

CHARACTERISTICS OF SOIL TEMPERATURE AND MOISTURE,  
GERMINATION OF JACK PINE SEED, AND SEEDLING ESTABLISHMENT  
ON SEEDBEDS CREATED BY A MIDDLEBUSTER PLOW IN SOUTHEASTERN MANITOBA

Project MS-222

by

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FOREST RESEARCH LABORATORY

WINNIPEG, MANITOBA

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## INTRODUCTION

The successful regeneration of jack pine in southeastern Manitoba is greatly dependent upon seedbed preparation. One method currently being used creates a furrow two to three inches deep and three to four feet wide with an overturned-sod ridge on each side. In 1962 a study was begun to assess the capacities of the seedbeds created for germination, survival, and growth. Preliminary studies<sup>1</sup> on three sites - oligotrophic dry, mesotrophic fresh-minus, and oligotrophic fresh (Mueller-Dombois 1964) - indicated that the dry site was the most critical, and in 1964 the study was intensified on such a site. However, studies on the original three sites have been continued in less detail and will be terminated by growth and mortality measurements in 1966. In this report the original study on these sites will be referred to as study A, while the more intensive study on the dry site will be referred to as study B.

## WORK COMPLETED IN 1966

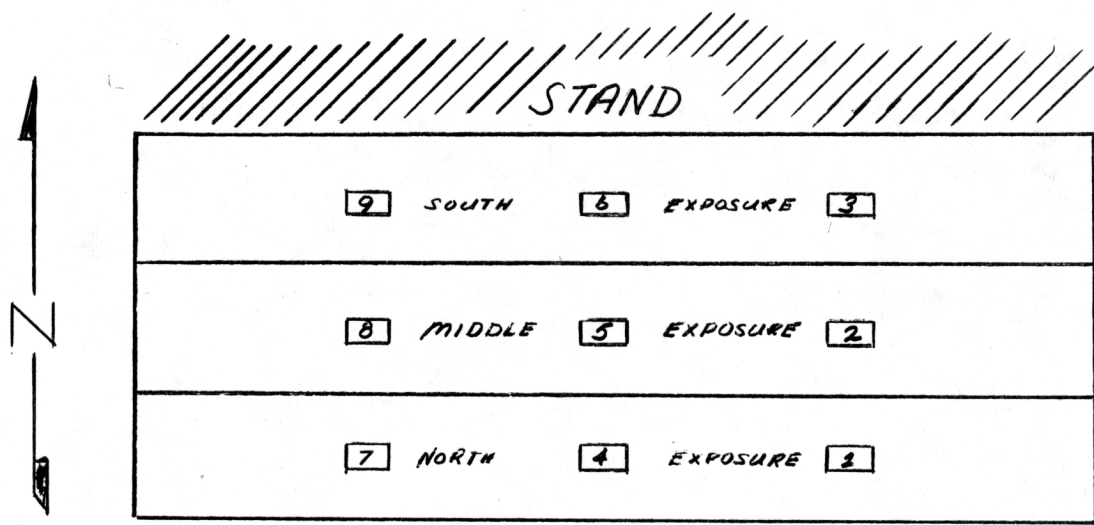
### Methods

Establishment of sample plots -- study B. A new east-west strip was located and plowed in 1965. Cutting was carried out during the winter of 1965-66. Nine plots were subjectively located so that the north, south and middle one-third of the strip contained three plots each, (Figure 1).

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1. For further details the reader is referred to earlier reports prepared for this project (Sims, H.P. 1963, 1964, 1965, 1966).

Figure 1

Plot layout - Study B



Scale 1 chain = 1 inch

Each plot contained the following treatments:

- (1) Three seedspots per seedbed condition (ridge, trough, undisturbed, base of north-facing slope and base of south-facing slope)<sup>2</sup> seeded with 50 treated seeds each. Sub-plot size one milacre.
- (2) Five two-year-old seedlings planted on each seedbed condition. Sub-plot size one milacre.

Seeding and planting were done in early May. The area was fenced to prevent breakage of instruments by mammals.

Seedspot and planting stock tally and measurement - study A. Mortality of seedlings established in 1964 was tallied in May and again in late August of 1966. Total height, 1966 growth and root collar diameters were measured in late August. The seedlings were harvested and oven-dry weights obtained.

Seedspot tally and measurement - study B. Germination occurring on the 1966 seedspots was studied. Seedlings were marked with colored plastic toothpicks and different colors were used to identify each week of germination. As mortality occurred, the location of dead seedlings was marked with a red toothpick, and the seedling was collected for examination by a pathologist. During peak periods of germination and mortality, tallies were taken daily; at other times weekly records were maintained.

Seedspots established in 1964 and 1965 were checked for mortality in early May and late August. In August, total heights of 1966, 1965 and 1964 seedlings were obtained as well as 1966 growth of 1965 and 1964 seedlings. Root collar diameters of the 1964 seedlings were measured, the seedlings harvested and oven-dry weights obtained.

Planting tally and measurement - study B. Mortality of 1966 planting stock was recorded at weekly intervals from the time of planting. Mortality of 1964 and 1965 stock was recorded in May and late August of 1966. Total heights and 1966 growth of 1966, 1965 and 1964 planting stock were recorded in late August of 1966; at this time the 1964 stock was measured for root-collar diameter, harvested and oven-dry weights obtained.

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<sup>2</sup> Throughout the remainder of the report, seedbeds will be defined as follows: Ridge = R; Undisturbed = U; Trough = T; Base of south-facing slope = BSF; Base of north-facing slope = BNF.

Temperature measurement - study B. Soil surface temperatures were measured by means of 45 twenty-four-gauge copper-constantan thermocouples using two Elektronik 15, Universal 24-point strip-chart recorders. One thermocouple was anchored on each of the five seedbeds on each plot and covered with a layer of soil one particle in thickness. Leads from each plot to the recorder were encased in a flexible spiral sheath. For illustrations of the equipment, the reader is referred to an earlier report of this project (Sims, 1966).

The recorders were set for a 10-second print cycle so that each individual seedbed temperature was recorded every four minutes. Each recorder was equipped with a timer and recorded temperature only from 1000 to 1800 hours. The chart drive speed was set at 30 inches per hour; a chart lasted six days. Records were obtained for the period May 23 to October 1. During this time, a total of eight recorder days were lost due to equipment or power failure.

Air temperature was measured by two thermocouples, one from each recorder, mounted in a sandwich screen and by a thermograph located in a bird cage shelter.

Soil moisture measurement - study B. Soil samples from the surface  $\frac{1}{2}$  inch, from  $1\frac{1}{2}$  to 2 inches and from 3 to 4 inches, were taken for gravimetric determination of moisture contents at intervals of 1, 3 and 5 days after rain, and every 5 days thereafter. One sample from each depth was taken on an R, U and T seedbed on each exposure.

Samples were collected in tins, sealed immediately with masking tape, and weighed as soon as possible after collection. All samples were oven-dried, at the field station, for 36 hours at 105°C and moisture content was calculated.

Precipitation measurement - studies A and B. Rainfall was collected at weekly intervals beginning May 11 and ending August 29 on study A areas, and at weekly intervals beginning May 24 and ending October 3 on the 1966 area of study B. Three Beal-type rain gauges were used in each case. In addition, a Cassella siphon recording rain gauge was located on the 1966 study B area.

Solar radiation - study B. Solar radiation measurements were obtained by means of a Robitzsch - Fuess bimetallic actinograph.

## Results

Germination and survival on 1966 seedspots - study B. Germination began during the week of June 6 to 12 and extended into late September. However, most germination occurred on all exposures during the period June 6 to July 17; it dropped off abruptly after July 17 in all cases. The northern exposure supported the greatest number of germinants, with 73.0 per cent of the total germination for the area. Middle and south<sup>3</sup> exposures supported 13.2 and 13.8 per cent respectively.

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<sup>3</sup>Hereafter the southern exposure will be referred to as S, middle exposure as M, and northern exposure as N.

Germination on the N exposure reached a peak during the period June 20 to July 3, when 66.5 per cent of the total germination on the exposure occurred. Peak germination on the M and S exposures occurred during July 4 to 17; percentages of total germination on each exposure were 59.8 and 54.3 respectively.

Table 1 gives germination percentages for each exposure and seedbed. Germination on the N exposure is lowest on the U and highest on the BNF seedbeds. The R seedbed of the M and S exposures produced the lowest germination; the BNF on the M exposure and the T on the S exposure produced the highest. Considering the area as a whole, the lowest germination occurred on the R seedbed, the highest on the BNF seedbed. Average germination for all seedbeds was greatest on the N exposure.

Mortality percentages for each exposure and seedbed are shown in Table 2. The highest mortality occurred on the M exposure followed by S and N. Seedbeds showing the highest mortality on each exposure were as follows: BNF (23.8 per cent) on N; T (51.4 per cent) on M; and BSF (62.5 per cent) on S. Seedbeds with lowest mortality on each exposure were as follows: R (11.6 per cent) on N; U (33.3 per cent) on M; and R (no mortality) on S. Considering all exposures, the lowest mortality occurred on the R seedbed, the highest on the BNF seedbed.

Cause of mortality occurring on each exposure is shown in Table 3. Damping-off was the most prevalent cause on all exposures. Chewing, except on the N exposure, was the second most prevalent cause. Heat was the second most prevalent cause on the N exposure but caused least mortality on the M and S exposures.

Periodic mortality occurring to October 3 on each exposure is shown in Table 4. Mortality began during the week of June 20 to 26 and continued throughout the field season. Most of the mortality on the area, however, occurred during the period of June 27 to July 31, with a peak being reached during the week of July 11 to 17. The chief cause of mortality during these periods was damping-off. Mortality occurring after July 31 was attributed mostly to heat, and occurred primarily on the N exposure.

Mortality for each weekly germination period is shown in Table 5. Considering the area as a whole, mortality percentages ranged from zero for seedlings germinating during June 6 to 12, to 50 per cent for seedlings germinating during July 18 to 31. On each exposure the highest mortality was suffered by seedlings germinating between June 27 and July 31.

Mortality on 1964 seedspots - study A. A comparison of mortality on the 1964 seedspots for the periods September 1965 to September 1966 is shown in Table 6. The data express third-year mortality on moisture regimes 1, 2 and 3. Winter mortality was higher than summer mortality on MRs 2 & 3. Moisture regime 1 suffered the highest mortality for the year (17.6 per cent) followed by MR2 at 10.8 per cent and MR3 at 6.2 per cent; the U seedbed showed the highest mortality on all moisture regimes excepting MR2.

