WHITE GRUB CONTROL STUDIES 1965-66

by

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INTRODUCTION

The study of the white grub problem was initiated in 1960 following reports of significant seedling mortality by white grubs in new coniferous plantations in southeastern Manitoba. This work was continued in 1965 and 1966. Studies of the use of insecticides in machine planting began in 1963, and insecticide in combination with fertilizer in 1964 (Nairn and Ives, 1965). In 1966, the application of insecticides in hand planting was tested. This work is being carried out in co-operation with the following agencies; the Forest Management Branch of the Manitoba Department of Mines and Natural Resources has supplied machinery and labor for planting and soil sampling, and Chipman Chemicals Limited, Winnipeg, has supplied insecticides and technical advice through their representative Mr. G.R. Fraser.

METHODS

Experimental Planting Areas:

The location of experimental planting areas used in 1963 and 1964 have been described by Warren and Ives (1964) and Nairn and Ives (1965). The 1965 and 1966 experimental areas and planting dates are as follows:

Plot No.	Planting Method	Area	Location	Planting Date
IV	Machine	Wampum, Sandilands For. Res.	L.S. 2-17-1-13E and L.S. 15-8-1-13E	May 3-5, 1965
VII	Machine	Vasser Sandilands For. Res.	L.S. 1-19-2-13E	May 7-8, 1965
VIII	Machine	Piney Sandilands For. Res.	L.S. 9, 10, 15-4-2-13E	May 12-14, 1965
IX	Hand	Badger	L.S. 12-29-3-12E	May 10-12, 1966
X	Hand	Badger	L.S. 11, 14-29-3-12E	May 13-17, 1966
XI	Hand	Badger	L.S. 16-29-3-12E	May 18-21, 1966

Plot IV has been described by Nairn and Ives (1965). Plots VII and VIII are located on former farmlands which had been used for pasture from 1960 to 1964 and under cultivation prior to 1960. The soil in both areas is sandy loam on glacial outwash with increasing amounts of clay in low lying areas. Plots IX, X, and XI are within a ½ mile radius in an area that had been severely burned in 1953. The soil is in the Woodridge series, well drained, orthic grey wooded on a mixture of sand and gravel deposits. The sites were prepared for hand planting in 1965 with furrows ploughed at 6 foot spacing.

Planting methods and chemical treatment - 1965.

The 1965 plantings were done with a Lowther tree planter modified to spot treat the soil around each seedling with a measured amount of liquid insecticide and/or granular fertilizer (Ives and Warren, 1964). Plots IV and VII were planted with 2-2 red pine seedlings, Plot VIII was planted with 2-2 red pine, jack pine and white spruce. The methods of planting and chemical treatment were similar to those carried out in 1964 (Nairn and Ives, 1965) except that insecticide application was modified to permit application through a spray nozzle or the open tube which was used in previous years. This was accomplished by the addition of a 3-way valve and a no. 147 adjustable spray nozzle (similar to nozzles on knap-sack fire pumps). The nozzle was suspended from a 30" hydraulic hose line to permit flexibility over rough terrain.

As in 1964, seedlings were planted at 6 x 6 foot spacing, with an untreated buffer row between each treated row. Four blocks containing 21 rows, 660 feet long, were planted to red pine in each of Plots IV and VII. Six blocks were planted in Plot VIII, where in addition to four blocks of red pine, one block each of jack pine and white spruce were planted. The layout of the blocks for the three plots is shown in Figure 1.

In Plots IV, VII and VIII five treatments were applied to the red pine seedlings in each block as follows:

(i) Aldrin - emulsifiable form, 10 ml. of 2% aldrin per seedling (0.44 lbs. active ingredient per 1000 seedlings).

(ii) Aldrin - emulsifiable form, 10 ml. of 4% aldrin per seedling (0.88 lbs. active ingredient per 1000 seedlings).

(iii) MAGAMP^{R} (Magnesium, ammonium, phospate, 8-40-0), a controlled release fertilizer at the rate of 33 grams per seedling.

(iv) MAGAMP and 2% aldrin.

(v) Control.

The treatments were applied in a modified random block design of 10 treatment rows with alternate buffer rows and were replicated four times with the following exceptions. Aldrin was applied by the spray nozzle to one row in each block and by the open orifice to the other row. Due to a short supply, no fertilizer was applied to red pine seedlings in block 4-Plot VII and block 4-Plot VIII. In the jack pine and white spruce blocks in Plot VIII, aldrin was applied by spray nozzle only, and in the white spruce block only one row per treatment was planted. The arrangements of randomized treatments and the number of seedlings per treatment for the 1965 machine plantings is shown in Table I.

Planting methods and chemical treatments - 1966.

All 1966 experimental plots were hand planted in areas that had been prepared for hand planting in 1965 with furrows ploughed at 6-foot spacing. Plot IX is an irregular shaped area of approximately 4 acres. It is bordered on three sides by small stands of poplar and a narrow strip of poplar is located within the plot. The 64 planting furrows vary in length from 300 to 600 feet. Plot X, approximately 2½ acres, is 120 furrows long (720' approximately) and 150 feet in width. This plot is separated into three equal blocks of 40 rows each. Plot XI, approximately one acre, is 40 furrows long and 165 feet in width. This plot is separated into two equal blocks of 20 rows each. Plots IX and X were planted with 2-1 red pine seedlings. One block in Plot XI was planted with 2-1 red pine and the other with 2-1 jack pine. The layout of these plots is shown in Figure 2.

