INFLUENCE OF SEED WEIGHT ON EARLY DEVELOPMENT OF EASTERN WHITE PINE

M. E. Demeritt, Jr. and H. W. Hocker, Jr.[1]

In the Northeast, eastern white pine (Pinus strobus L.) cannot be relied upon to consistently regenerate naturally due to the destruction of the cone crops by the white pine cone beetle (Conopthorus coniperda Schwarz). The white pine cone beetle has been reported to have destroyed the white pine cone crops for nine consecutive years in one area of southern Maine (Graber 1964). Artificial seeding or planting is necessary to obtain adequate regeneration.

The objective of the study was to determine what influence seed weight has on one- and two-year-old seedlings grown under two environments. The two environments were: (1) in the field as a result of direct-seeding and (2) in pots in a greenhouse.

Pauley et al. (1955) reported on the influences of seed weight on nursery grown and pot culture seedlings and Spurr (1944) on some seed lots with seed individually weighed and grown under controlled conditions in artificial soil and in a hydroponicum.

METHODS

Cones were collected from five eastern white pine stands in New Hampshire in the fall of 1966. Seed was extracted from the cones and average seed weight per source determined. Three sources were selected for the study because of differences in their average seed weights and the number of seedlings produced (Table 1).

1. Direct seeding.--The direct-seeding experiment was initiated in October, 1966, (autumn) and April, 1967, (spring) using fifty seeds from each of the three sources each season. The two planting seasons afforded the opportunity to determine if there was any difference in season of seeding on early development.

[1] The authors are, respectively, Research Plant Geneticist, U. S. Forest Service, Northeastern Forest Experiment Station, Durham, New Hampshire, and Professor of Forest Resources, Institute of Natural and Environmental Resources, University of New Hampshire, Durham, New Hampshire. Published with the approval of the Director of the New Hampshire Agricultural Experiment Station as Scientific Contribution No. 749.

Unstratified and stratified seeds were used for the autumn and spring phases of the experiment, respectively. Stratification consisted of soaking the seed for 24 hours in room temperature tap water, draining the excess water off, placing the damp seed in plastic bags in a dark control chamber at 40° F for 60 days prior to spring seedling.

Direct-seeding consisted of planting ten seeds from the appropriate seed source in a spot determined by the epxerimental design. The experimental design consisted of five planting locations (blocks), where each seed source was randomly assigned a planting spot each season (autumn and spring). The litter was removed around each spot to expose mineral soil. No chemical treatment or physical protection was used to protect the seed from loss due to rodents, birds, or damping off.

In September, 1968, after two growing seasons the seedlings were counted, lifted, and measured. Seedlings at each spot or experimental unit were lifted and the soil and seedlings placed in plastic bags for transport to the laboratory for analysis. In the laboratory the soil was washed from the seedlings' roots. Root and shoot measurements were recorded for each seedling to the nearest millimeter. Each seedling was cut at its root collar and green weight for each segment determined and recorded to the nearest of a gram. The segments were placed in an oven at 60°C for 48 hours and reweighed to determine dry weight.

An analysis of variance was not made on the data because of the number of spots without seedlings. Seed and seedling weights were determined on seed source and seed spot basis, respectively.

II. Greenhouse.--The seed to be used for the greenhouse experiment from each of the three sources was separated into high and low average weight groups. This was done by means of an air seed separator.[2] Next, the seed was stratified and planted in late May, 1967, in vermiculite filled plastic flats. Comparison of weight groups from each source would test the influence of intra-source seed weight on seedling development. Stratification of seed was identical to the method used for the spring direct--seeding phase of the direct-seedling experiment.

The experimental design was a randomized complete block with six weight-group comparisons, three weeks of germination comparisons randomly assigned to each of four blocks with two blocks distributed on each of two greenhouse benches.