TABLE 1

PER CENT GERMINATION ON SEEDSPOTS ACCORDING TO SEEDBED AND EXPOSURE  
STUDY B

Exposure	P l o t	Per cent germination <sup>1</sup> Seed bed					
		R	T	U	BNF	BSF	All Seedbeds
North (N)	1	33.0	39.6	17.6	59.4	57.9	41.5
	4	24.9	42.5	10.3	44.7	39.6	32.4
	7	17.6	53.5	4.4	46.9	44.7	33.4
	Average 1, 4, 7	25.2	45.2	10.8	50.4	47.4	35.8
Middle (M)	2	0.0	8.8	2.2	22.0	11.0	8.8
	5	0.0	7.3	0.0	4.4	8.8	4.1
	8	0.0	11.0	2.2	15.4	3.7	6.4
	Average 2, 5, 8	0.0	9.0	1.5	13.9	7.8	6.4
South (S)	3	2.2	10.3	5.1	18.9	3.7	7.0
	6	1.5	10.3	0.0	11.0	1.5	4.8
	9	2.2	18.3	1.5	18.2	6.6	8.4
	Average 3, 6, 9	2.0	13.0	2.2	12.7	3.9	6.7
Average N, M, S	All plots	9.0	22.4	4.8	25.6	19.7	16.3

<sup>1</sup> Based upon seed viability of 90.9 per cent when sown

TABLE 2

PER CENT MORTALITY OF GERMINATION ACCORDING TO SEEDBED  
AND EXPOSURE

## STUDY B

Exposure	P 1 0 +	Per cent mortality <sup>1</sup> Seedbed					
		R	T	LL	BNF	BSF	All Seedbeds
North (N)	1	11.1	22.2	16.7	21.0	8.9	15.9
	4	8.8	13.8	28.6	19.7	24.1	18.1
	7	16.7	9.6	16.7	31.2	11.5	17.1
	Average 1, 4, 7	11.6	14.6	20.4	23.8	13.9	16.9
Middle (M)	2	—	75.0	33.3	20.0	26.7	33.3
	5	—	20.0	—	50.0	66.7	46.4
	8	—	53.3	33.3	61.9	40.0	54.5
	Average 2, 5, 8	—	51.4	33.3	38.6	43.8	43.2
South (S)	3	0.0	42.8	28.6	15.8	40.0	27.1
	6	0.0	35.7	—	20.0	0.0	24.2
	9	0.0	52.0	100.0	33.3	88.9	50.8
	Average 3, 6, 9	0.0	45.3	44.4	23.1	62.5	36.2
Average N.M.S	All plots	10.8	25.4	25.4	26.3	21.1	23.0

<sup>1</sup> Based upon number of germinants

TABLE 3

MORTALITY FOR EACH SEEDBED AND EXPOSURE ACCORDING TO CAUSE  
STUDY BPer cent mortality <sup>1</sup>

	North exposure				Middle exposure				South exposure				Avg. all exposures.			
Cause	Heat	Damping off	chewing	Other	Heat	Damping off	Chewing	Other	Heat	Damping off	Chewing	Other	Heat	Damping off	Chewing	Other
R	1.9	5.8	1.9	1.9	—	—	—	—	0.0	0.0	0.0	0.0	1.8	5.4	1.8	1.8
T	4.9	7.6	1.1	1.1	0.0	32.4	18.9	0.0	1.9	24.5	13.2	5.7	3.6	14.2	5.8	1.8
U	6.8	4.5	4.5	4.5	0.0	16.7	0.0	16.7	0.0	22.2	22.2	0.0	5.1	8.5	6.8	5.1
BNF	6.3	9.7	1.4	6.3	0.0	21.0	14.0	3.5	0.0	17.3	5.8	0.0	4.1	13.0	4.4	4.8
BSF	1.5	8.8	2.1	1.5	0.0	18.8	25.0	0.0	0.0	25.0	37.5	0.0	1.2	11.2	7.4	1.2
All Seedbeds.	4.1	8.1	1.8	3.0	0.0	23.5	17.4	2.3	0.7	20.3	13.0	2.2	3.1	11.8	5.4	2.8

<sup>1</sup> Expressed as a per cent of germination per seedbed

TABLE 4

SEASONAL MORTALITY OF GERMINATION OCCURRING AT SPECIFIED PERIODS

Mortality period	Per cent mortality <sup>1</sup>																			
	North exposure					Middle exposure					South exposure					Avg. all exposures				
	Hedt	Damping off	Chewing	Other	Total	Hedt	Damping off	Chewing	Other	Total	Hedt	Damping off	Chewing	Other	Total	Hedt	Damping off	Chewing	Other	Total
June 20 - June 26		0.4	0.3	0.1	0.8		2.3			2.3							0.6	0.2	0.1	0.9
27 July 3	0.3	3.0		0.4	3.7		0.8		0.8	1.5	0.7	2.2			2.9	0.3	2.6		0.4	3.3
July 4 10		0.7	0.8	1.5	3.0		2.3	0.8	0.8	3.8		1.4	4.3	1.4	7.2		1.0	1.3	1.4	3.7
11 17		2.3	0.3	0.3	2.9		15.2	10.6		25.8		13.0	4.3	0.7	18.1		5.5	2.2	0.3	8.0
18 24	1.1	1.4	0.1	0.3	2.9		2.3	2.3	0.8	5.3		2.2	2.9		5.1	0.8	1.6	0.8	0.3	3.5
25 31	1.2	0.3	0.1	0.3	1.9		0.8	3.8		4.5		0.7	0.7		1.4	0.9	0.4	0.7	0.2	2.2
Aug. 1 Aug 7	0.1		0.1		0.3								0.7		0.7	0.1		0.2		0.3
8 14	0.4				0.4											0.3				0.3
15 21	0.1				0.1											0.1				0.1
22 28																				
29 Sept. 4	0.1				0.1							0.7			0.7	0.1	0.1			0.2
Sept. 5 11	0.3				0.3											0.2				0.2
12 18	0.3				0.3											0.2				0.2
19 25																				
26 Oct. 3	0.1				0.3											0.1			0.1	0.2

<sup>1</sup> Expressed as a per cent of germination per exposure

TABLE 5  
SEASONAL MORTALITY OF GERMINATION OCCURRING AT SPECIFIED PERIODS  
STUDY B

Per cent mortality occurring to October 3 <sup>1</sup>									
Germination Period	N		M		S		N,M,S		
	Number germ.	Per cent mortality	Number germ.	Per cent mortality	Number germ.	Per cent mortality	Number germ.	Per cent mortality	
June 6 - June 12	9	0.0	5	0.0	1	0.0	15	0.0	
13 19	82	3.6	9	33.3	10	0.0	101	5.9	
20 26	255	7.8	15	0.0	30	3.3	300	7.0	
27 July 3	232	26.7	16	25.0	18	27.8	266	26.7	
July 4 10	75	26.7	52	51.9	45	53.3	172	41.3	
11 17	69	26.1	27	74.1	30	60.0	126	44.4	
18 24	3	0.0	2	100.0	1	100.0	6	50.0	
25 31	3	33.3	1	100.0	0	-	4	50.0	
Aug. 1 Aug. 7	1	0.0	0	-	0	-	1	0.0	
15 21	1	0.0	2	0.0	0	-	3	0.0	
22 28	0	-	0	-	3	33.3	3	33.3	
Sept. 5 Sept. 11	1	0.0	0	-	0	-	1	0.0	
12 18	0	-	1	0.0	0	-	1	0.0	
19 25	1	0.0	2	0.0	0	-	3	0.0	

<sup>1</sup> Expressed as a per cent of periodic germination

TABLE 6

A COMPARISON OF SEASONAL MORTALITY ON 1964 SEEDSPOTS - STUDY A

Per cent mortality <sup>1</sup>												
	MR 1			MR 2			MR 3			Avg. MR 2, 2, 3		
Seedbed	Sept 1965 to May 1966	May 1966 to Sept 1966	Sept 1965 to Sept 1966	Sept 1965 to May 1966	May 1966 to Sept. 1966	Sept. 1965 to Sept. 1966	Sept. 1965 to May 1966	May 1966 to Sept. 1966	Sept. 1965 to Sept. 1966	Sept. 1965 to May 1966	May 1966 to Sept. 1966	Sept. 1965 to Sept. 1966
R	-	-	-	-	-	-	-	-	-	-	-	-
T	33.3	0.0	33.3	13.5	0.0	13.5	7.5	1.4	8.8	10.0	0.9	10.8
U	0.0	40.0	40.0	-	-	-	-	-	-	0.0	40.0	40.0
BNF	0.0	0.0	0.0	9.5	3.5	14.3	0.0	0.0	1.0	3.5	1.2	5.9
BSF	0.0	-	-	0.0	0.0	0.0	4.1	8.5	12.2	2.6	5.3	7.7
All Seedbeds	5.9	12.5	17.6	8.5	1.7	10.8	3.5	2.3	6.2	5.4	2.5	8.3

<sup>1</sup> Based upon seedlings remaining at the beginning of each period

Mortality on 1965 seedspots - study F. Mortality occurring on 1965 seedspots for the periods September 1965 to September 1966 is shown in Table 7. The data shown is for second-year survival. Winter mortality was higher than summer mortality on the N and S exposures, and equal to summer mortality on the M exposure. The BNF seedbed on the N exposure and the U seedbed on the M and S exposure showed the highest mortality for the year; lowest mortality occurred on the T seedbed of N and S exposures and R and T seedbeds of the M exposure. Appendix VI shows per cent mortality occurring on the 1965 seedspots from September 1965 to September 1966.

Survival of planted stock - study A. A comparison of first, second- and third-year survival of planted stock is shown in Table 8. Per cent survival from the time of planting to September 1966 is poorest for the 1963 planting and best for 1962 planting on all moisture regimes. Seedlings were harvested three years after planting.

Survival of planted stock - study B. Survival of 1964, 1965 and 1966 planted stock is given in Table 9. Survival has been good to excellent on all seedbeds and exposures since time of planting.

Growth on seedspots - study A. A graphic illustration of height growth on 1962, 1963 and 1964 seedspots is presented in Figures 2 and 3. Basis for these data may be found in Appendix I of this report. After three years growth the average height, for all moisture regimes, of seedlings established in 1962, 1963 and 1964 was 7.0, 8.8, 5.5 inches respectively. Height of 1964 seedspot seedlings was greatest on MR1, while height of 1962 and 1963 seedspot seedlings was greatest on MR3. Lowest heights occurred on MR2 in each case.

Growth on seedspots - study B. Average heights for seedlings established in 1964, 1965 and 1966 on each exposure are shown in Table 10. Considering the area as a whole, at the end of the 1966 growing season the greatest seedling heights for seedlings established in 1964 occurred on the BNF seedbed; for seedlings established in 1965 and 1966 heights were greatest on the R and U seedbeds respectively. To date, growth has been considerably better on the M and S exposures than on the N exposure.

Height growth of planted stock - study A. Growth of planted stock is illustrated graphically in Figures 4, 5 and 6. Basis for the graphs may be found in Appendix II of this report. The best third-year growth on seedlings planted in 1962, 1963 and 1964 occurred on MR3, the poorest on MR2. Seedbeds on MR3 showing the best growth were T for seedlings established in 1962 and BSF for seedlings established in 1963 and 1964; the poorest growth for seedlings established in 1962 occurred on U, for 1963 on R, and for 1964 on BNF. The best growth on MR2 for the 1962 and 1963 seedlings occurred on T seedbeds, for 1964 on BNF seedbeds. The poorest growth for 1962, 1963 and 1964 seedlings occurred on the U seedbed.