Ten millilitres of 2% aldrin emulsion (0.44 lbs. active ingredient per 1000 seedlings) was sprayed to the roots and planting hole of each of the treated seedlings. Untreated seedlings were used as controls. A Root Lowell Pro Sprayer No. 9081, a hand sprayer with a two gallon capacity, was used by a three-man crew in applying the insecticide: two planted the seedlings while the third applied the insecticide at the root of the seedling as it was held in place before closing the planting hole. It was found that the sprayer operator was capable of applying a fairly constant volume (about 10 ml) to each seedling after a short period of practice.

The seedlings were planted in the furrows at 6-foot spacings, with an untreated buffer row planted between each treatment row. The insecticide and control treatment rows were randomized in Plots X and XI. In Plot IX, because of the irregular length of the rows, the two treatments were carried out in alternate rows. The arrangement of the treatments and the number of seedlings per treatment for the 1966 hand plantings is shown in Table II.

Grub population assessment.

Soil sampling for white grubs during the year of planting was carried out in mid July in 1965. Twenty-five 1-cubic foot samples were taken at random from the buffer rows in each block, 13 including a seedling and 12 between the seedlings. The soil sampling was done in late July in 1966 and because of small size of the plots only 25 samples per plot were taken. The samples were processed with a power-driven shaker from which the soil passes onto a continuous conveyer belt where it is carefully examined for grubs. Counts were made of Phyllophaga, Serica, Dichelonyx and Diplotaxis larvae, pupae, and teneral adults.

Seedling Mortality and Growth Assessment

Seedling mortality was assessed in 1965 on the 1963, 1964 experimental plantations in October 1965. In 1966, all plantations were again assessed including the 1966 hand plantings. The seedlings in the treatment rows were examined, the dead seedlings were removed and the cause of mortality was assigned to one of the following categories; (1) white grubs, (ii) planting error (only in the current year of planting), and (iii) unknown causes.

The effect of fertilizer treatments in the 1964 and 1965 plantations was evaluated in 1965 and 1966 by measurement of the current years height growth. Height growth was measured to the nearest centimeter for a 10% sample of the red pine and a 25% sample of the jack pine and white spruce.

Seeding of white grub larvae on treated trees.

In the spring of 1965, a small area on Plot V was planted with red pine in anticipation that white grub larvae might be collected to study the effectiveness of the insecticide by "seeding" the larvae directly to the roots of trees. The trees were machine planted with alternate rows of trees treated with 2% aldrin and untreated trees. Alternate buffer rows were planted between each row.

White grub larvae were hand collected by following machine planters in operation elsewhere in the area and examining the furrows of the newly planted rows. The daily collections of grubs were refrigerated at about 35°F to prevent starvation and/or cannibalism. Approximately 200 apparently healthy second and third instar grubs (Phyllophaga spp.) were collected for the seeding experiment.

The plantation was divided into 8 rows of 50 trees per row, 4 rows having been treated with aldrin and the remainder untreated. One grub per tree was placed at the roots of the seedlings (through a hole in the soil made with a wooden rod) in two aldrin treated rows and two untreated rows. The controls were the remaining treated and untreated rows with no grubs.

RESULTS

Mortality Assessment in the 1963 Experimental Planting.

Mortality assessment of the treatment rows in the 1963 red pine experimental plantations have been carried out in the fall of each year 1963 to 1966. The 1963 and 1964 results have been reported by Warren and Ives (1964) and Nairn and Ives (1965). In 1965 and 1966 the percentage of seedlings killed by white grubs continued to be very low although both liquid and granular aldrin and liquid heptachlor again appears to give better control than granular toxaphene. The percentage of seedling mortality by white grubs for all treatments in each of the years 1963 to 1966 and the total for the four-year period is shown in Table III. The cumulative mortality from grubs for the four years does not exceed 5% on any of the three plantations. However, for the same period, less than 1% mortality was found for the two aldrin and the heptachlor treatments. Granular toxaphene appears to be the least effective of the four insecticide treatments.

The majority of trees in the 1963 plantations are now well established, the trees are 2 to 3 feet in height and have well developed root systems. In 1966, no grub mortality was found among the vigorous trees and the seedlings that were killed by grubs were among those trees that were poorly established and had attained little growth from the time they were planted.

Mortality Assessments in the 1964 Experimental Plantations.

The 1964 seedling mortality in the 1964 plantations has been reported by Nairn and Ives (1965). The results of the 1965 and 1966 assessment is shown in Table IV. The percentage of trees killed by white grubs was extremely low on all plots in 1965 and 1966 and conclusive evaluation of the effectiveness of the insecticide is not possible. Generally, the white grub damage has declined with each succeeding year from the time of planting.

Mortality from unknown causes for all treatments continued to be higher in the Whitemouth Lake plantation (Plot VI) than at Wampum (Plot IV). The per cent mortality in both plots was decidely greater in 1966 than 1965. A comparison of unknown mortality between treatments shows the highest mortality occurring in the fertilizer and fertilizer-aldrin treatments. The jack pine plantings (Plot V) show very low mortality for all treatments in 1965 and 1966.

