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
INTERNAL REPORT MS-28

DEPARTMENT OF FORESTRY
APRIL, 1966

CONTENTS

CONTENTS (continued)

ACKNOWLEDGEMENT

The author wishes to express his appreciation to the Forest Insect and Disease Survey, particularly Mr. Ken Mortensen, who collected and identified insects on the study areas.

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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 2 to 3 inches deep and 3 to 4 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[1] on three sites - oligotrophic dry, mesotrophic fresh-minus and oligtrophic 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 the following paper 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.

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

WORK COMPLETED IN 1965

Methods

Establishment of sample plots - Nine plots were located on a new east-west strip which had been plowed in 1964 and cut during the winter of 1964-65 (Study B). The plots were subjectively located so that the north, south and middle one-third of the strip each contained three plots (Figure 1).

Each plot contained the following treatments:

(1) Three spots per seedbed condition (ridge, undisturbed, trough, base of south-facing slope, and base of north-facing slope)[2] seeded with 50 seeds each. Sub-plot size one milacre.

(2) Five 2-year-old seedlings planted on each seedbed condition. Sub-plot size one milacre.

Seeding was done April 29 and planting was done on May 4.

Study - B area was fenced to prevent breakage of instruments by mammals. No new plots were located on Study - A areas.

Seedspot and planting stock tally and measurement - study A. Seedlings established in 1963 and 1964 were checked for mortality in May and late August of 1965. Total heights and 1965 growth were measured in late August of 1965; root collar diameters of 1963 seedlings were also measured. The latter seedlings were then harvested and oven-dry weights obtained.

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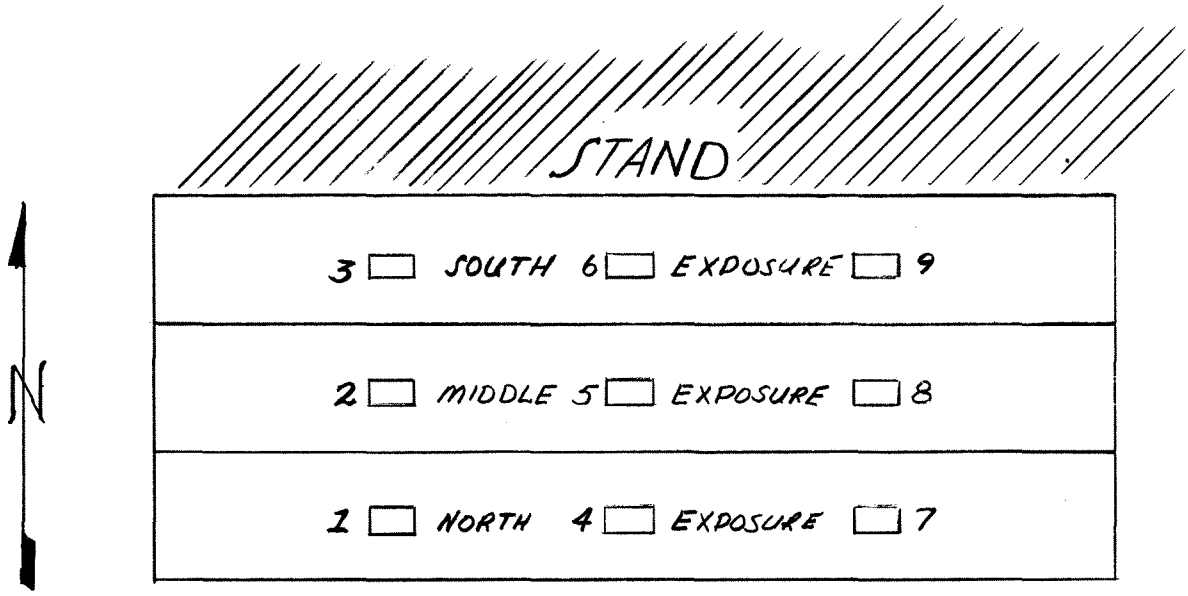
[2] Throughout the remainder of the report, seedbeds will be defined as follows: Ridge = R; Undisturbed = U; Trough = T; Base of south-facing slope = BSF; Base of north-facing slope = BNF.

Figure 1

Plot layout - Study B



Scale 1 ch = 1 in.

Seedspot tally and measurement - study B. Daily records were maintained during peak periods of germination and mortality. Otherwise weekly records were kept. As germination occurred on the 1965 plots, each seedling was marked with a colored skewer. Each week of germination was depicted by a different color. Mortality was marked with red skewers and dead seedlings were collected for examination by a pathologist.