**TABLE 7**  
MORTALITY ON 1965 SEEDSPOTS SEPTEMBER 1965 TO SEPTEMBER 1966  
STUDY B

Per cent mortality <sup>1</sup>												
Exposure	N			M			S			Avg. N, M, S		
Period of mortality	Sept. 1965 to May 1966	May 1966 to Sept. 1966	Sept. 1965 to Sept. 1966	Sept. 1965 to May 1966	May 1966 to Sept. 1966	Sept. 1965 to Sept. 1966	Sept. 1965 to May 1966	May 1966 to Sept. 1966	Sept. 1965 to Sept. 1966	Sept. 1965 to May 1966	May 1966 to Sept. 1966	Sept. 1965 to Sept. 1966
R	6.7	0.0	6.7	0.0	0.0	0.0	0.0	4.0	4.0	4.0	1.4	5.3
T	0.8	0.8	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5	1.0
U	3.9	0.0	3.9	4.3	4.5	8.7	25.0	33.3	50.0	4.8	2.0	6.8
BNF	12.5	6.1	17.8	0.0	2.0	2.0	3.9	0.0	3.9	5.7	2.7	8.2
BSF	2.8	1.5	4.3	2.6	0.0	2.6	3.2	0.0	3.2	2.9	0.7	3.6
All seedbeds	4.3	1.4	5.6	1.4	1.4	2.7	2.6	1.4	4.0	3.3	1.4	4.6

<sup>1</sup> Based upon number of seedlings remaining at the beginning of each period.

TABLE 8

COMPARISON OF FIRST, SECOND AND THIRD YEAR SURVIVAL OF PLANTED STOCK — STUDY A

Seedbed	Year of planting	MR1								MR2								MR3								Average MR 1,2,3							
		Number planted	Seedlings remaining end of first year	First year survival per cent.	Seedlings remaining end of second year	Second year survival per cent.	Seedlings remaining end of third year	Third year survival per cent.	Percent survival time of planting to time of harvest	Number planted	Seedlings remaining end of first year	First year survival per cent.	Seedlings remaining end of second year	Second year survival per cent.	Seedlings remaining end of third year	Third year survival per cent.	Percent survival time of planting to time of harvest	Number planted	Seedlings remaining end of first year	First year survival per cent.	Seedlings remaining end of second year	Second year survival per cent.	Seedlings remaining end of third year	Third year survival per cent.	Percent survival time of planting to time of harvest	Number planted	Seedlings remaining end of first year	First year survival per cent.	Seedlings remaining end of second year	Second year survival per cent.	Seedlings remaining end of third year	Third year survival per cent.	Percent survival time of planting to time of harvest
A	1962	15	15	100.0	15	100.0	14	93.3	93.3	15	14	93.3	14	100.0	14	100.0	93.3	10	10	100.0	10	100.0	10	100.0	100.0	40	39	97.5	39	100.0	38	97.4	95.0
	1963	15	10	66.7	3	30.0	2	66.7	13.3	15	5	33.3	2	40.0	2	100.0	13.3	15	10	66.7	10	100.0	10	100.0	66.7	45	25	55.6	15	60.0	14	93.3	31.1
	1964	15	12	80.0	12	100.0	12	100.0	80.0	15	2	13.3	2	100.0	1	50.0	6.7	15	11	73.3	11	100.0	11	100.0	73.3	45	26	55.6	25	100.0	24	96.0	53.3
T	1962	15	15	100.0	15	100.0	15	100.0	100.0	15	15	100.0	15	100.0	14	93.3	93.3	10	10	100.0	10	100.0	10	100.0	100.0	40	40	100.0	40	100.0	39	97.5	97.5
	1963	15	15	100.0	14	93.3	14	100.0	93.3	15	13	86.7	8	61.5	7	87.5	46.7	15	11	93.3	11	100.0	11	100.0	73.3	45	39	86.7	33	84.6	32	97.0	71.1
	1964	15	15	100.0	15	100.0	15	100.0	100.0	15	15	100.0	14	93.3	14	100.0	93.3	15	14	93.3	14	100.0	12	85.7	80.0	45	44	97.8	43	97.7	41	95.3	91.1
U	1962	15	15	100.0	15	100.0	14	93.3	93.3	15	14	93.3	13	92.9	11	84.6	73.3	10	10	100.0	10	100.0	10	100.0	100.0	40	39	97.5	38	97.4	35	92.1	87.5
	1963	15	5	33.3	3	60.0	3	100.0	20.0	15	7	46.7	5	71.4	3	60.0	20.0	15	11	73.3	11	100.0	11	100.0	73.3	45	23	51.1	19	82.6	17	89.5	37.8
	1964	15	13	86.7	13	100.0	13	100.0	86.7	15	10	66.7	9	90.0	9	100.0	60.0	15	12	80.0	11	91.7	11	100.0	73.3	45	35	77.8	33	94.3	33	100.0	73.3
BNF	1962	15	15	100.0	15	100.0	13	86.7	86.7	15	15	100.0	15	100.0	13	86.7	86.7	10	10	100.0	10	100.0	9	90.0	90.9	40	40	100.0	40	100.0	38	87.5	87.5
	1963	15	12	80.0	9	75.0	8	88.9	53.3	14	11	78.6	8	72.7	7	87.5	50.0	14	12	85.7	12	100.0	12	100.0	85.7	43	35	81.4	29	82.8	27	93.1	62.8
	1964	15	15	100.0	15	100.0	14	93.3	93.3	15	15	100.0	15	100.0	14	93.3	93.3	15	14	93.3	13	92.8	13	100.0	86.7	45	44	97.8	43	97.7	41	95.3	91.1
BSF	1962	15	15	100.0	15	100.0	15	100.0	100.0	15	15	100.0	15	100.0	14	93.3	93.3	10	10	100.0	10	100.0	10	100.0	100.0	40	40	100.0	40	100.0	39	97.5	97.5
	1963	15	9	60.0	6	66.7	5	83.3	33.3	14	6	42.9	5	83.3	5	100.0	35.7	15	14	93.3	13	92.8	13	100.0	86.7	44	29	65.9	24	82.8	23	95.8	52.3
	1964	15	15	100.0	15	100.0	15	100.0	100.0	15	11	73.3	10	90.9	9	90.0	60.0	15	12	80.0	11	91.7	10	90.0	66.7	45	38	84.4	36	94.7	34	94.4	75.6
All seedbeds	1962	75	75	100.0	75	100.0	71	94.7	94.7	75	73	97.3	72	98.6	66	91.7	88.0	50	50	100.0	50	100.0	49	98.0	98.0	200	198	99.0	197	99.5	186	94.4	93.0
	1963	75	51	68.0	35	68.6	32	91.4	42.7	73	42	57.5	28	66.7	24	85.7	32.9	74	58	78.4	57	98.3	57	100.0	77.0	222	151	68.0	120	79.5	113	94.2	50.9
	1964	75	70	93.3	70	100.0	69	92.6	92.0	75	53	70.7	50	94.3	47	94.0	62.7	75	63	84.0	60	95.2	57	95.0	76.0	225	186	82.7	180	96.8	173	96.1	76.9

TABLE 9

## FIRST, SECOND AND THIRD YEAR SURVIVAL OF PLANTED STOCK - STUDY B

			N								M								S								Average N, M, S							
Seedbed	Year of planting	Number planted	Seedlings remaining end of first year	First year survival per cent	Seedlings remaining end of second year	Second year survival per cent.	Seedlings remaining end of third year	Third year survival per cent.	Per cent survival time of planting to Sept. 1966	Seedlings remaining end of first year	First year survival per cent	Seedlings remaining end of second year	Second year survival per cent.	Seedlings remaining end of third year	Third year survival per cent.	Per cent survival time of planting to Sept. 1966	Seedlings remaining end of first year	First year survival per cent	Seedlings remaining end of second year	Second year survival per cent.	Seedlings remaining end of third year	Third year survival per cent.	Per cent survival time of planting to Sept. 1966	Number planted	Seedlings remaining end of first year	First year survival per cent.	Seedlings remaining end of second year	Second year survival per cent	Seedlings remaining end of third year	Third year survival per cent.	Per cent survival time of planting to Sept. 1966			
R	1964	15	12	80.0	12	100.0	12	100.0	80.0	11	73.3	11	100.0	11	100.0	73.3	9	60.0	9	100.0	9	100.0	60.0	45	32	71.1	32	100.0	32	100.0	71.1			
	1965	15	13	86.7	13	100.0			86.7	12	80.0	12	100.0			80.0	15	100.0	14	93.3			93.3	45	40	88.9	39	97.5			86.7			
	1966	15	15	100.0					100.0	14	93.3					93.3	13	86.7					86.7	45	42	93.3					93.3			
T	1964	15	13	86.7	13	100.0	13	100.0	86.7	14	93.3	14	100.0	14	100.0	93.3	15	100.0	15	100.0	15	100.0	100.0	45	42	93.3	42	100.0	42	100.0	93.3			
	1965	15	15	100.0	15	100.0			100.0	14	93.3	14	100.0			93.3	15	100.0	15	100.0			100.0	45	44	97.8	44	100.0			97.8			
	1966	15	15	100.0					100.0	14	93.3					93.3	15	100.0					100.0	45	44	97.8					97.8			
U	1964	15	15	100.0	15	100.0	14	93.3	93.3	11	73.3	11	100.0	11	100.0	73.3	12	80.0	10	83.3	9	90.0	60.0	45	38	84.4	36	94.7	34	94.4	75.6			
	1965	15	14	93.3	12	85.7			80.0	12	80.0	12	100.0			80.0	15	100.0	15	100.0			100.0	45	41	91.1	39	95.1			86.7			
	1966	15	15	100.0					100.0	14	93.3					93.3	14	93.3					93.3	45	43	95.6					95.6			
BNF	1964	15	15	100.0	15	100.0	15	100.0	100.0	14	93.3	14	100.0	14	100.0	93.3	15	100.0	14	93.3	13	92.8	86.7	45	44	97.8	43	97.7	42	97.7	93.3			
	1965	15	15	100.0	14	93.3			93.3	15	100.0	14	93.3			93.3	15	100.0	15	100.0			100.0	45	45	100.0	43	95.6			95.6			
	1966	15	15	100.0					100.0	15	100.0					100.0	15	100.0					100.0	45	45	100.0					100.0			
BSF	1964	15	15	100.0	15	100.0	15	100.0	100.0	14	93.3	14	100.0	14	100.0	93.3	12	80.0	11	91.7	11	100.0	73.3	45	41	91.1	40	97.6	40	100.0	88.9			
	1965	15	15	100.0	15	100.0			100.0	15	100.0	15	100.0			100.0	15	100.0	15	100.0			100.0	45	45	100.0	45	100.0			100.0			
	1966	15	15	100.0					100.0	15	100.0					100.0	15	100.0					100.0	45	45	100.0					100.0			
All Seedbeds	1964	75	70	93.3	70	100.0	69	98.6	92.0	64	85.3	64	100.0	64	100.0	85.3	63	84.0	59	93.6	57	96.6	76.0	225	197	87.6	193	98.0	190	98.4	84.4			
	1965	75	72	96.0	69	95.8			92.0	68	90.7	67	98.5			89.3	75	100.0	74	98.7			98.7	225	215	95.6	210	97.7			93.3			
	1966	75	75	100.0					100.0	72	96.0					96.0	12	96.0					96.0	225	219	97.3					97.3			