Mortality Assessment in the 1965 Experimental Plantations.

Soil sampling showed the 1965 white grub populations to be very low in all 1965 plantings and this was confirmed with the subsequent low tree mortality from white grubs found in 1965 (Table V). A synopsis of the 1965 grub population and tree mortality data on the untreated rows from Table V is as follows:

	PLOT				
	IV(rP)	VII(rP)	VIII(rP)	VIII(jP)	VIII(wS)
Grubs per foot^3	0.10	0.02	0.02	0.00	0.00
Seedling mortality %					
All causes	3.3	3.3	4.3	5.6	5.8
Grub damage	0.6	0.1	0.1	0.0	0.0

The 1966 damage by white grubs was almost non-existent in the untreated control rows, ranging from nil to 0.2 per cent (Table V).

The 1965 and 1966 seedling mortality from unknown causes as shown in Table V is worthy of note. For red pine, this mortality for all treatments was highest in Plot VIII, Plot VII was next and Plot IV had the least mortality. There was a significant increase in unknown mortality in the second year following planting in Plots VII and VIII. The general higher mortality in plots VII and VIII may be attributed to their being poorer red pine sites with heavier clay soils. In addition, a definite increase in competition from grasses and weeds was observed on these former pasture-lands in 1966. In Plot VII a problem with stray cattle occurred in 1965 and 1966 with the animals walking in the furrows and trampling some of the trees. Although the stems were pressed into the soil, these trees appear to have recovered with new terminal growth showing on the bent stems. To date the mortality from this trampling appears to be minor but the growth of these trees has definitely been affected.

The jack pine mortality in Plot VIII was similar to that found for red pine. White spruce in Plot VIII showed less unknown mortality in 1966 than in 1965. However, it should be noted that extreme difficulty was encountered in locating the small spruce seedlings in 1966 due to the heavy growth of grasses in the rows. It is possible that the failure to locate many of the dead seedlings in 1966 would account for the low mortality in fertilizer and fertilizer-aldrin treatment rows and the discrepancy between the total trees recorded in 1965 compared with 1966.

A comparison of various treatments and unknown tree mortality shows that generally a greater mortality was recorded in fertilizer treated rows on both red pine and jack pine. This was particularly true in 1966, following two growing seasons from planting.

Effect of treatments on height growth of red pine.

The effect of fertilizer and other treatments on the 1965 and 1966 height growth in the 1964 and 1965 plantings was examined with an analysis of growth data by multiple range tests (Kramer 1956). The results of these analysis are shown in Table VI. The 1964 analysis (Nairn and Ives, 1965) are included in order to show the year to year changes of the relative differences between treatments.

The 1964 red pine plantation in Plot IV showed height growth in 1964 to be significantly better on trees treated with fertilizer combined with aldrin than the untreated control trees and those treated with 4% aldrin. In 1965, combined fertilizer-aldrin and 2% aldrin treatments gave significantly better growth than the other three treatments namely, fertilizer, 4% aldrin and the controls. No significant differences were found between treatments on the 1966 height growth of these plantings.

On the 1965 plantation in the same area (Plot IV), height growth after one growing season was significantly better on seedlings treated with fertilizer and the combination of fertilizer and aldrin than on the controls. In 1966, both fertilizer and fertilizer-aldrin treatments again showed a significantly better height growth, but in this year all three other treatments were significantly inferior in growth.

On Plot VI at Whitemouth Lake, no difference in height growth was found between treatments in 1964. In 1965 at the end of the second growing season from planting, both fertilizer and fertilizer-aldrin treated trees had significantly inferior growth than the controls and those treated with 2% and 4% aldrin. In 1966 growth was again inferior on the fertilizer and fertilizer-aldrin treated tree; in addition, seedlings treated with fertilizer alone had significantly less growth than those treated with the combination of fertilizer-aldrin.

In Plot VII, a 1965 plantation, no significant differences were found between the five treatments in 1965 and 1966. As previously stated, a problem with cattle was prevalent on this former pastureland.

In Plot VIII, planted in 1965, seedling growth in 1965 was significantly better when treated with fertilizer alone and 2% aldrin than with 4% aldrin but these two treatments did not show a significant difference from the controls and trees with the fertilizer-aldrin combination. In 1966 growth of seedlings with fertilizer alone and the fertilizer-aldrin was significantly better than the controls. Fertilizer alone treatments showed superior growth over 4% aldrin.

Effect of treatments on height growth of jack pine.

In the 1964 plantation, Plot IV, jack pine seedlings treated with fertilizer combined with aldrin showed significantly better growth than the control seedlings and those treated with 2% aldrin in 1964. In both 1965 and 1966, fertilizer and fertilizer-aldrin treated trees showed superior growth over the control trees and those treated with 2% aldrin.

In the 1965 plantation, Plot VIII, seedlings treated with the combination fertilizer-aldrin showed significantly inferior 1965 growth compared to the controls, fertilizer alone, and the two aldrin treatments. No significant differences were found between treatments in the 1966 height growth.

Effect of treatments on height growth in white spruce.

