

SOWING AND PLANTING SEASON FOR WESTERN YELLOW PINE¹

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INTRODUCTION

In experiments with the western yellow pine (*Pinus ponderosa*) at the Savenac Nursery at Haugan, Mont., many helpful things have been learned, although it may now be seen that the first years of experimentation were not as effective as they might have been. The problem was attacked in much the same way as that of the western white pine (*Pinus monticola*), because at that time there was no means of knowing that the western yellow pine has no such decided preference for one season of sowing over another as is the case with the western white pine. For at least two seasons sowings were made in the fall and the next spring, with the purpose of watching developments of the following season and comparing the results of the fall and spring sowings. These comparisons were carefully made and they indicated advantages for both sowing seasons. Later, when several sowing dates in the fall were compared, it became evident that the time of sowing within the fall or spring season is a larger factor than season itself. It was realized that efforts should first be directed toward the determination of the optimum time to sow within each season, and that these dates could then be used for comparisons between seasons.²

EARLY COMPARISONS OF SPRING AND FALL SOWINGS

Plots of western yellow pine were sown on September 15, 1913, and on May 1, 1914, and observed during 1914. The germination from fall-sown seeds started in the middle of April and was 98 per cent complete before

May 18, while the spring-sown seeds had not sprouted a single individual by that date. The plants resulting from the fall sowing were also better developed in most respects than those from the spring sowing. They were slightly more top-heavy, however, the ratio of tops to roots by weight being 4 per cent larger. Weights of 100 and measurements of 200 plants were taken. From these figures it appears that promptness of germination and superior development of the plants are results of fall sowing. (See Table I.)

On October 23, 1915, two beds were sown with 8,000 seeds each, and on May 6, 1916, a similar pair of beds was sown in the same way. The spring-sown beds led in germination by nearly 50 per cent and in survival at the end of the season by 12 per cent. In top-root ratio by weight the fall-sown were more top-heavy by 8 per cent. However, the value of this comparison must be discounted because of the later finding that good results can not be expected from sowing so late in the fall.

The hold-over tendency of seed, so important with western white pine, deserves mention in connection with the western yellow pine. In most cases with fall sowing the hold-over germinations are entirely absent, although 0.2 per cent of hold over has been noted. With spring sowings the tendency is greater. Although it is usually less than 1 per cent, it may amount to more than 25 per cent under certain conditions. The 28 per cent hold over which resulted from a sowing on May 21, 1919, has been attributed to the extremely dry spring that year. (See Table III.)

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² The early field work for these experiments was conducted by E. C. Rogers, assisted by P. C. Kitchin. Their manuscript progress reports cover the earlier experiments cited.

TABLE I.—Average weights and measurements of 2-year-old seedling stock, western yellow pine

Date sown	Length of stem	Length of main root	Length of needles	Average number of rootlets, by grades, in each range of root lengths				Weight of top	Weight of root system	Total weight of plant
				Primary		Secondary				
				0.5-2.0 inches	Over 2 inches	0.5-2.0 inches	Over 2 inches			
Sept. 15.....	Ins. 4.0	Ins. 13.9	Ins. 2.8	No. 12.8	No. 6.7	No. 1.3	No. 0.05	Gm. 2.05	Gm. 0.42	Gm. 2.47
May 1.....	3.3	14.1	1.9	12.7	4.4	1.0	.06	1.09	.29	1.38

TABLE II.—Germination and development of 1-year-old western yellow pine seedlings

Date of sowing, 1914	Total first season germination	Total loss in seed sown from damping off and sun scorch	Development of seedlings	
			Average length of 200 stems	Average diameter of 200 stems
	Per cent	Per cent	Inches	Mm.
May 1.....	33.1	3.4	2.89	2.12
May 15.....	32.3	2.9	2.57	1.98
June 1.....	26.9	4.8	2.48	1.93

TABLE III.—Total germination from spring sowings

Date of sowing *	Percentage of seed sown germinating			
	1919	1920	1921	Total
1919				
May 5.....	10.0	12.7	-----	22.7
May 21.....	12.5	27.9	-----	40.4
1920				
Apr. 16.....	-----	62.2	1.9	64.3
May 5.....	-----	35.9	9.4	45.3

* 2,000 seeds sown on each date.