TABLE 10

AVERAGE SEEDLING HEIGHTS 1964, 1965 AND 1966 SEEDSPOTS  
STUDY B

Exposure	Date of establishment	Growth Period Years	R		T		U		BNF		BSF		All Seedbeds	
			No. seedling	Avg. ht. inches	No. seedling	Avg. ht. inches	No. seedling	Avg. ht. inches	No. seedling	Avg. ht. inches	No. seedling	Avg. ht. inches	No. seedling	Avg. ht. inches
N	1964	3	2	7.7	20	6.6	18	6.7	21	5.0	25	5.9	86	6.0
	1965	2	42	2.1	125	1.2	73	1.3	47	1.2	67	1.8	353	1.5
	1966	1	93	1.0	161	0.5	34	1.2	155	0.3	165	0.4	608	0.5
M	1964	3	5	4.6	8	6.5	5	6.3	10	9.6	8	6.3	36	7.0
	1965	2	5	1.9	31	2.8	21	2.9	50	3.8	37	3.8	144	3.5
	1966	1	0	—	17	0.5	4	1.1	35	0.8	18	0.4	74	0.7
S	1964	3	2	6.9	23	6.3	0	—	27	7.2	4	5.0	56	6.7
	1965	2	24	4.7	40	3.0	2	2.0	49	3.6	30	2.0	145	3.2
	1966	1	8	1.6	30	0.6	5	1.2	38	0.6	10	1.8	91	0.8
Average N, M, S	1964	3	9	5.8	51	6.4	23	6.6	58	6.8	37	5.9	178	6.4
	1965	2	71	3.3	196	1.8	95	1.7	146	2.9	133	2.4	642	2.3
	1966	1	101	1.0	208	0.5	43	1.2	228	0.5	193	0.5	773	0.6

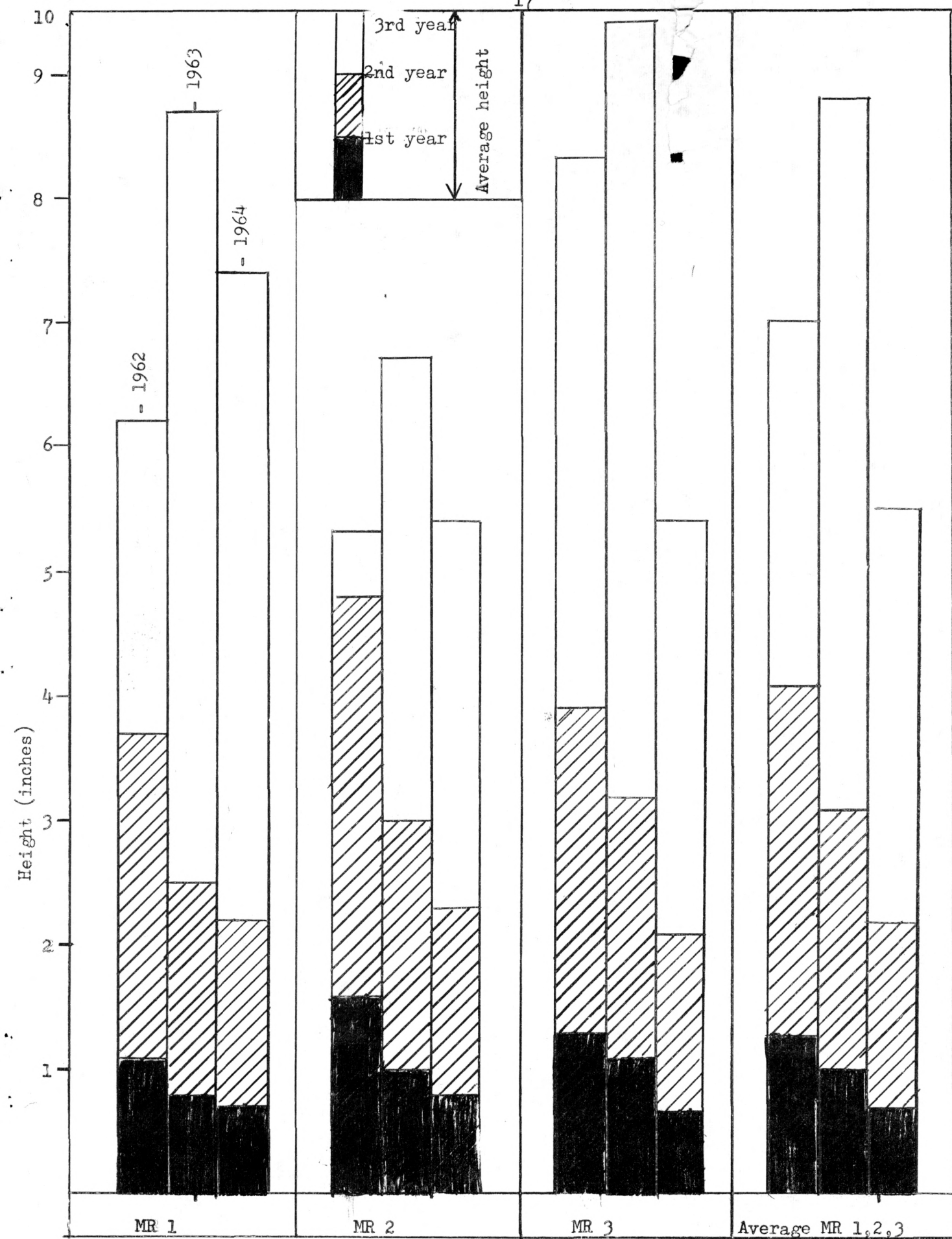


Figure 2: Average height of 1962, 1963 and 1964 seedspot seedlings for each moisture regime - study A.

Figure 3: Average height of 1962, 1963 and 1964 seedspot seedlings for each moisture regime and seedbed Study A

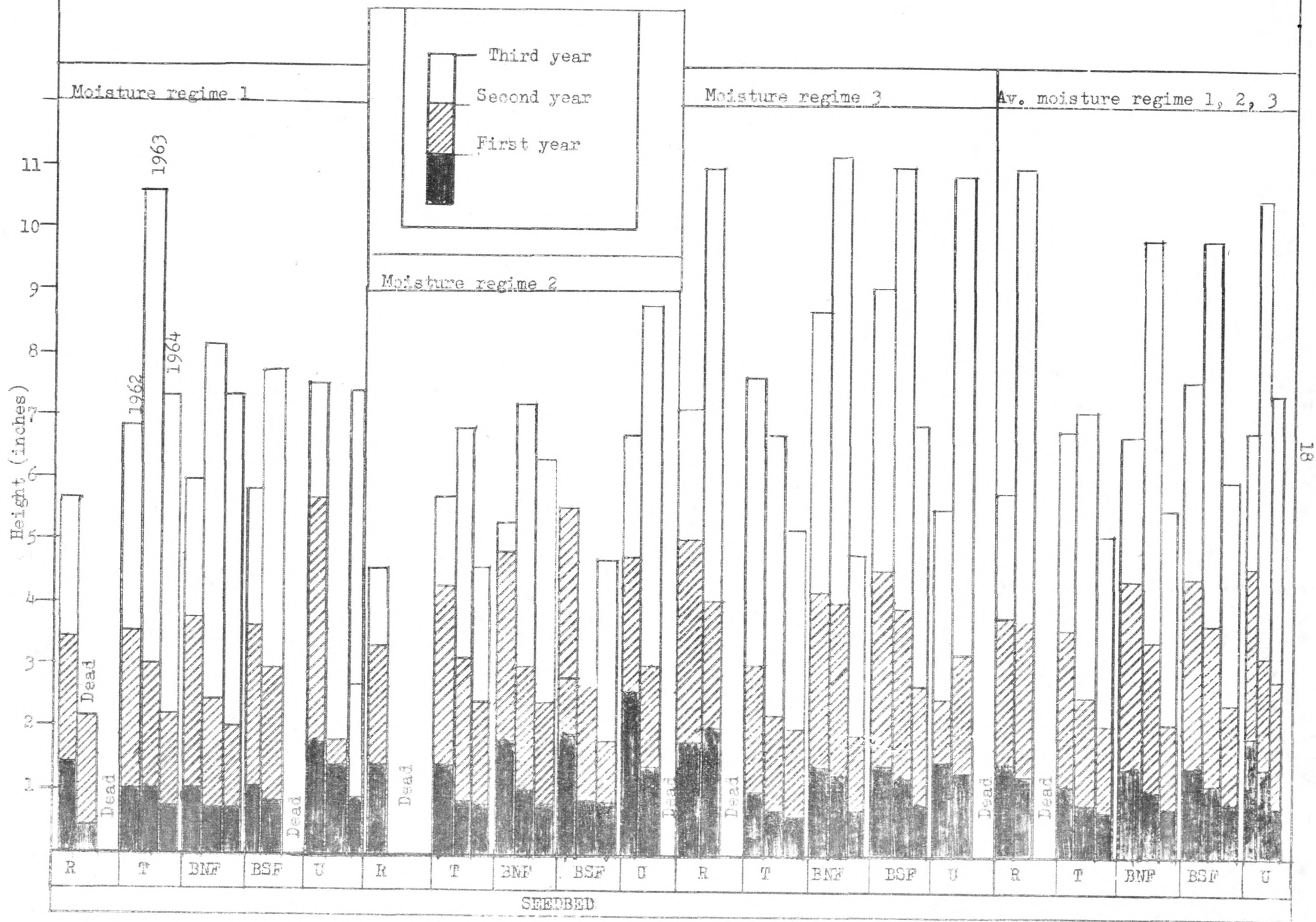


Figure 4: Average third-year growth of 1962, 1963 and 1964 planting stock for each seedbed and moisture regime - Study A.