In the 1965 white spruce plantings, Plot VIII, no significant differences in the 1965 height growth were found between the five treatments that were applied to these trees. In 1966, growth on trees treated with 2% aldrin was significantly superior than on the other four treatments. In addition, trees treated with fertilizer alone and the comination of fertilizer-aldrin had significantly better growth than the controls and those treated with 4% aldrin. It should be pointed out that any conclusions drawn from these differences between treatments of the 1966 growth must be tempered by the fact that only one row of spruce per treatment was planted.

Phytotoxic effect of treatments.

The analysis of red pine height growth by treatments has shown that fertilizer combined with aldrin has increased growth on Plot IV and VIII, while showing no effect on Plot VII, and decreased growth on Plot VI. The effect of fertilizer alone on red pine is not so distinct. In Plot IV, no effect was shown in the 1964 plantation while it gave increased growth in the 1965 plantation, particularly in the second growing season after planting. No advantage was shown in Plot VII while the fertilizer increased growth in Plot VIII. For jack pine, both fertilizer and fertilizer-aldrin increased growth in Plot V, while the combination fertilizer-aldrin was detrimental to growth in Plot VIII.

It appears evident that there are numerous factors involved that may effect the growth of these trees under the various treatments. From the above results it is obvious that site differences are an important factor, with fertilizer-aldrin treatments showing to best advantage on light sandy soils similar to that found in Plot IV and V. Seedlings planted in two successive years but in the same area with identical treatments show differences in growth responses. Therefore variations in climate are probably a major factor that contributes to these relative differences in growth of trees receiving the same treatments.

Carter and Lyle (1966) have discussed some of the factors influencing the response of pine trees to fertilization including the greater demand of available moisture by increased undergrowth, the reduction of drought-resistance due to increased nitrogen concentration and the losses of applied nutrients on porous soils causing growth response to be obscured. A further evaluation of tree mortality from unknown causes for the various treatments (Tables IV and V) was carried out. Table VII shows the unknown seedling mortality in the 1964 and 1965 plantings arranged in order of rank (1 = highest mortality) for the five treatments by species plot, year of planting and number of growing seasons following planting when each mortality assessment was made. For red pine, at the end of the first growing season there is an indication that both fertilizer alone and fertilizer-aldrin treated trees are frequently suffering the greatest mortality in the various plots. At the end of the second growing season the fertilizer alone treatment ranks highest in tree mortality in every plantation and the fertilizer-aldrin treatment has the second highest mortality. These two treatments were again ranked either first or second in tree mortality at the end of the third growing season. For jack pine, where there are only two plantings, both fertilizer treatments ranked one and two in tree mortality in the second and third year from planting. However, the jack pine data is inconclusive due to the negligible mortality occurring on Plot V in the second and third year from planting. No apparent trend is shown for white spruce.

Mortality assessment in the 1966 hand plantings.

Soil sampling showed the 1966 grub population to be low in the three 1966 plantations, ranging from 0.12 grubs per cubic-foot in Plot XI, 0.08 in Plot IX, to zero in Plot X. Seedlings mortality from all causes is shown in Table VIII. Damage by white grubs in the control was low in the red pine plantings on all three plots, the highest being 2.1% on Plot XI. However, the jack pine on Plot XI control trees suffered 8% damage. The difference in mortality from grubs in the small (one acre) area may be attributed to a small pocket of grubs existing on that side of the plot in which the jack pine were planted. A total of 12 jack pine were attacked compared with three red pine seedlings. The reduction of grub mortality from 8.6% in the controls of jack pine to 1.5% on those trees treated with aldrin is an indication that the insecticide is giving some degree of protection, but the total number of trees involved is small.

In all three plots, seedling mortality from unknown causes appears to be drastically high on trees treated with insecticide compared with the mortality in the control trees. This mortality ranges from approximately 2 to 15 times greater in the treated trees compared with the controls for red pine with a high of 34% mortality in Plot XI. For jack pine, mortality was 58% in the treated trees or 5 times greater mortality than on the controls. In addition, mortality attributed to planting error is obviously higher in the insecticide treated trees than the controls. This would indicate that poorly planted treated trees suffered greater losses than poorly planted control trees because planting errors are random when planted by one crew. It would appear that the 2% aldrin treatment has a definite phytotoxic effect on both red pine and jack pine when applied by a hand

operated pack sprayer directly to the exposed roots during hand planting. On machine planted trees in the 1964 and 1965 plantations, there was no apparent phytotoxic effect from applications of 2% and 4% aldrin. A 10 ml solution of insecticide was applied in both methods of plantings. However in machine planting the insecticide was dispensed automatically and the treatment was applied to the soil along the furrow in a 12 inch strip and the seedling roots received a relatively smaller amount of aldrin.

Effect of seeding grubs on treated and untreated trees.

No conclusive results were obtained in the grubs seeding experiment. There was no tree mortality from white grubs in the treated and untreated rows on which grubs had been applied directly to the roots. The trees were examined periodically from late June to mid-August and about half of the trees to which grubs had been placed were dug and the surrounding soil examined for living or dead larvae. There was no evidence of grub feeding and only one living larva was found in one of the untreated rows. No dead larvae were found.