SPRING SOWING

In the spring of 1914 five plots of 2,000 seeds each were sown, one on May 1, two on May 15, and two on June 1. (See Table II.) Early sowing gave a greater total germination for the first season. This appears to be due to the longer germinating period and to the favorable conditions for germination which occur during May. Early sowing appeared to favor survival slightly, although on this point the figures are not entirely in agreement. At the end of the season larger stock resulted from early sowing. In the spring of 1915 also two sowings of 6,000 seeds each were made on May 6 and May 15. Although these were but

nine days apart, the total germination was again larger for the plots sown early and it was also more prompt.

Subsequent to these tests no more sowings were made and no opportunity was afforded to compare different spring sowings until 1919 and 1920, as shown in Table III. The better results in 1920 were again obtained from the earlier spring sowing, though the tendency appears to have been reversed in 1919. The unusual hold over from 1919 sowings has already been mentioned and ascribed to the dry season. The exceptional season may also be the cause of an exception to the general rule of larger totals from earlier sowings.

Both of these tests were observed in connection with a companion series sown on different dates the previous fall. In each case of spring sowing the germination was slow in starting, the bulk of it being in June and July and running through August, while the fall sowings all germinated promptly. The latter were most active in April and May and were complete by the end of June.

Seeds which do not germinate promptly in the spring, as fall and late spring sowings of western yellow pine, result in inferior plants. This has been observed both in sowing at the nursery and in direct seeding trials on planting sites. When germination takes place from the latter part of July to the end of the season, seedlings take on a characteristic abnormal appearance. At the end of the second season in the seed bed they have no fascicles of needles in twos and threes, or only one or two

bunches of them. The second season's growth bears pale green straplike leaves, and the bud lacks the strong mature appearance it has in earlier-sowed plants. These inferior plants remain far behind the earlier individuals in development, and tests have shown that when field planted as 2-0 stock³ they remain at a standstill during the first season. In all shipments of 2-0 stock it is necessary to sort out these plants. In 1915 the loss from this cause was fully 25 per cent of the stock in spring-sown beds. If sowing is done in the spring it should be as early as possible.

FALL SOWING

During 1916 to 1919 sowings were made in the fall on several dates which afford comparisons of the effect on germination of the time of fall sowing. (See Table IV and fig. 1.)

TABLE IV.—Percentage of germination of western yellow pine seeds sown on various dates in the fall

DATES OF SOWING •

1916

Germination	Aug. 21	Sept. 1	Sept. 12	Sept. 21	Oct. 4	Oct. 14	Oct. 28
Premature (fall).....	3.6	4.7	0.0	0.0	0.0	0.0	0.0
Effective (next season).....	32.3	30.4	39.2	43.1	50.0	48.5	41.0
Hold over (second season).....	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total.....	35.9	35.1	39.2	43.1	50.0	48.5	41.0

1917

Germination	Aug. 27	Sept. 7	Sept. 17	Sept. 27	Oct. 6	Oct. 20	Nov. 3
Premature (fall).....	7.0	1.0	0.1	0.0	0.0	0.0	0.0
Effective (next season).....	33.3	39.4	34.2	38.9	34.6	35.9	20.1
Hold over (second season).....	0.0	0.0	0.0	0.0	0.1	0.0	0.2
Total.....	40.3	40.4	34.3	38.9	34.7	35.9	20.3

1918

Germination	Aug. 27	Sept. 9	Sept. 21	Oct. 1	Oct. 14	Oct. 23	Nov. 4
Premature (fall).....	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Effective (next season).....	69.7	54.5	73.1	67.7	66.8	60.7	54.8
Hold over (second season).....	0.0	0.0	0.0	0.0	0.0	0.1	0.5
Total.....	69.7	54.5	73.1	67.7	66.8	60.8	55.3

1919

Germination	Aug. 28	Sept. 8	Sept. 16	Sept. 28	Oct. 8
Premature (fall).....	0.1	0.0	0.0	0.0	0.0
Effective (next season).....	54.3	46.8	40.5	46.0	37.8
Hold over (second season).....	0.0	0.0	0.0	0.0	0.0
Total.....	54.4	46.8	40.5	46.0	37.8

³ In nursery practice the age of plant stock is indicated by figures, the first indicating the number of growing seasons in seed beds; the second, the number in transplant beds. Occasionally a third figure is added to indicate another transplanting. Thus 2-0 indicates 2-year-old seedlings; 1-1-1 indicates 3-year-old stock, 1 year in seed beds and 2 years in transplant beds, but transplanted twice.