[2] Model D-Air Seed Separator (Patent No. 2,579,228) manufactured by E. L. Erickson Products, Brookling, N. D,
Mention of products or equipment is for information, only, and should not be considered an endorsement by the Department of Agriculture or the Forest Service,

Seedlings that germinated each week were lifted and transplanted in Jiffy-mix[3] filled ten-inch plastic azalea pots. Each plastic pot was divided into five wedge shaped plots with six seedling locations per plot positioned so that each seedling would have equal growing space and hopefully similar environmental conditions. In each block, twelve seedlings from each weight-group were randomly assigned and planted in two six-tree plots each week. Surplus seedlings were planted in seedling locations that were empty due to insufficient seedlings in some weight-groups. Seedlings were fertilized every two weeks and watered when necessary.

In September, 1967, all the seedlings were measured for root and shoot segment length and half the seedlings from each plot were harvested for later green and dry weight determinations. The remaining seedlings were transplanted individually in No. 6 standard plastic pots filled with Jiffy-mix. Prior to measurement the planting medium was washed from each seedling's root system and its root and shoot measured and recorded to the nearest millimeter. The seedlings from each plot that were harvested were sealed individually in plastic bags and quick frozen for subsequent green and dry weight determinations.

Green and dry weight determinations were made in October and November, 1967. Seedlings were thawed, cut at their root collar, and each segment weighted separately before and after drying in an oven at 60° C for 48 hours to furnish green and dry weights, respectively. Each segment was weighed to the nearest ten-thousandth of a gram.

In February, 1968, the replanted seedlings were placed in a cold room at 40°F for six weeks to give the buds a dormant period prior to growth initiation. After the dormant period, the seedlings were returned to the greenhouse, fertilized every two weeks, and watered when necessary.

The two-year seedlings were measured and harvested in September, 1968, using the same procedures as in 1967. Green and dry weight determinations were made in October and November, 1968, using the same procedure as in 1967.

The one and two-year green and dry weight and length data were analyzed using the method of unweighted means. It was felt that with the uniform growing medium and space that data within the same block, week, and weight-group could be pooled with little error.

RESULTS AND DISCUSSION

Autumn direct-seeding of unstratified eastern white pine was superior to spring seeding of unstratified seed. After two growing seasons, 57 percent of the 15 autumn spots and 47 percent of the 15 spring spots had at least one seedling, Of the spots that had at least one seedling, autumn spots averaged 5.9 seedlings compared to 3.7 seedlings for spring spots. Autumn seedlings from the same seed source were larger and heavier than spring seedlings, but not nearly as large and as heavy as greenhouse seedlings (Table 1), For example, greenhouse seedlings at the end of two growing seasons had an average shoot dry weight 20 times that of trees from autumn sown direct seeded seed and 30 times that of trees from spring sown direct seeded seed.

[3] Jiffy-mix is an artificial soil made according to the specifications of "Cornell University Mix-A."

Table 1.--Average length, green weight, and dry weight of two-year eastern white pine.

Source Number / Average Seed Weight	Experiment	Number of Observations	Root Length	Shoot Length	Root Green Weight	Shoot Green Weight	Root Dry Weight	Shoot Dry Weight
(gms)			(mm)	(mm)	(gms)	(gms)	(gms)	(gms)
1	Greenhouse	118	486	187	22.35	16.32	3.71	4.94
	Autumn Seedling	20	135	99	0.36	1.01	0.16	0.42
0.0230	Spring Seedling	12	93	87	0.20	0.49	0.07	0.20
2	Greenhouse	90	498	203	26.45	19.60	4.47	5.81
	Autumn Seedling	36	105	104	0.23	0.58	0.09	0.24
0.0208	Spring Seedling	19	97	82	0.19	0.53	0.10	0.23
3	Greenhouse	134	503	195	23.51	18.29	3.89	5.57
	Autumn Seedling	44	89	93	0.15	0.44	0.06	0.19
0.0157	Spring Seedling	21	78	73	0.12	0.27	0.06	0.12
All Sources	Greenhouse	342	496	194	23.88	17.95	3.98	5.42
	Autumn Seedling	100	104	98	0.22	0.60	0.09	0.26
	Spring Seedling	52	88	79	0.17	0.42	0.08	0.18