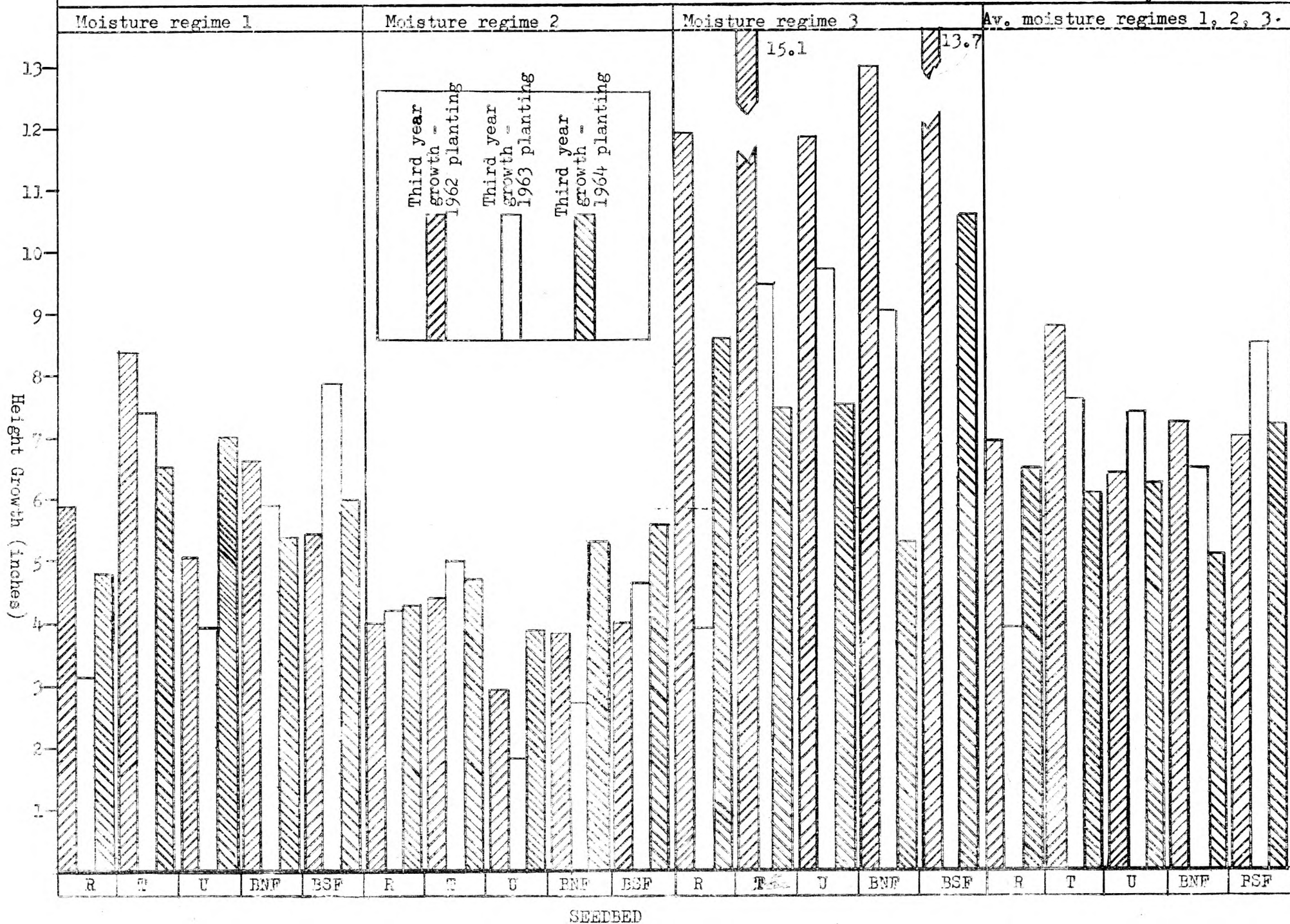


Figure 5.  
Average height growth seedbeds of  
1962, 1963 and 1964 planting stock for  
each moisture regime - Study A

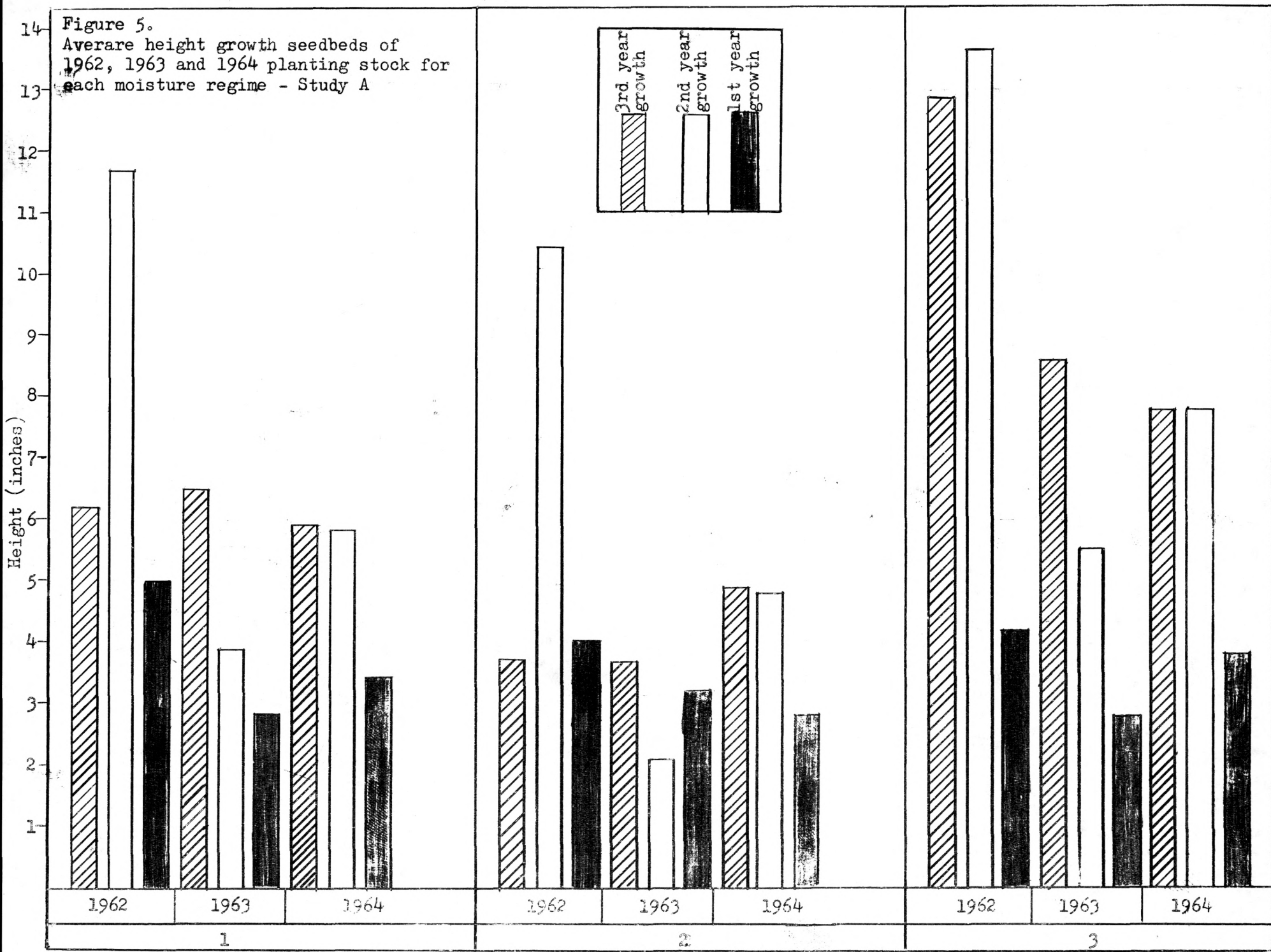
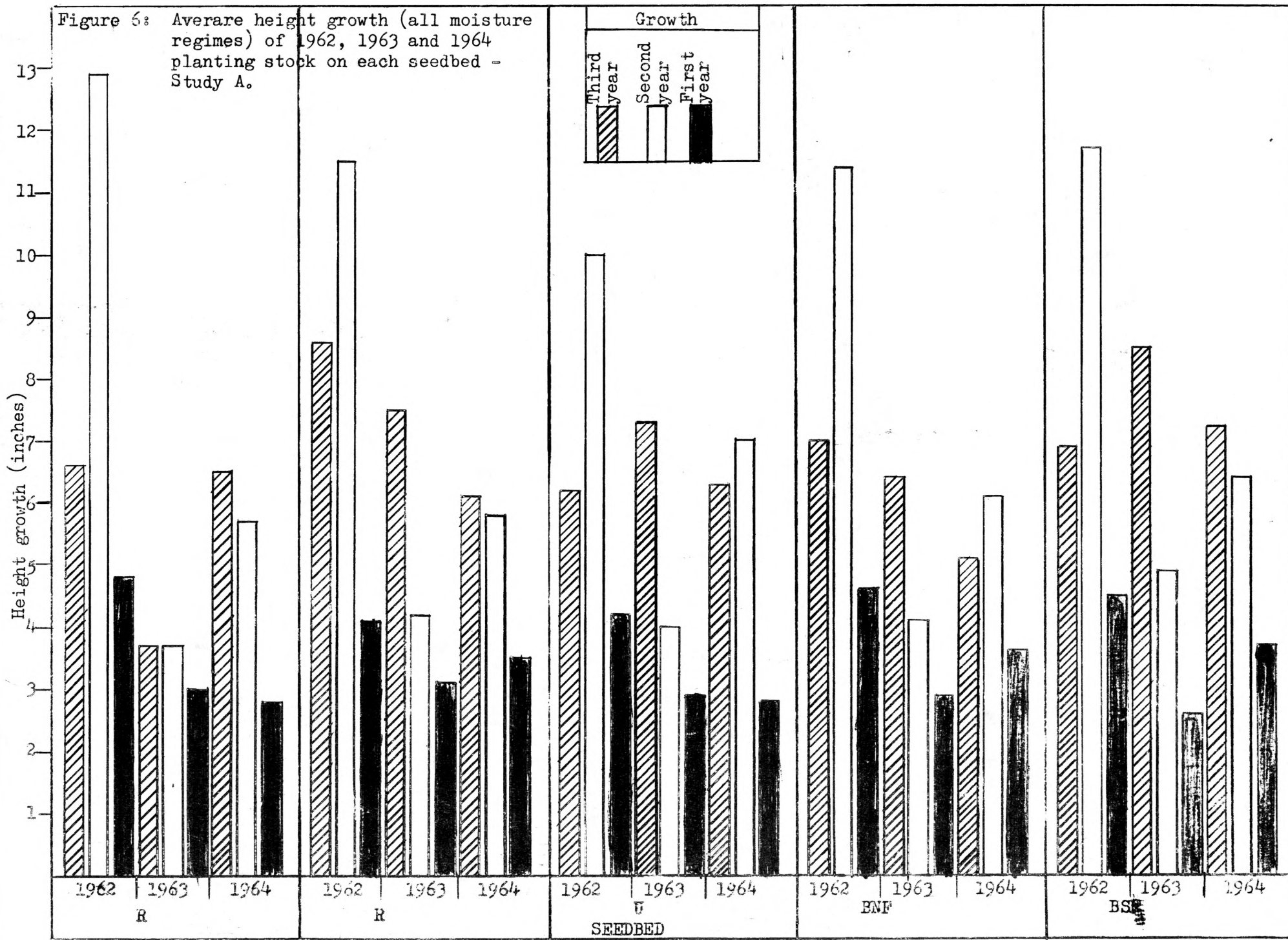


Figure 6: Average height growth (all moisture regimes) of 1962, 1963 and 1964 planting stock on each seedbed - Study A.



Height growth of planted stock - study B. Height of 1964, 1965 and 1966 stock is illustrated in Figure 7. Basic data for the figure may be found in Appendix III.

After three growing seasons the 1964 planting exhibited best growth on the N exposure and poorest growth on the S exposure; seedlings growing on the U seedbed of N exposure and on the BNF of M and S exposures showed the greatest growth. Considering the area as a whole, the greatest average height was found on the U seedbeds.

The 1965 planting showed the best growth on the S exposure and poorest on the N exposure after two growing seasons. Seedlings showing the greatest average height on each exposure were found on the following seedbeds - R of the N exposure, BNF of the M, and U of the S exposures.

The 1966 planting, after one growing season, showed the best growth on the N exposure; however, growth on all exposures was similar.

Root-collar diameter and oven-dry seedling weights of 1964 seedlings - study A. Seedling weights and root-collar diameters are given in Tables 11A, 11B, 14A and 14B. Oven dry seedling weights for the planted and seeded stock were greatest on MR1 and lowest on MR2. The T seedbed on MR1, the BNF on MR2 and BSF on MR3 produced the greatest seedling weights for the seeded stock. The BSF seedbed on MR1, the R on MR2 and the BNF on MR3 produced the greatest oven dry weights for the planted stock.

The largest root-collar diameters (average of all seedbeds) for the seeded and planted stock occurred in MR1 and the smallest on MR2. Planted seedlings with the largest root-collar diameters were found on the U seedbed of MR1, R seedbed of MR2 and BNF seedbed of MR3. Planted seedlings with the smallest diameters were found on the R seedbeds of MR1, T seedbeds of MR2 and BSF seedbeds of MR3. Seeded stock having the largest diameters were found on the T of MR1, BNF of MR2 and BSF seedbeds of MR3; smallest diameters were found on the U seedbeds of MR1, BSF of MR2 and BNF of MR3.