* 2,000 seeds were sown on each date.

These data for western yellow pine at Savenac Nursery indicate the following conclusions: There is practically no hold-over germination from fall sowings. When sowing is done too early in the fall, considerable "premature" germination, which is lost over winter, may result. It would be better not to sow until after the first week in September. When sowing is done too late, a marked drop in germinative capacity usually results. It would be better not to sow after October 15. Between the two extremes the results show no consistent fluctuations. The five-week period between September 7 and October 15 appears, from our present knowledge, to be a safe time to sow.

The effect, however, as has been shown, is to lower germinative capacity and not necessarily to affect the development of plants from the seeds which do germinate. The date of sowing in the spring seems early enough for the average season. The plants used, therefore, may be considered representative of the two classes of stock to be compared.

About April 20, 1918, this planting was duplicated. In each case the necessary precautions were taken to eliminate as far as possible all variables except the one being tested. All planting was done by the same man. The spring and fall planted rows alternated, and plants from spring and fall

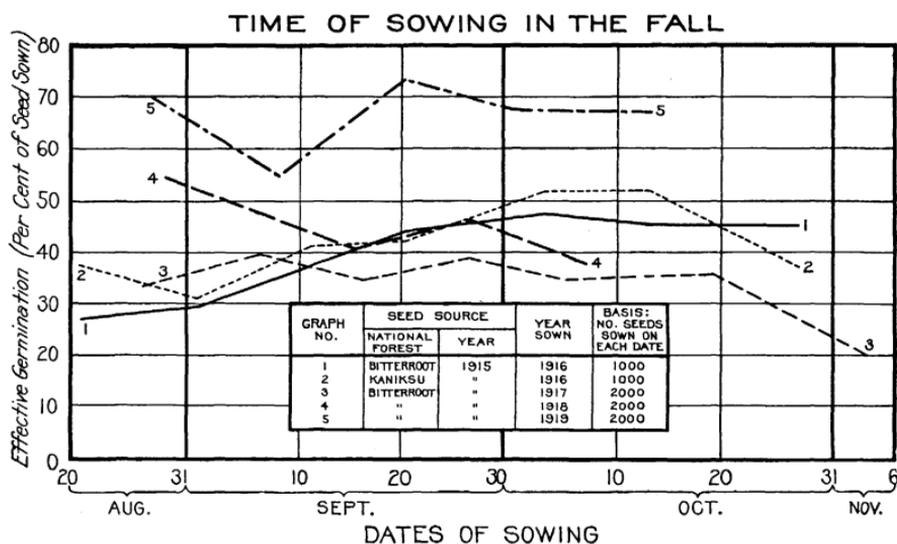


Fig. 1.—Germination of western yellow pine seed at Savenac Nursery as influenced by time of sowing in the fall

It has been observed that 1-2 yellow pine stock from fall sowings is larger, more unwieldy, and more expensive to plant than 1-2 stock from spring sowings. For the production of this class of stock, sowing should be done in the spring.

FIELD-PLANTING EXPERIMENTS WITH STOCK FROM SPRING AND FALL SOWINGS

About October 20, 1917, approximately 600 plants each of 2-0 fall-sown and 2-0 spring-sown stock were planted on a westerly aspect near Savenac Nursery. The fall sowing had been done on October 23 and the spring sowing on May 6 from the same lot of seed. At that time (1915-16) it was not realized that this date in the fall is for the average year about a week late, for best

sown seed alternated within the rows. The plantation was examined five times in 1918 and all plants were grouped in an intensive 12-term classification. The more significant points resulting from this mass of data are reported here.

Six hundred plants from each lot would seem to be an adequate number to yield reliable averages for the test. A smaller number would often be sufficient for quite uniform stock. In order to be sure that all irregularities in the stock were actually compensating within this number, the plantation was divided into four blocks. Each block was examined and recorded separately. The comparisons within each block corresponded closely for all blocks. Therefore in order to simplify this report the tabulations are confined to data from the plantation as a whole.