Fall seeding of unstratified seed is favored over spring seeding of stratified seed and confirms the findings of previous studies (Abbott and Hilton, 1965, Baldwin 1965). The greater seedling density from fall seeding should not be a problem. Evaluations of seeded and planted young stands reveals no evidence that seedling density due to direct seeding affects growth or yield (Derr and Mann 1971).

Seed weight positively influences the size and weight of two-year-old direct-seeded seedlings, with few exceptions (Table 1). Two-year data indicated that seed sources with larger seeds can be selected for direct-seeding to furnish larger seedlings. It is unknown from this study how long this relationship will hold.

Greenhouse seedling physical measurements were not correlated with seed weight among sources after one and two years. Seed sources were not significantly different except for shoot length after one year. Mean physical measurements of seed sources were significantly different, but not correlated with seed weight, for all measurements except root length after two years (Table 2 and 3). After two years the source with the lightest average seed weight produced seedlings that were larger and heavier than seedlings produced from the source with the heaviest average seed weight (Table 1). For example, seed source three had an average seed weight of 0.0157 grams and produced seedlings that averaged 194 mm in shoot length and 5.42 grams in shoot dry weight compared to seed source one which had an average seed weight of 0.0230 grams but produced seedlings which averaged 187 mm in shoot length and 4.94 grams in shoot dry weight. Seed source two had an average seed weight of 0.0208 grams but produced the largest and heaviest seedlings averaging 203 mm in shoot length and 5.81 grams in shoot dry weight (Table 1).

Within sources greenhouse seedling physical measurements were correlated with seed weight after one and two years. Weight groups were significantly different for all physical measurements after one and two years, except root and shoot lengths after two years (Table 2). Larger and heavier seedlings within a source were produced from its heavier weight group seed (Table 3).

Seedlings that germinated earlier, even if only by one week, furnished larger seedlings after one year, but the importance decreased after two years (Table 2, line 2). Significant differences were found among weeks of germination for all measurements except shoot length after one year and only for root green weight and shoot dry weight after two years. The effect of week of germination appears to be transient and of very little importance after one year under near optimum growing conditions.

The lack of correlation between seed weight and physical seedling measurements among sources grown under near optimum conditions can be supported by previous studies. Spurr (1944), working with seed from individual trees, found individual seed weights were correlated with the shoot weights of resulting plants, but the mean seed weights of the different lots were poorly correlated with their respective shoot weights. Pauley et al, (1955) showed that various seed sources differed significantly in growth both on an unadjusted and on an adjusted (for seed weight differences) basis. They further concluded that there can be no question that growth differences exist for eastern white pine between collections from single trees in a given locality and from trees in different localities.

Table 2.--Significant differences of one and two-year lengths and weights of eastern white pine seedling segments: Greenhouse Study.

Source of Variation	d.f.	One Year						Two Year					
		Length		Green Wt.		Dry Weight		Length		Green Wt.		Dry Weight	
		Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot
1-Block	3	ns	ns	ns	ns	ns	ns	ns	ns	*	*	*	*
2-Week	2	*	ns	*	*	*	*	ns	ns	*	ns	ns	*
3-Source	2	ns	*	ns	ns	ns	ns	ns	*	*	*	*	*
4-Weight Group	1	*	*	*	*	*	*	ns	ns	*	*	*	*
1 x 2	6	ns	ns	ns	ns	ns	ns	*	*	*	*	*	*
1 x 3	6	ns	ns	ns	ns	ns	ns	ns	ns	ns	*	ns	ns
1 x 4	3	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
2 x 3	4	ns	*	ns	ns	ns	*	ns	ns	ns	ns	ns	ns
2 x 4	2	ns	ns	ns	ns	ns	ns	ns	ns	*	ns	ns	ns
3 x 4	2	ns	ns	ns	*	ns	*	ns	ns	ns	ns	ns	ns
1 x 2 x 3	12	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
1 x 2 x 4	6	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
1 x 3 x 4	6	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
2 x 3 x 4	4	*	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
1 x 2 x 3 x 4	12	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Error	285,270[a]												