Root-collar diameters and oven-dry weights of 1964 seedlings - study B. Average root collar diameters and oven-dry seedling weights may be found in Tables 12A, 12B, 13A and 13B. Greatest oven-dry seedling weights were found on the S, M and N exposures respectively for the seed stock and on the M, N and S exposures respectively for the planted stock. Considering all exposures the BNF seedbed produced the largest seedlings and the BSF the smallest for the seeded stock and the R the largest and T the smallest for the planted stock.

The largest root-collar diameters on the planted stock (average of all seedbeds) were found on seedlings in the M exposure followed by the N and S exposures. Considering the area as a whole, the largest diameters were found on the R seedbeds, the smallest on the T seedbeds. Seeded stock exhibited largest root-collar diameters (average of all seedbeds) on the S exposure followed by the M and N exposures. Largest seedling diameters on the area were found in the T and BNF seedbeds, the smallest on the U seedbeds.

TABLE 11A  
AVERAGE OVEN-DRY SEEDLING WEIGHTS 1964 SEEDSPOTS  
STUDY A

Moisture regime	Oven-dry seedling weights (grams)					
	Seedbed					
	R	T	U	BNF	BSF	All seedbeds
1	—	3.9	1.3	2.4	—	2.7
2	—	0.6	—	0.8	0.5	0.6
3	—	0.8	—	0.6	0.9	0.8
All moisture regimes	—	0.8	1.3	0.8	0.7	0.8

TABLE 11B  
AVERAGE OVEN-DRY SEEDLING WEIGHTS 1964 PLANTING  
STUDY A

moisture regime	Oven-dry seedling weights. (grams)					
	Seedbed					
	R	T	U	BNF	BSF	All seedbeds.
1	20.5	21.8	27.0	24.2	28.3	24.4
2	17.1	6.9	8.3	12.6	7.6	9.3
3	18.2	20.0	23.8	25.8	16.6	21.1
All moisture regimes	19.3	16.2	20.8	20.8	19.4	19.2

TABLE 12A

AVERAGE OVEN-DRY SEEDLING WEIGHTS 1964 SEEDSPOTS  
STUDY B

Exposure	Oven-dry seedling weights (grams) Seedbed					
	R	T	U	BNF	BSF	All seedbeds
N	2.6	2.8	1.4	1.7	1.6	1.9
M	1.6	1.9	0.8	3.0	2.1	2.1
S	1.6	2.1	—	3.0	1.6	2.5
All exposures	1.8	2.3	1.3	2.5	1.7	2.1

TABLE 12B

AVERAGE OVEN-DRY SEEDLING WEIGHTS 1964 PLANTING  
STUDY B

Exposure	Oven-dry seedling weights (grams) Seedbed					
	R	T	U	BNF	BSF	All seedbeds
N	39.2	18.4	37.7	23.8	33.2	30.3
M	42.2	19.9	25.4	38.9	37.2	32.6
S	31.0	22.1	17.6	29.8	24.3	25.0
All exposures	37.9	20.2	28.4	30.7	32.2	29.5

TABLE 13A

AVERAGE ROOT-COLLAR DIAMETER 1964 PLANTING-STUDY B

Exposure	Root-collar diameters (cm.) seedbed					
	R	T	U	BNF	BSF	All seedbeds
N	1.14	0.82	1.12	0.89	0.93	0.98
M	1.16	0.82	1.01	1.09	1.04	1.02
S	1.07	0.92	0.90	0.99	0.95	0.96
Average N,M,S.	1.13	0.86	1.03	0.99	0.97	0.99

TABLE 13B

AVERAGE ROOT-COLLAR DIAMETER 1964 SEEDSPOTS STUDY B

Exposure	Root-collar diameters (cm.) Seedbed					
	R	T	U	BNF	BSF	All Seedbeds
N	0.38	0.32	0.27	0.25	0.26	0.28
M	0.25	0.30	0.30	0.36	0.34	0.32
S	0.32	0.33	—	0.35	0.33	0.34
Average N,M,S	0.30	0.32	0.27	0.32	0.28	0.30

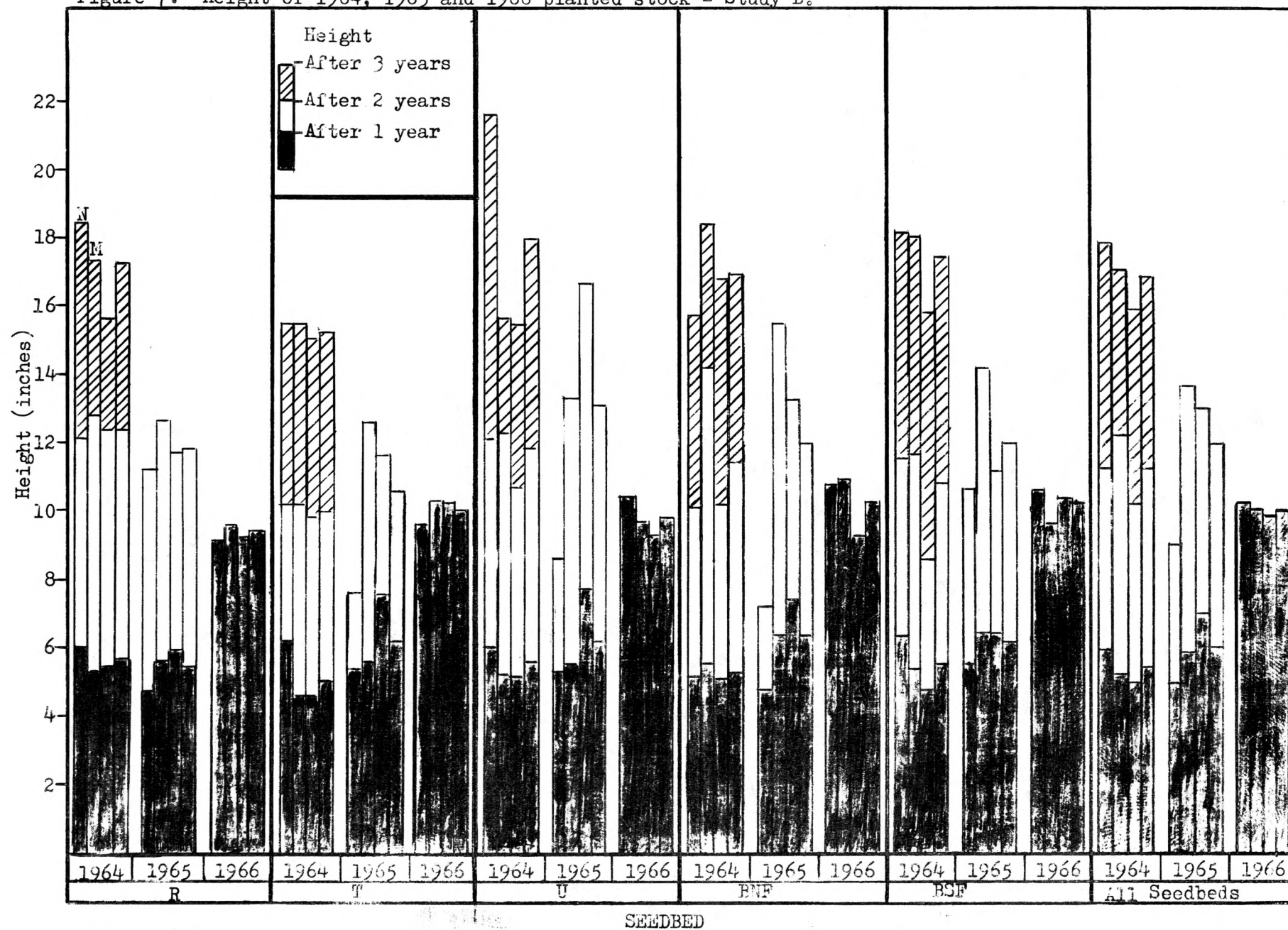
TABLE 14A  
AVERAGE ROOT-COLLAR DIAMETER 1964 PLANTING STUDY A

Moisture regime	Root-collar diameters (cm.)					
	R	T	U	BNF	BSF	All seedbeds
1	0.83	0.89	1.02	0.90	0.96	0.92
2	0.99	0.62	0.71	0.71	0.66	0.68
3	0.84	0.86	0.77	0.94	0.75	0.84
Average 1, 2 & 3	0.84	0.79	0.85	0.85	0.82	0.83

TABLE 14B  
AVERAGE ROOT-COLLAR DIAMETER 1964 SEEDSPOTS STUDY A

Moisture regime	Root-collar diameters (cm.)					
	R	T	U	BNF	BSF	All seedbeds
1	—	0.41	0.28	0.31	—	0.32
2	—	0.20	—	0.21	0.16	0.20
3	—	0.21	—	0.19	0.24	0.21
Average 1, 2 & 3	—	0.21	0.28	0.20	0.21	0.21

Figure 7: Height of 1964, 1965 and 1966 planted stock - Study B.



Soil temperature, 1966 - study B. Seasonal extreme soil surface temperatures and total time (in minutes) seedbed temperatures remained over 120°F are shown in Table 15. Soil surface temperatures did not exceed 120°F on the T seedbeds of the N exposure nor the BNF seedbeds of N and M exposures. Total time of temperatures  $\geq 120^\circ\text{F}$  on the M and S exposures far exceeded that of N exposure. Overall exposures, seedbeds in order of decreasing total critical temperature minutes were U, BSF, R, T and BNF.

Average maximum air temperature for the period May 23 to October 2 was 74.7°F; maximum air temperature reached 94.0°F, however, temperatures above 90°F were recorded for three days only.

Precipitation, 1966 - study A. Rainfall for each moisture regime is shown in Table 16. Total rainfall for MRs 1, 2 and 3 was above the 30-year average for the area.

Precipitation, 1966 - study B. Rainfall for the period May 24 to October 3 is given in Table 17. Rainfall is only slightly above the 30-year average for the area.

Solar radiation - study B. Difficulties were experienced with the actinograph and incomplete records were obtained. They are not presented in this report.

Forest insect survey. The following species were collected on the study areas.