TABLE V.—Condition of 2-0 western yellow pine plantations during 1918 expressed in percentage of total number planted (600 each lot each season)

PLANTED OCTOBER 20, 1917

Condition of the plants	Date of examination									
	June 1		June 17		July 8		July 31		Sept. 20	
	Fall sown	Spring sown	Fall sown	Spring sown	Fall sown	Spring sown	Fall sown	Spring sown	Fall sown	Spring sown
Vigorous.....	37.7	62.5	38.2	62.5	16.0	34.5	12.5	25.5	14.1	24.6
Failing.....	23.3	8.0	17.1	7.2	2.9	1.3	1.5	.5	1.2	.5
Dead.....	9.1	4.0	22.4	12.1	48.9	30.5	68.2	52.4	74.8	58.9
Miscellaneous—unthrifty*	29.9	25.5	22.3	18.2	32.2	33.7	17.8	21.6	9.9	16.0
Total.....	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

PLANTED APRIL 20, 1917

Vigorous.....	91.6	90.8	89.6	90.1	50.9	51.7	37.4	37.3	36.3	32.6
Failing.....	2.7	1.8	1.5	2.2	.7	.5	.7	0	.3	0
Dead.....	.7	.7	2.5	2.3	16.0	18.9	46.4	48.2	51.6	53.0
Miscellaneous—unthrifty*	5.0	6.7	6.4	5.4	32.4	28.9	15.5	14.5	11.8	14.4
Total.....	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

*These percentages cover totals derived from nine additional plants classes which are not reported in detail here because none of them individually show any significant contrast between the behavior of spring and fall sown stock.

At the end of the first season in the field (September 20) following fall planting there were, based on fall sowing, (1) 174 per cent, or three-fourths more vigorous plants in the lot derived from spring sowing; (2) 42 per cent, or less than half as many failing plants among the spring sown; (3) 79 per cent, or four-fifths as many spring-sown plants dead as fall sown; and, on the other hand, (4) 162 per cent, or nearly two-thirds more plants unthrifty in different ways in the spring-sown lot. This last class, however, contains many plants with but slight symptoms of disorder, from which, as is indicated by the 1919 records, most of them recovered. Table V shows that these tendencies were discernible, for the most part, as early as June 1. Injury or death by accident or animal enemies was found to be small and nearly equal in the two lots, hence it does not affect the comparisons.

The second half of Table V shows the results of spring planting as they appear during the first growing season. Taken as a whole, there is very little difference between the lots from spring and fall sown seed. Both, but particularly the fall sown, have done better than when fall planted.

Figure 2 shows graphically the survival in these plantations during 1918. The steeper the curve, the more favor-

able the water relations, which were evidently at their worst during July. The flattening of the curves at the beginning and end of the season shows the presence of more moisture.

During 1918, also, the current height growth of the season was measured on all thrifty plants. It was as follows:

Fall planted, fall sown, 74 plants average.....	Inch	0.66
Fall planted, spring sown, 125 plants average.....		.83
Spring planted, fall sown, 170 plants average.....		.76
Spring planted, spring sown, 170 plants average.....		.80

The spring-sown plants lead the fall sown in both cases, and this lead was greater in the case of fall planting. There was more irregularity in the spring-sown lot, due, undoubtedly, to the variation in germination dates following spring sowing.

In 1919 a simpler plant classification was used for these plantations. (See Table VI.) Again basing percentages upon the results of fall sowing, it may be seen that: (1) 143 per cent, or two-fifths more of the spring-sown than of the fall-sown plants survived when fall planted; (2) 98 per cent, or about equal survival was attained from the two lots when spring planted; (3) 134

per cent,⁴ or one-third greater growth for the season was attained by the spring lot when fall planted; and (4) 82 per cent, or four-fifths as great growth was made by the spring-sown lot when spring planted.

Judging from the experiences of 1918-19, then, 2-0 western yellow

The question naturally arises: Why are fall-sown seedlings of this species less able to withstand the rigors of the planting site when fall planted, and yet fully the equal of spring-sown seedlings when spring planted? This leads to a consideration of the differences between plants from spring