[a] d.f. for years one and two, respectively

* Significant at 5%

ns Nonsignificant

Table 3.--Average length, green weight and dry weight of one and two-year eastern white pine growth from seedlots separated into high and low weight classes.

Source Number	Weight Group	Average Seed Weight	Number of Observations	Root Length	Shoot Length	Root Green Weight	Shoot Green Weight	Root Dry Weight	Shoot Dry Weight
		(gms)		(mm)	(mm)	(gms)	(gms)	(gms)	(gms)
				One Year Data					
1	High	0.0242	67	329	96	1.09	1.07	0.22	0.29
	Low	0.0217	59	312	92	1.04	1.09	0.21	0.29
2	High	0.0223	48	334	96	1.36	1.27	0.26	0.33
	Low	0.0182	44	309	88	0.96	0.95	0.20	0.25
3	High	0.0177	71	328	101	1.13	1.15	0.22	0.30
	Low	0.0136	68	293	101	0.88	0.97	0.17	0.26
				Two Year Data					
1	High	0.0242	65	486	193	23.53	17.07	3.92	5.19
	Low	0.0217	53	486	180	20.89	15.40	3.44	4.65
2	High	0.0223	45	522	204	29.03	21.72	4.99	5.35
	Low	0.0182	45	475	201	23.87	17.47	3.95	6.26
3	High	0.0177	69	512	194	25.69	19.52	4.28	5.98
	Low	0.0136	65	494	196	21.19	16.98	3.47	5.14

After eight years, the largest tree was the product of the smallest seed, and there was some indication that with a large sample and wider spacing, the smaller seeds might be shown to produce larger trees (Pauley et al. 1955),

Early results of seed source trials should be interpreted with caution. This study revealed that seed sources behave quite differently when direct-seeded or grown under near optimum conditions. Pauley et al. (1955) state that growth rates characteristic of a given seed source apparently occur under a wide range of soil fertility levels. Spurr (1944) in a study where competition and soil nutrition were relatively uniform, found correlation between seed and plant size less important as the tree grows older. He attributed this decrease in correlation to hereditary, physiological, and other internal factors.

This study indicates that the influence of seed weight on seedling development can be minimized by growing seedlings in a greenhouse under near optimum conditions for one year before outplanting. This will be a great help to forest geneticists because they not only will have larger seedlings. but will be able to evaluate their plantings at earlier ages. We will no longer have to wait eight to ten years to evaluate plantings with the hope that the effect of initial seed weight among sources or lots has become minimal.

LITERATURE CITED

Abbott, H. G., and R. L. Hilton. 1965. Seeding white pine under poor quality hardwoods. In Direct Seeding in the Northeast, a Symposium. Univ. of Mass. pp. 34-37.

Baldwin, H. I. 1965. Summary of direct seeding in New Hampshire 1924-62. In Direct Seeding in the Northeast, a Symposium. Univ. of Mass. PP. 59-64.

Derr, H. J., and W. F. Mann, Jr. 1971. Direct-seeding pines in the south. USDA Agric. Handbook No. 391. 68 pages.

Graber, R. E. 1964. Impact of the white pine cone beetle on a pine seed crop. J. For. 62:499-500.

Pauley, S. S., S. H. Spurr, and F. W. Whitmore. 1955. Seed source trials of eastern white pine. Forest Science 1:244-256.

Spurr, S. H. 1944. Effect of seed weight and origin on the early development of eastern white pine. J. Arnold Arboretum 24:467-480.