Study A - MR3 - Archips cerasivoranus - ugly nest  
tortrix

Choristoneura pinus - jack pine  
budworm

Study B - 1964 area - Toumeyella numismaticum - pine tortoise  
scale

Choristoneura pinus - jack pine  
budworm

Phenacaspis pinifoliae - pine needle  
scale

Study B - 1965 area - Choristoneura pinus - jack pine  
budworm

Study B - 1966 area - Phenacaspis pinifoliae - pine needle  
scale

Choristoneura pinus - jack pine  
budworm

TABLE 15

SEASONAL EXTREME SOIL SURFACE TEMPERATURES  
AND TOTAL TIME  $\geq 120^{\circ}\text{F}$  FOR EACH SEEDBED AND EXPOSURE  
STUDY B

Seedbed	Seasonal maximum ( $^{\circ}\text{F}$ )				Average time $\geq 120^{\circ}\text{F}$ (minutes)			
	Exposure				Exposure			
	N	M	S	N,M,S.	N	M	S	N,M,S.
R	131.9	152.6	147.2	152.6	252	25,252	17,135	42,639
T	<120	147.2	138.2	147.2	—	5,128	2,491	7,619
U	146.3	179.6	162.5	179.6	914	37,909	35,833	74,656
BNF	<120	<120	122.9	122.9	—	—	151	151
BSF	128.3	151.7	154.4	154.4	126	19,973	35,345	55,444
				Total	1,292	88,262	90,955	180,509

TABLE 16  
PRECIPITATION DURING THE PERIOD  
MAY 11 TO AUGUST 29, 1966 STUDY A

Precipitation (inches)					
Collection period	Total	MR1	MR2	MR3	30 year avg. Sprague
May 11 - May 23		1.69	0.56	0.37	
24 30		0.18	0.12	0.14	
31		0.09	0.11	0.11	
	May 11 - 31	1.96	0.79	0.62	1.32
June 1 - June 6		0.55	0.69	0.64	
7 13		1.61	1.10	1.18	
14 20		0.39	0.12	0.15	
21 27		1.26	1.54	1.42	
28 30		0.72	1.26	1.05	
	June 1 - 30	4.53	4.71	4.44	3.06
July 1 - July 4		0.96	1.67	1.39	
5 11		1.11	1.32	2.45	
12 18		NIL	NIL	NIL	
19 25		1.04	0.20	0.17	
26 31		0.55	0.48	0.24	
	July 1 - 31	3.66	3.67	4.25	2.92
Aug. 1 - Aug -		0.09	0.09	0.02	
2 8		0.89	0.85	0.72	
9 15		0.56	0.53	0.60	
16 22		1.30	0.52	0.58	
23 29		NIL	0.19	NIL	
	Aug 1 - 29	2.84	2.18	1.92	3.28
Total	May 11 - Aug 29	12.99	11.35	11.23	10.58

**TABLE 17**  
**PRECIPITATION DURING THE PERIOD**  
**MAY 24 TO OCTOBER 3, 1966, STUDY B**

Precipitation (inches)				
Collection period	Total	Casella recording gauge	Beal gauge	30 year avg. Sprague
May 24 - May 30 31	May 24 - 31	0.14	0.16	0.50
		0.09	0.10	
		0.23	0.26	
June 1 June 6 7 13 14 20 21 27 28 30	June 1 - 30	0.56	0.57	3.06
		1.44	1.46	
		0.26	0.24	
	June 1 - 30	1.22	1.20	3.06
		0.53	0.54	
		4.01	4.01	
July 1 July 4 5 11 12 18 19 25 26 31	July 1 - 31	0.71	0.72	2.92
		1.09	1.00	
		0.01	NIL	
	July 1 - 31	1.61	1.60	2.92
		0.48	0.52	
		3.90	3.84	
Aug. 1 Aug. 8 2 15 9 22 16 29 23 31 30 31	Aug. 1 - 31	0.08	0.09	3.51
		0.91	0.93	
		0.63	0.65	
	Aug. 1 - 31	1.11	1.14	3.51
		0.06	NIL	
		0.43	0.43	
	Aug. 1 - 31	3.22	3.24	
Sept. 1 Sept. 5 6 12 13 19 20 26 27 30	Sept. 1 - 30	1.08	1.07	2.28
		0.01	NIL	
		0.10	NIL	
	Sept. 1 - 30	NIL	NIL	2.28
		0.15	0.22	
		1.34	1.29	
Oct. 1 Oct. 3	Oct 1 - 3	0.11	0.17	0.12
Total	May 24 - Oct 3	12.81	12.81	12.39

Mortality - Microclimate Relationships - study B. Damping-off appeared to be the most prevalent cause of mortality on each exposure. No mortality from damping-off occurred after July 31, with the exception of S exposure where damping-off occurred during the week of August 29 to September 4. Mortality after July 31 was mostly confined to the north exposure and attributed to heat. The M exposure suffered the highest mortality loss; S exposure was second highest and N was least. Peaks of mortality on the S and M exposures were preceded by rainfall of over an inch and accompanied by high temperatures.

#### WORK PROPOSED, 1967 - STUDY B

##### Measurements

- (a) Seeding and planting. Mortality of the 1965 and 1966 stock will be recorded in May and September of 1967.

At the end of the 1967 growing season, height growth and total height of all 1965 and 1966 stock will be measured. The 1965 stock will be harvested in September of 1967 and root-collar diameters and oven-dry weights obtained.

- (b) Precipitation. Precipitation on one of the three areas will be collected by means of three Beal-type rain gauges.

##### Co-operation With the Forest Insect and Disease Survey

The Forest Insect and Disease Survey will be contacted for assistance in the assessment of insect problems.

#### ANALYSIS OF RESULTS

Analysis of results will be carried out as described in the 1964 progress report at the end of the 3-year duration of Study B.

## REFERENCES

- Mueller-Dombois, D. 1964. The forest habitat types in southeastern Manitoba and their application to forest management. Can. Jour. Bot. 42:1417-1444.
- Sims, H.P. 1963. Characteristics of soil temperature and moisture, germination of jack pine seed, and seedling establishment on seedbeds created by a Middlebuster plow in southeastern Manitoba. Dept. of Forestry Canada, For. Res. Br. Unpublished mimeo 63-MS-11: 14 p.
- Sims, H.P. 1964. Characteristics of soil temperature and moisture, germination of jack pine seed, and seedling establishment on seedbeds created by a Middlebuster plow in southeastern Manitoba. Dept. of Forestry Canada, For. Res. Br. Unpublished mimeo 64-MS-17: 38 p.
- Sims, H.P. 1965. Characteristics of soil temperature and moisture, germination of jack pine seed, and seedling establishment on seedbeds created by a Middlebuster plow in southeastern Manitoba. Dept. of Forestry Canada, For. Res. Br. Unpublished mimeo 65-MS-18: 64 p.

## APPENDIX I

## AVERAGE SEEDLING HEIGHTS

1962, 1963 and 1964 SEEDSPOTS

STUDY A.

Date of seedspot establishment	Growth period years	MR	P 1 0 +	R		U		T		BNF		BSF		All seedbeds		
				No. Seedling	Av. ht. inches	No. Seedling	Av. ht. inches	No. Seedling	Av. ht. inches	No. Seedling	Av. ht. inches	No. Seedling	Av. ht. inches	No. Seedlings	Total ht inches	Av. ht inches
1964	3	1	10					2	7.3	4	9.5					
1963			1			1	8.9	3	6.4	5	6.9					
1962			4					12	4.8	19	5.7	17	6.0			
1964	3	1	11							3	5.2					
1963			2					3	16.2	3	7.4					
1962			5	1	5.6			26	8.4	12	5.6	16	7.2			
1964	3	1	12			4	7.4			2	6.3					
1963			3					2	8.4	13	8.7	2	7.7			
1962			6			7	7.5	4	4.9	15	6.3	14	4.1			
1964	3	Average MR 1				4	7.4	2	7.3	9	7.3			15	110.3	7.4
1963						1	8.9	8	10.5	21	8.1	2	7.7	32	278.8	8.7
1962				1	5.6	7	7.5	36	6.8	46	5.9	47	5.8	137	847.5	6.2
1964	3	2	13					1	7.0	3	6.2	1	8.4			
1963			4			1	8.5	6	8.9	3	8.7	3	5.8			
1962			1	1	3.3			26	6.0	14	5.1	13	5.2			
1964	3	2	14					30	4.3	46	6.2	27	4.5			
1963			5					10	7.5	1	6.2	1	4.0			
1962			2	1	2.9	1	6.6	27	6.2	27	4.8	10	6.3			
1964	3	2	15					1	11.3	8	6.6	1	6.7			
1963			6			1	9.0	9	4.6	3	6.0	2	4.4			
1962			3	8	5.0			21	4.7	24	4.4	12	5.1			
1964	3	Average MR 2						32	4.6	57	6.3	29	4.7	118	642.4	5.4
1963						2	8.8	25	6.8	7	7.2	6	5.0	40	267.6	6.7
1962				10	4.6	1	6.6	74	5.7	65	4.7	35	5.5	185	973.4	5.3
1964	3	3	17					40	6.8	43	6.1	31	7.1			
1963			8	2	14.9	4	8.3	5	13.0	6	14.5	10	13.2			
1962			8	4	10.4	1	10.2	60	8.0	47	9.4	60	9.9			
1964	3	3	16					10	3.0	19	3.4					
1963			7			4	12.4	39	5.8	24	10.2	6	12.8			
1962			7	5	4.5	4	4.3	47	7.1	41	7.7	43	7.8			
1964	3	3	18					23	3.5	36	4.0	12	6.4			
1963			9	3	8.3	2	12.6	5	7.3	11	11.2	13	8.4			
1962			-													
1964	3	Average MR 3						73	5.2	98	4.8	43	6.9	214	1152.2	5.4
1963				5	10.9	10	10.8	49	6.7	41	11.1	29	11.0	134	1265.4	9.4
1962				9	7.1	5	5.5	107	7.6	88	8.6	103	9.0	312	2594.3	8.3
1964	3	Average MR 1,2 & 3.				4	7.4	107	5.1	164	5.5	72	6.0	347	1904.9	5.5
1963				5	10.9	13	10.3	82	7.1	69	9.8	37	9.8	208	1811.8	8.8
1962				20	5.8	13	6.7	217	6.8	199	6.7	185	7.6	634	4415.2	7.0

APPENDIX II

HEIGHT GROWTH OF 1962, 1963 and 1964

PLANTED STOCK

STUDY A.

Moisture regime	Seed bed	Average 1966 Growth (inches)	Average 1965 growth (inches)		Average 1964 growth (inches)			Average 1963 growth (inches)		Average 1962 growth (inches)
		1964 planting	1963 planting	1964 planting	1962 planting	1963 planting	1964 planting	1962 planting	1963 planting	1962 planting
1	R	4.8	3.0	5.0	5.7	2.0	3.1	12.7	3.0	5.4
	U	7.0	3.9	7.2	5.0	3.3	2.9	11.7	2.8	4.9
	T	6.5	7.4	5.4	8.3	4.0	3.5	10.8	3.2	4.3
	BNF	5.4	5.8	5.5	6.4	4.3	3.4	11.8	2.8	5.4
	BSF	6.0	7.8	6.0	5.3	4.4	3.8	11.5	2.1	5.0
	All seedbeds	5.9	6.5	5.8	6.2	3.9	3.4	11.7	2.8	5.0
2	R	4.3	4.2	4.8	3.9	1.8	1.3	11.7	3.0	4.6
	U	3.9	1.8	6.6	2.8	2.0	2.4	9.9	2.3	3.9
	T	4.7	4.9	4.9	4.3	2.0	2.9	10.7	3.6	4.1
	BNF	5.3	2.6	4.6	3.7	2.0	2.8	9.3	3.0	3.9
	BSF	5.6	4.6	3.4	3.9	3.0	3.5	11.0	4.6	3.8
	All seedbeds	4.9	3.7	4.8	3.7	2.1	2.8	10.5	3.2	4.0
3	R	8.6	3.8	6.5	11.6	4.7	2.8	14.8	3.0	4.1
	U	7.5	9.7	7.1	11.7	5.2	2.9	12.6	3.2	3.5
	T	7.3	9.4	7.2	15.1	6.6	4.2	13.8	2.5	3.8
	BNF	5.3	9.0	8.7	12.8	5.3	4.7	13.9	3.0	4.6
	BSF	10.6	10.3	9.8	13.5	5.6	3.9	13.2	2.6	5.0
	All seedbeds	7.7	8.6	7.8	12.9	5.5	3.8	13.7	2.8	4.2
Average 1, 2 & 3	R	6.5	3.7	5.7	6.6	3.7	2.8	12.9	3.0	4.8
	U	6.3	7.3	7.0	6.2	4.0	2.8	11.3	2.9	4.2
	T	6.1	7.5	5.8	8.6	4.2	3.5	11.5	3.1	4.1
	BNF	5.1	6.4	6.1	7.0	4.1	3.6	11.4	2.9	4.6
	BSF	7.2	8.5	6.4	6.9	4.9	3.7	11.7	2.6	4.5
	All seedbeds	6.2	6.9	6.2	7.1	4.2	3.3	11.8	2.9	4.4

APPENDIX III

SEEDLING HEIGHTS

1964 AND 1965 PLANTING

STUDY B.