The failure of the grubs to feed when placed directly on the roots of the seedlings may be due to this food being undesirable to the insect at this time of year (grubs were seeded May 17). The grubs probably wandered to the side of the furrows and then began to feed on the newly developing grass roots between the furrows. Assuming no grubs were present in the area prior to seeding, the maximum density of the seeded grubs would be one grub per 72 square feet and at this low density the chance of locating a seedling (one tree per 36 square ft.) would be small.

Pre-planting soil surveys for grubs.

Tests were carried out in 1965 to assess the practical use of sequential sampling techniques developed for preplanting white grub soil surveys to determine if control measures are necessary (Ives and Warren, 1965). Twenty-five typical pine planting sites were sampled. A three-man crew, with the aid of the power-driven soil shaker, could complete one survey in approximately one and a half hours. An average of 14 samples were required to reach a decision in each survey and this time included randomizing, digging, and processing the soil samples. One sequential survey for each 40 acres of planting area was considered a practical sampling ratio. However, good judgement should be used while sampling any given area. The number of surveys should be increased if "hot spots" are suspected and reduced where no grubs are encountered. In addition, post-planting surveys of seedling mortality by grubs should be carried out in order that, if necessary, refinements may be made to the sampling system.

In 1966, all 35 proposed fall and spring provincial planting areas for the 1966-67 season in Southern Manitoba were examined and those areas considered susceptible to white grubs were sampled. Areas less than 12 acres were considered too small to warrant economical samplings. White grub populations were found to be low and no control measures were recommended for all of the 19 areas sampled. These areas will be assessed for white grub tree mortality in the fall of 1967 in order to obtain further information on the accuracy of sequential sampling surveys.

REFERENCES

Carter, M.C. and Lyle, E.S. 1966. Fertilization of loblolly pine on two Alabama soils: effects on growth and foliar mineral content. Bull. Ala. Agric. Exp. Sta. no. 370, pp. 18. Auburn Univ.

Ives, W.G.H. and Warren, G.L. 1964. Tree planter attachments for chemical treatment of coniferous seedlings. Forestry Chronicle 40:505-508.

Ives, W.G.H. and Warren, G.L. 1965. Sequential sampling for white grubs. Can. Ent. 97:596-604.

Kramer, C.Y. 1956. Extension of multiple range tests to group means of unequal numbers. Biometrics 12:307-310.

Nairn, L.D. and Ives, W.G.H. 1965. White grub studies - 1964. Can. Dept. For. Interim Res. Rpt. For. Ent. Lab. Winnipeg, Manitoba.

Warren, G.L. and Ives, W.G.H. 1964. A preliminary study of the chemical control of white grub in conifer plantations in southeastern Manitoba. Can. Dept. For. Information Rpt. For. Ent. Lab. Winnipeg, Manitoba.