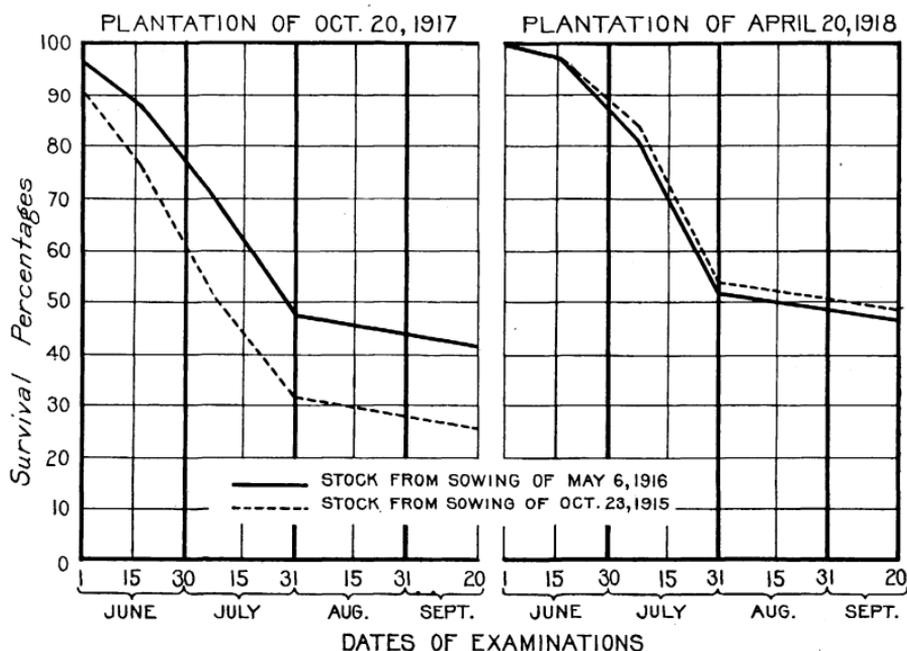


FIG. 2.—First-year survival on the planting site. Fall and spring plantings of western yellow pine 2-0 stock derived from fall and spring sowings (each curve is based on 600 plants)

TABLE VI.—Records of the second growing season of 2-0 western yellow pine

Season planted	Season sown	Survival percentages ^a				Growth data	
		Thrifty	Un-thrifty	Total living	Total	Average stem-height growth in 1919	Number of measurements ^b
Fall	Spring	13.1	3.2	16.3	83.7	0.82	32
Fall	Fall	7.7	3.7	11.4	88.6	.61	32
Spring	Spring	18.1	4.2	22.3	77.7	.50	94
Spring	Fall	18.2	4.5	22.7	77.3	.61	94

^a Figures based on examination of 600 plants in each lot.

^b The largest common number of thrifty individuals used in determining averages.

pine seedlings from spring sowing survive and grow better than those from fall sowing when planted in the fall. When planted in the spring, there is practically no difference in survival as a result of season of sowing, but during the second field season the fall-sown plants lead in growth.

and fall sowings. Time of sowing seems to be only an indirect factor, one which is influential only in its effect on time of germination, which in turn affects plant development and hence ability to survive and grow in the field. The inferior plants resulting from late germination were described

⁴ The basis for this figure is too small to insure accurate averages

under "Spring sowing." The effect of time of sowing upon time of germination has been given, and plant development, as shown in Table I, also has a bearing on the answer to this question. The ratio of tops to roots by weight was 4 per cent larger for fall-sown plants in this case; in other cases it has been found to be 8 per cent larger. The fact that fall-sown plants become more "top-heavy" is believed to be the key to the explanation sought.

When plantings are made in late October, the soil surrounding the roots remains at a temperature⁵ low enough to retard water intake by any absorbing surfaces left intact by the planting act. In the meantime transpiration from the tops proceeds, the draft being made chiefly upon the moisture contained in the seedlings when planted. Gradually the saturation deficit is increased until death or a weakened condition, which handicaps the plant the following spring, results. The greater the transpiring surface in proportion to the absorbing surface present and able to function, the faster the drying process proceeds with its injurious or fatal results. Following spring plant-

ing, conditions are quite different. New absorbing surfaces are believed to develop after planting, thus preventing any long break in water absorption.

CONCLUSION

The results of these studies show that when western yellow pine is to be field planted in the northern Rocky Mountain region it is much better to use stock resulting from spring sowings for fall planting, but when spring planting is done it makes very little difference whether spring-sown or fall-sown stock be used.

When spring sowing is practiced, it should be as early in the spring as possible.

Fall sowing, if used, should be between September 7 and October 15.

Both seasons of sowing have definite advantages, but, all considered, spring seems to be the safest season as a general policy. Furthermore, spring sowing dovetails well with the general nursery work when there is a large amount of western white pine seed to be sown in the fall.

⁵ From Oct. 21 to 27, 1918, at a depth of 5 inches on the site used, the daily maximum soil temperature averaged 42.0° and the daily minimum 38° F.