	R		T		LL		BNF		BSF		All seedbeds	
Exposure	No. seedlings	Avg. ht. (inches)	No. seedlings	Avg. ht. (inches)	No. seedlings	Avg. ht. (inches)	No. seedlings	Avg. ht. (inches)	No. seedlings	Avg. ht. (inches)	No. seedlings	Avg. ht. (inches)
1964 planting - height after one growing season												
N	12	6.0	13	6.2	15	6.0	15	5.2	15	6.3	70	5.9
M	10	5.3	14	4.6	11	5.2	15	5.5	14	5.3	64	5.2
S	9	5.4	15	4.6	13	5.1	15	5.1	12	4.7	64	5.0
Avg. N, M, S.	31	5.6	42	5.1	39	5.5	45	5.3	41	5.5	198	5.4
1964 planting - height after two growing seasons												
N	12	12.1	13	10.2	15	12.1	15	10.0	15	11.5	70	11.2
M	11	12.8	14	10.2	11	12.3	14	14.2	14	11.6	64	12.2
S	9	12.4	15	9.8	9	12.7	14	10.2	11	8.6	58	10.2
Avg. N, M, S.	32	12.4	42	10.0	35	11.8	43	11.4	40	10.8	192	11.2
1964 planting - height after three growing seasons												
N	12	18.4	13	15.4	14	21.6	15	15.7	15	18.1	69	17.8
M	11	17.3	14	15.4	11	15.6	14	18.4	14	18.0	64	17.0
S	9	15.6	15	14.9	9	15.4	13	16.8	11	15.7	57	15.7
Avg. N, M, S.	32	17.2	42	15.2	34	18.0	42	16.9	40	17.4	190	16.9
1965 planting - height after one growing season.												
N	14	4.7	15	5.3	15	5.3	15	4.8	15	5.5	74	5.1
M	12	5.5	14	5.6	12	5.5	15	6.4	15	6.4	68	5.8
S	15	5.9	15	7.6	13	7.7	15	7.4	15	6.4	75	7.0
Avg. N, M, S.	41	5.4	44	6.2	40	6.2	45	6.3	45	6.1	217	6.0
1965 planting - height after two growing seasons.												
N	13	11.2	15	7.6	12	8.6	14	7.2	15	10.6	69	9.0
M	12	12.6	14	12.6	12	13.1	14	15.4	15	14.2	67	13.6
S	14	11.7	15	11.6	15	16.7	15	13.2	15	11.2	74	12.9
Avg. N, M, S.	39	11.8	44	10.6	39	13.1	43	12.0	45	12.0	210	11.9
1966 planting - height after one growing season.												
N	15	9.1	15	9.6	15	10.4	15	10.7	15	10.5	75	10.1
M	13	9.5	14	10.3	14	9.7	15	10.9	15	9.6	71	10.0
S	13	9.2	15	10.2	14	9.2	15	9.3	15	10.3	72	9.7
Avg. N, M, S.	41	9.3	44	10.0	43	9.8	45	10.3	45	10.2	218	9.9

APPENDIX IV

MORTALITY ON 1964 SEEDSPOTS,  
SEPTEMBER 1963 TO SEPTEMBER 1965  
STUDY A.

Moisture regime	No. seedlings Sept. 1965	No. seedlings died Sept. 1965 - May 1966	Per cent mortality Sept. 1965 - May 1966	No. seedlings May 1966	No. seedlings died May 1966 - Sept. 1966	Per cent mortality May 1966 - Sept. 1966	No. seedlings Sept. 1966	No. seedlings died Sept. 1965 - Sept. 1966	Per cent mortality Sept. 1965 - Sept. 1966
<i>R</i>									
MR1	—	—	—	—	—	—	—	—	—
MR2	—	—	—	—	—	—	—	—	—
MR3	—	—	—	—	—	—	—	—	—
Total	—	—	—	—	—	—	—	—	—
<i>T</i>									
MR1	3	1	33.3 <sup>1</sup>	2	0	0.0	2	1	33.3
MR2	37	5	13.5	32	0	0.0	32	5	13.5
MR3	80	6	7.5	74	1	1.4	73	7	8.8
Total	120	12	10.0	108	1	0.9	107	13	10.8
<i>UL</i>									
MR1	5	0	0	5	2	40.0	3	2	40.0
MR2	—	—	—	—	—	—	—	—	—
MR3	—	—	—	—	—	—	—	—	—
Total	5	0	0	5	2	40.0	3	2	40.0
<i>BNE</i>									
MR1	9	0	0	9	0	0.0	9	—	0.0
MR2	63	6	9.5	57	3	5.3	54	9	14.3
MR3	98	0	0	98	0	0.0	98	0	0.0
Total	170	6	3.5	164	3	1.8	161	9	5.6
<i>BSF</i>									
MR1	—	—	—	—	—	—	—	—	—
MR2	29	0	0	29	0	0.0	29	—	0.0
MR3	49	2	4.1	47	4	8.5	43	6	12.2
Total	78	2	2.6	76	4	5.3	72	6	7.7
<i>All seedbeds</i>									
MR1	17	1	5.9	16	2	12.5	14	3	17.6
MR2	129	11	8.5	118	3	2.5	115	14	10.8
MR3	227	8	3.5	219	5	2.3	214	13	10.1
Total	373	20	5.4	353	10	2.8	343	30	8.7

<sup>1</sup> Per cent based upon number of seedling remaining at the beginning of each period.

## APPENDIX V

MORTALITY ON 1964 SEEDSPOTS  
SEPTEMBER 1965 TO SEPTEMBER 1966  
STUDY B.

Exposure	No. seedlings Sept. 1965	No. seedlings died Sept. 1965 - May 1966	Per cent mortality <sup>1</sup> Sept. 1965 - May 1966	No. seedlings May 1966	No. seedlings died May 1966 - Sept. 1966	Per cent mortality May 1966 - Sept. 1966	No. seedlings Sept. 1966	No. seedlings died Sept. 1965 - Sept. 1966	Per cent mortality Sept. 1965 - Sept. 1966
<i>R</i>									
<i>N</i>	3	0	0.0	3	1	33.3	2	1	50.0
<i>M</i>	5	0	0.0	5	0	0.0	5	0	0.0
<i>S</i>	2	0	0.0	2	0	0.0	2	0	0.0
Total	10	0	0.0	10	1	10.0	9	1	11.1
<i>T</i>									
<i>N</i>	20	0	0.0	20	0	0.0	20	0	0.0
<i>M</i>	8	0	0.0	8	0	0.0	8	0	0.0
<i>S</i>	23	0	0.0	23	0	0.0	23	0	0.0
Total	51	0	0.0	51	0	0.0	51	0	0.0
<i>LL</i>									
<i>N</i>	18	0	0.0	18	0	0.0	18	0	0.0
<i>M</i>	5	0	0.0	5	0	0.0	5	0	0.0
<i>S</i>	0	0	0.0	0	0	0.0	0	0	0.0
Total	23	0	0.0	23	0	0.0	23	0	0.0
<i>BNF</i>									
<i>N</i>	24	1	4.2	23	1	4.3	22	2	9.1
<i>M</i>	13	0	0.0	13	0	0.0	13	0	0.0
<i>S</i>	29	0	0.0	29	2	6.9	27	2	7.4
Total	66	1	1.5	65	3	4.6	62	4	6.4
<i>BSF</i>									
<i>N</i>	25	0	0.0	25	0	0.0	25	0	0.0
<i>M</i>	6	0	0.0	6	0	0.0	6	0	0.0
<i>S</i>	4	0	0.0	4	0	0.0	4	0	0.0
Total	35	0	0.0	35	0	0.0	35	0	0.0
<i>All seedbeds</i>									
<i>N</i>	90	1	1.1	89	2	2.2	87	3	3.4
<i>M</i>	37	0	0.0	37	0	0.0	37	0	0.0
<i>S</i>	58	0	0.0	58	2	3.4	56	2	3.6
Total	185	1	0.5	184	4	2.2	180	5	2.8

<sup>1</sup> Per cent based upon number of seedlings remaining at the beginning of each period.

APPENDIX VI  
MORTALITY ON 1965 SEEDSPOTS  
SEPTEMBER 1965 TO SEPTEMBER 1966  
STUDY B.

Exposure	No. seedlings Sept. 1965	No. seedlings died Sept. 1965 - May 1966	Per cent mortality Sept. 1965 - May 1966	No. seedlings May 1966	No. seedlings died May 1966 - Sept. 1966	Per cent mortality May 1966 - Sept. 1966	No. seedlings Sept. 1966	No. seedlings died Sept. 1965 - Sept. 1966	Per cent mortality Sept. 1965 - Sept. 1966
<i>R</i>									
<i>N</i>	45	3	6.7	42	0	0	42	3	6.7
<i>M</i>	5	0	0	5	0	0	5	0	0
<i>S</i>	25	0	0	25	1	4.0	24	1	4.0
Total	75	3	4.0	72	1	1.4	71	4	5.3
<i>T</i>									
<i>N</i>	127	1	0.8	126	1	0.8	125	2	1.6
<i>M</i>	31	0	0	31	0	0	31	0	0
<i>S</i>	40	0	0	40	0	0	40	0	0
Total	198	1	0.5	197	1	0.5	196	2	1.0
<i>CL</i>									
<i>N</i>	76	3	3.9	73	0	0	73	3	3.9
<i>M</i>	23	1	4.3	22	1	4.5	21	2	8.7
<i>S</i>	4	1	25.0	3	1	33.3	2	2	50.0
Total	103	5	4.8	98	2	2.0	96	7	6.8
<i>BNF</i>									
<i>N</i>	56	7	12.5	49	3	6.1	46	10	17.8
<i>M</i>	51	0	0	51	1	2.0	50	1	2.0
<i>S</i>	51	2	3.9	49	0	0	49	2	3.9
Total	158	9	5.7	149	4	2.7	145	13	8.2
<i>BSF</i>									
<i>N</i>	70	2	2.8	68	1	1.5	67	3	4.3
<i>M</i>	38	1	2.6	37	0	0	37	1	2.6
<i>S</i>	31	1	3.2	30	0	0	30	1	3.2
Total	139	4	2.9	135	1	0.7	134	5	3.6
<i>All seedbeds</i>									
<i>N</i>	374	16	4.3	358	5	1.4	353	21	5.6
<i>M</i>	148	2	1.4	146	2	1.4	144	4	2.7
<i>S</i>	151	4	2.6	147	2	1.4	145	6	4.0
Total	673	22	3.3	651	9	1.4	642	31	4.6

1 Per cent based on number of seedlings remaining at the beginning of each period.