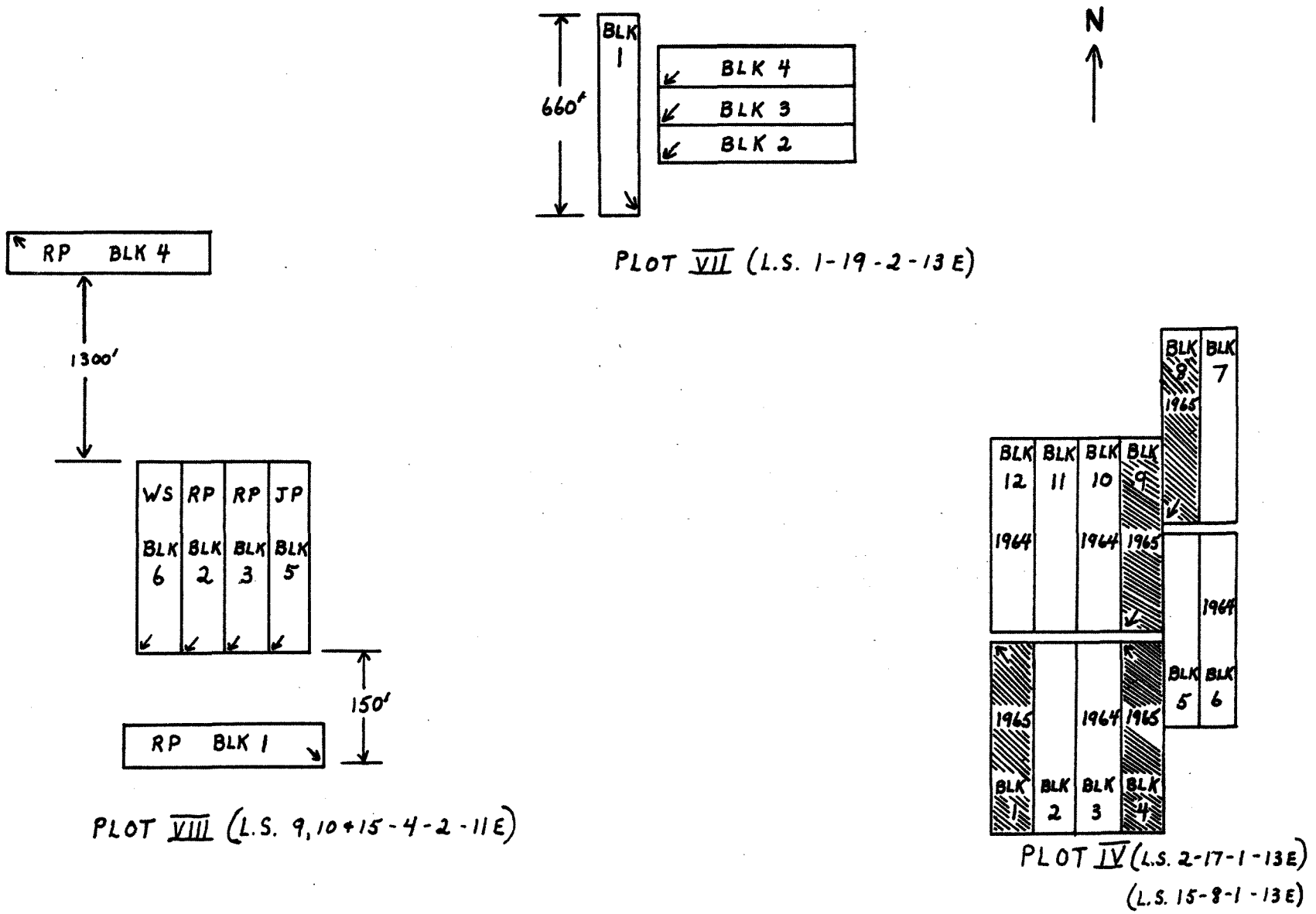

Fig. 1. Orientation of Blocks and Rows in 1965 Plantations.
Arrow (↗) Indicates Position of Row 1 in Each Block.

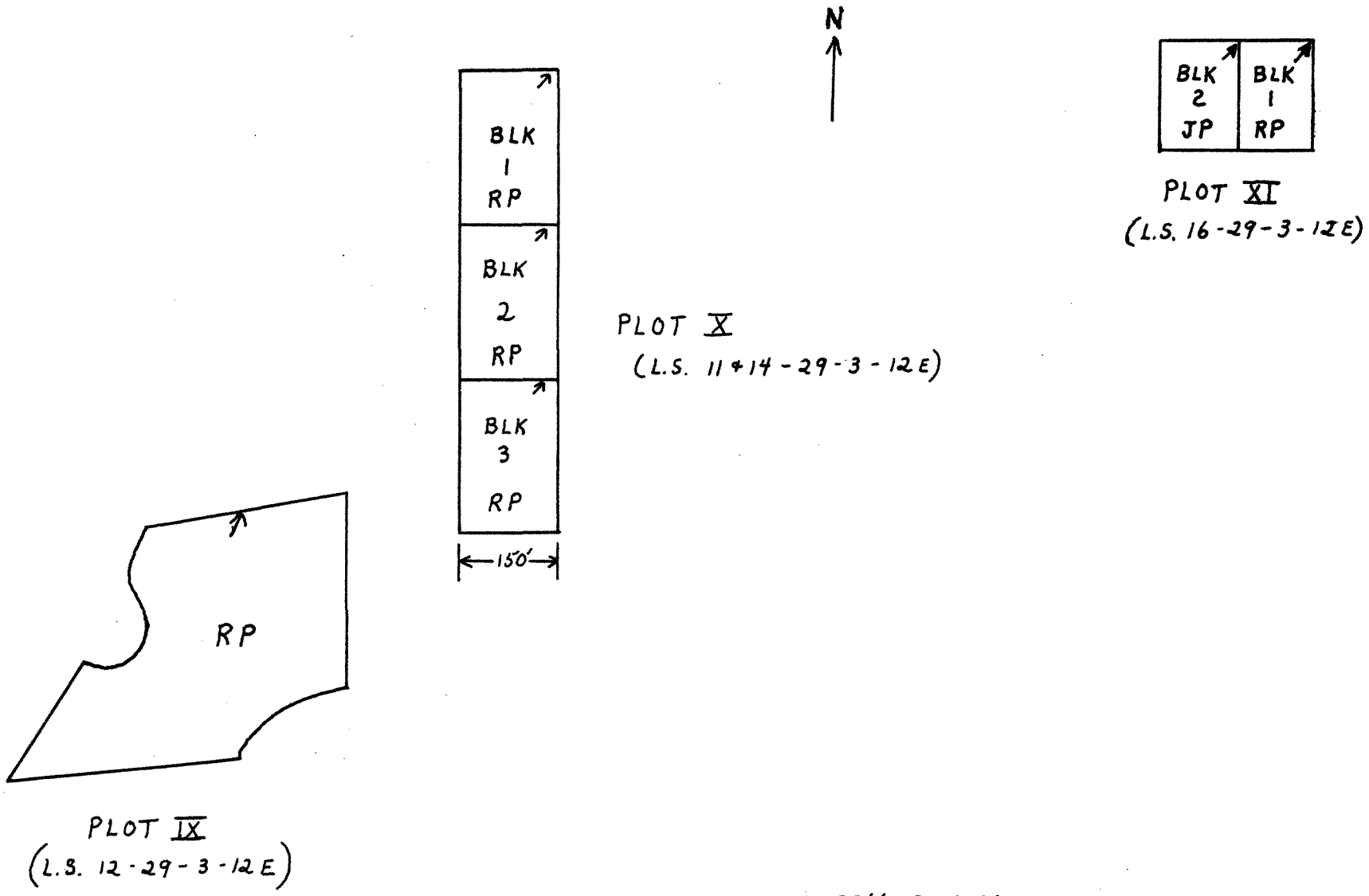

Fig. 2 Orientation of Blocks and Rows in 1966 Plantations.
Arrow (↗) Indicates Position of Row 1 in Each Block.