Seedspots established in 1964 were checked for mortality in May and late August of 1965. Total heights of 1965 seedlings, and total heights and 1965 growth of 1964 seedlings, were measured in late August of 1965.

Planting tally and measurement - study B - At weekly intervals after planting, 1965 stock was checked for mortality. Dead seedlings were removed for examination by a pathologist. In late August of 1965, all seedlings were measured to obtain shoot growth in 1965.

Forest insect survey - study A and - B sites - In late August an insect collection was made from all planted and seeded stock.

Temperature measurement - study B - Soil surface temperatures were measured by means of 45 twenty-four-guage copper-constantan thermocouples using two Electronik 15, Universal 24-point strip-chart recorders (Figures 2 and 3). 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 (Figure 4).

The recorder was set for a 5-second print cycle so that each individual seedbed temperature was recorded every two minutes. Each re-

corder was equipped with a time switch and recorded temperature only from 1000 to 1800 hours; with the chart drive speed set at 60 inches per hour a chart lasted three days and records were extremely clear (Figure 5). Records were obtained for the period June 6 to September 28. During this time a total of 17 recorder days were lost due to equipment or power failure. One recorder accounted for 15 of these lost days.

Air temperature was measured by two thermocouples mounted in a sandwich screen (Figure 6) and by a thermograph located in a bird-house shelter.

Soil moisture measurement - study B - Soil samples from the surface ½ inch, from 1½ to 2 inches and from 3 to 4 inches, were taken gravimetrically at intervals of 1, 3 and 5 days after rain, and every 5 days thereafter when applicable. 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, usually 1 or 2 hours after collection. All samples were oven dried, at the field station, for 36 hours at 105°C and moisture content calculated. Field capacity and permanent wilting point were measured in the laboratory by gravitational and standard sunflower method, respectively.

Precipitation measurement - studies A and B. Precipitation was obtained weekly for the period May 13 to September 22 by means of 3 Beal-type rain gauges on each area. In addition to the Beal-type gauges, a Cassela siphon recording rain gauge was located on the Study B area.

Fig. 2. Recorder shelters on strip - Study B.

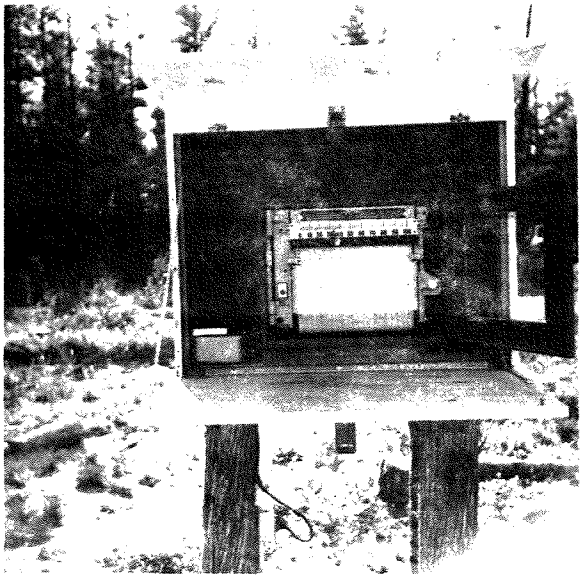


Fig. 3. Recorder mounted in shelter - Study B.

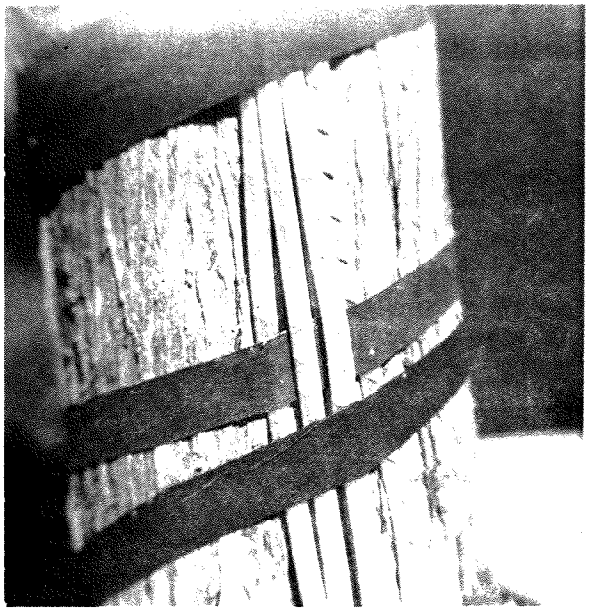


Fig. 4. Polyethelene spiral sheaths used to encase thermocouple leads. Each ¼ inch diameter sheath contains 5 leads - Study B.

