8	80.8	88.0
February 1	78.6	50.6	34.0	54.4	96.0	83.4	71.8	83.7	75.4	59.2	76.6	70.4	92.4	82.8	78.0	84.4	114.0	79.0	80.2	91.1	73.2	68.2	75.6	72.3
February 8	48.2	59.2	58.4	55.2	70.0	69.2	76.4	71.8	59.6	92.0	80.8	77.4	112.0	82.8	74.0	89.6	57.4	92.4	110.0	86.6	68.4	76.0	74.0	72.8
February 15	72.2	42.0	80.2	64.8	81.2	76.0	76.0	77.7	77.4	77.6	52.2	69.0	92.4	75.0	66.4	77.9	100.0	94.6	99.4	98.0	76.0	71.6	67.6	71.7
February 22	66.8	45.4	33.2	48.4	67.8	66.0	41.8	58.5	50.0	63.6	-	56.8	118.8	55.2	54.8	76.2	79.8	72.2	50.8	67.6	75.4	51.6	53.6	60.2
March 1	73.2	57.0	37.4	55.8	-	29.2	52.0	40.6	48.4	57.6	46.4	50.8	67.2	66.0	79.0	70.9	66.6	75.8	66.6	69.6	67.0	61.6	41.0	56.5
March 8	41.6	30.0	49.2	40.2	46.6	24.4	28.0	33.0	36.2	17.6	10.4	21.4	66.8	34.0	64.0	54.9	79.0	54.6	81.0	68.5	25.0	36.6	57.0	39.5
March 15	49.8	39.0	51.2	46.7	45.6	43.8	32.4	40.6	32.0	56.8	37.0	41.9	57.2	61.4	-	59.3	68.0	56.4	-	62.2	60.0	57.4	40.0	52.5
March 22	46.0	33.8	21.8	33.8	41.4	45.4	29.8	38.8	37.2	42.0	21.4	33.5	39.4	50.5	36.8	42.2	52.8	68.0	42.0	54.2	51.6	43.4	24.4	39.8
March 29	23.0	23.2	12.8	19.6	27.8	26.0	19.2	24.3	22.4	19.8	2.8	15.0	48.2	35.6	30.2	38.0	54.6	31.4	30.0	38.6	30.2	25.8	22.0	26.0
April 5	22.8	11.2	0	11.3	0	22.8	22.2	15.0	9.4	5.4	0	4.9	35.8	36.0	24.4	32.1	56.0	39.8	43.6	46.4	28.0	19.2	25.4	24.2
April 12	0	0	14.0	4.6	0	0	0	0	0	0	0	0	0	0	0	0	25.4	23.6	27.8	25.6	22.4	10.6	19.0	17.3
April 19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21.4	11.2	16.2	16.3	14.0	10.2	3.0	9.1
April 26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25.4	13.8	11.0	16.9	2.8	15.8	3.6	7.8
May 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23.0	0	14.2	12.4	12.0	3.4	0	5.1
May 10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0