TABLE I

ARRANGEMENT OF RANDOMIZED TREATMENTS AND NUMBER OF SEEDLINGS PER TREATMENT IN THE 1965 EXPERIMENTAL PLANTATIONS

PLOT	ALDRIN 2%		ALDRIN 4%		FERTILIZER		FERT. + ALD. 2%		CONTROL	
	BLK.+ROW	# TREES	BLK.+ROW	# TREES	BLK.+ROW	# TREES	BLK.+ROW	# TREES	BLK.+ROW	# TREES
	1-6	92	1-3	100	1-2	97	1-1-s	100	1-5	102
	* -7-s	99	-4-s	98	-9	103	-10	100	-8	97
IV	4-3	107	4-5	108	4-1	108	4-4	99	4-2	124
	-10-s	98	-8-s	98	-7	102	-9-s	92	-6	103
RED PINE	8-5	99	8-6	91	8-3	106	8-2-s	105	8-1	109
	-10-s	102	-8-s	104	-7	104	-9	107	-4	101
	9-1	97	9-2	104	9-7	93	9-3	102	9-6	96
	-4-s	97	-5-s	101	-10A	102	-10-s	94	-9	99
			-8-s	92						
	TOTALS-	791		896		815		799		831
	1-5-s	108	1-2	94	1-1	102	1-4-s	86	1-3	86
	-10-s	111	-8-s	98	-6	106	-7	107	-9	104
VII	2-2	102	2-1	101	2-4	107	2-3-s	99	2-6	107
	-7-s	101	-9-s	105	-10	102	-5	103	-8	105
RED PINE	3-2-s	104	3-5	106	3-1	98	3-6-s	97	3-3	107
	-9	107	-10-s	102	-7	100	-8	103	-4	103
	4-1-s	107	4-5	106	4-3	106			4-2	105
	-7-s	98	-9-s	107	-4	106			-6	95
	-8	105								
	TOTALS-	943		819		827		595		812
	1-5-s	103	1-2-s	108	1-1	99	1-9	108	1-6	99
	-8	99	-3	110	-4	103	-10-s	104	-7	102
VIII	2-4-s	95	2-2-s	98	2-8	98	2-1-s	95	2-3	96
	-7	101	-6	96	-10	98	-9	101	-5	96
RED PINE	3-4	99	3-1	96	3-6	93	3-5-s	85	3-2	96
	-8-s	96	-3-s	101	-10	98	-7	98	-9	93
	4-4	106	4-1-s	103					4-2	108
	-5-s	108	-3	86					-6	108
	TOTALS	807		798		589		591		798
VIII	5-4-s	95	5-1-s	96	5-5	101	5-3-s	100	5-2	100
JACK	-9-s	99	-10-s	98	-8	97	-7-s	94	-6	98
PINE	TOTALS	194		194		198		194		198
VIII	6-2-s	89	6-1-s	86	6-5	86	6-4-s	66	6-3	86
WHITE SPRUCE	TOTALS	89		86		86		66		86

* S - INSECTICIDE APPLIED BY SPRAY NOZZLE

TABLE II

ARRANGEMENT OF TREATMENTS AND NUMBER OF SEEDLINGS PER TREATMENT IN THE 1966 EXPERIMENTAL PLANTATIONS

PLOT IX RED PINE				PLOT X RED PINE				PLOT XI RED PINE			
CONTROL		ALDRIN 2%		CONTROL		ALDRIN 2%		CONTROL		ALDRIN 2%	
BLK. & ROW	# TREES	BLK. & ROW	# TREES	BLK. & ROW	# TREES	BLK. & ROW	# TREES	BLK. & ROW	# TREES	BLK. & ROW	# TREES
1-2	38	1-1	50	1-1	23	1-3	27	1-4	29	1-1	27
-4	45	-3	47	-2	24	-5	26	-5	27	-2	25
-6	49	-5	52	-4	23	-7	26	-6	28	-3	28
-8	52	-7	51	-6	24	-11	26	-9	28	-7	26
-10	60	-9	53	-8	24	-12	26	-10	28	-8	27
-12	69	-11	62	-9	25	-14	26				
-14	71	-13	74	-10	24	-16	27	TOTAL	140	TOTAL	133
-16	78	-15	77	-13	24	-17	26				
-18	45	-17	49	-15	25	-18	24	PLOT XI JACK PINE			
-20	48	-19	52	-19	27	-20	25	CONTROL		ALDRIN 2%	
-22	53	-21	53	2-2	26	2-1	24	BLK. & ROW	# TREES	BLK. & ROW	# TREES
-24	52	-23	56	-3	28	-5	25	2-2	29	2-1	27
-26	56	-25	57	-4	26	-7	24	-3	28	-6	29
-28	87	-27	94	-6	25	-8	29	-4	29	-7	26
-30	68	-29	81	-9	27	-12	24	-5	29	-8	28
-32	60	-31	63	-10	26	-16	27	-9	25	-10	25
				-11	27	-17	23				
TOTAL	931	TOTAL	971	-13	24	-18	23	TOTAL	140	TOTAL	135
				-14	27	-19	22				
				-15	26	-20	22				
				3-1	26	3-4	23				
				-2	25	-5	23				
				-3	26	-6	24				
				-7	22	-12	24				
				-8	24	-13	24				
				-9	25	-14	24				
				-10	26	-16	23				
				-11	25	-18	23				
				-15	25	-19	23				
				-17	25	-20	25				
				TOTAL	754	TOTAL	738				

TABLE III

SEEDLING MORTALITY FROM WHITE GRUBS IN 1963, 1964, 1965 & 1966 IN THE 1963 EXPERIMENTAL PLANTATIONS

PLOT	TREATMENT	# SEEDLINGS 1966	% KILLED 1966	% KILLED 1965	% KILLED 1964	% KILLED 1963	TOTAL % KILLED
I AGASSIZ	ALDRIN 2% (LIQ.)	756	0.1	0.0	0.0	0.0	0.1
	HEPTACHLOR (LIQ.)	750	0.0	0.0	0.0	0.2	0.2
	ALDRIN (GRAN.)	740	0.0	0.0	0.0	0.4	0.4
	TOXAPHENE (GRAN)	718	0.6	0.7	1.4	0.1	2.8
	CONTROL	687	0.6	0.8	2.0	0.2	4.6
II MARCHAND	ALDRIN 2% (LIQ.)	831	0.0	0.0	0.4	0.0	0.4
	HEPTACHLOR (LIQ.)	824	0.0	0.0	0.0	0.0	0.0
	ALDRIN (GRAN.)	724	0.0	0.1	0.0	0.0	0.1
	TOXAPHENE (GRAN)	703	0.1	0.4	0.1	0.0	0.6
	CONTROL	796	0.1	0.1	1.1	0.0	1.3
III PINEY	ALDRIN 2% (LIQ)	540	0.2	0.0	0.0	0.5	0.7
	HEPTACHLOR (LIQ)	733	0.0	0.0	0.4	0.3	0.7
	ALDRIN (GRAN.)	712	0.0	0.4	0.3	0.0	0.7
	TOXAPHENE (GRAN)	683	0.2	2.3	1.6	0.1	4.2
	CONTROL	659	0.9	2.0	1.9	0.5	5.3

TABLE VI - Cont'd.

PLOT VIII - RED PINE

1965 plantation	AL4	Control	FEAL2	FE	AL2
1965 assessment	4.18	4.40	4.73	5.17	5.20
1966 assessment	Control	AL4	AL2	FEAL2	FE
	3.86	3.98	4.35	4.82	4.93

PLOT V - JACK PINE

1964 plantation	AL2	Control	FE	FEAL2
1964 assessment	6.48	6.66	7.85	9.14
1965 assessment	Control	AL2	FE	FEAL2
	15.54	17.06	22.54	24.32
1966 assessment	Control	AL2	FE	FEAL2
	22.7	23.94	27.14	29.60

PLOT VIII - JACK PINE

1965 plantation	FEAL2	AL4	AL2	FE	Control
1965 assessment	8.88	10.98	11.10	11.28	12.58
1966 assessment	AL2	Control	AL4	FE	FEAL2
	15.70	16.60	17.50	17.96	18.16

PLOT VIII - WHITE SPRUCE

1965 plantation	FE	FEAL2	AL4	AL2	Control
1965 assessment	3.32	3.40	3.52	3.56	3.60
1966 assessment	Control	AL4	FE	FEAL2	AL2
	4.32	4.56	5.56	6.04	6.84

[1]Any two means not underscored by the same line are significantly different and any two means underscored by the same line are not significantly different. Solid lines indicate significance attained at the 0.01 level and dotted lines indicate significance attained at the 0.05 level. Abbreviations: AL2, 2% aldrin; AL4, 4% aldrin; FE, fertilizer; FEAL2, fertilizer and 2% aldrin.

TABLE VIII

SEEDLING MORTALITY FROM ALL CAUSES FOR EACH TREATMENT IN THE 1966 EXPERIMENTAL PLANTATIONS

PLOT	TREATMENT	NO. SEEDLINGS	NO. GRUBS PER FT.^{3}	% SEEDLING MORTALITY			
				GRUBS	UNKNOWN	PLANTING	TOTALS
IX	CONTROL	931	0.08	0.6	8.6	3.4	12.6
	ALDRIN 2%	971		0.0	20.8	4.0	24.8
X	CONTROL	754	0.00	1.1	4.1	1.2	6.4
	ALDRIN 2%	738		0.0	13.0	4.1	17.1
XI RED PINE	CONTROL	140	0.12	2.1	2.1	0.0	4.2
	ALDRIN 2%	133		0.8	34.6	8.3	43.7
JACK PINE	CONTROL	140	0.12	8.6	11.4	2.1	22.1
	ALDRIN 2%	135		1.5	58.5	12.6	72.6