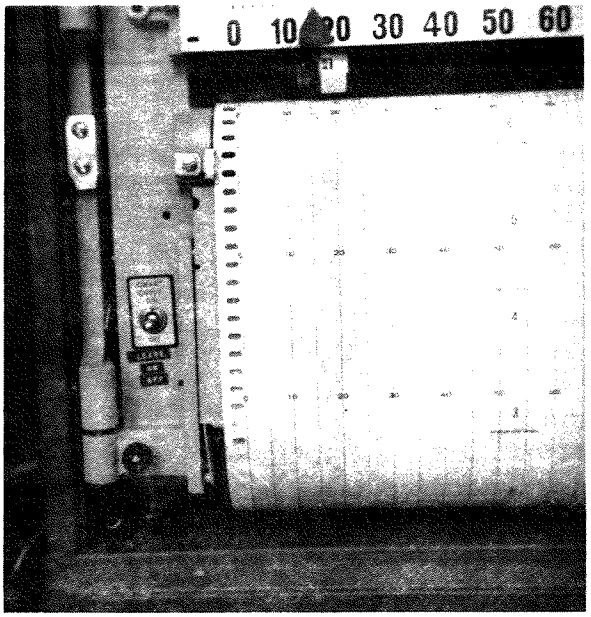


Fig. 5. View of recorder chart record - Study B.

Figure 6. Thermocouples mounted in sandwich screen - Study B.

Solar radiation - study B. Measurements of solar radiation were obtained by means of a Robitzch - Fuess bimetallic actinograph.

Results

Germination and survival on 1965 seedspots - study B - Germination began during the week of May 28 - June 3 and, due to cool moist weather conditions, extended into late August on all exposures.

During the first peak of germination, between May 28 and June 17, 87.0 per cent of total germination occurred on the south exposure[3], and 77.1 per cent occurred on the middle exposure; on the north exposure, 47.0 per cent of total germination occurred between June 4 and June 17. Overall exposures 63.2 per cent of total germination occurred between May 28 and June 17. The majority of germination during the peak occurred during the week of June 4 - 10. During this week 57.0 per cent of total germination occurred on S, 51.4 per cent on M and 29.2 per cent on N. Overall, 39.8 per cent occurred during this peak.

A second peak occurred during the week of July 2 - 8 on N and M. During this time per cents of total germination occurring were 22.1 and 7.3 respectively.

Germination to October 8 is shown in Table 1. Lowest per cent germination occurred on the R seedbed of the N and M exposures and on the U seedbed of the S exposure. Highest per cent germination occurred on the BNF seedbed of the M and S exposure and on the T seedbed of the N exposure. Average per cent germination for all plots was lowest on the R seedbed and highest on the T seedbed. Comparing exposures, average germination on all seedbeds was almost three times as great on the N exposure as on the M and S exposures.

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[3]Hereafter northern exposure will be referred to as N, middle exposure as M, and southern exposure as S.

TABLE 1

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

Exposure	Plot	Per cent germination[1] Seedbed R	V	T	BNF	BSF	All seedbeds
North (N)	1	6.3	9.8	39.2	15.4	23.8	18.9
	4	12.6	31.5	46.2	28.7	25.2	28.8
	7	23.1	27.3	44.1	32.9	21.3	30.9
	Average 1,4,7	13.8	22.5	42.6	25.3	25.1	28.1
Middle (M)	2	3.5	7.0	14.0	12.6	21.0	11.6
	5	0.0	19.6	5.6	14.7	9.8	9.9
	8	0.7	7.0	7.0	17.5	12.6	9.0
	Average 2,5,8	1.4	11.0	8.7	14.7	14.3	10.9
South (S)	3	3.5	6.3	9.8	14.7	3.5	7.6
	6	1.0	0.0	14.7	16.8	17.5	11.2
	9	11.9	0.0	8.4	14.7	11.9	9.3
	Average 3,6,9	1.4	2.1	10.8	15.2	10.8	10.0
Average N.M.S.	Average 1-9	7.8	12.4	21.6	19.2	17.4	19.6

[1] Based upon seed viability of 95.4 per cent when sown.

Mortality to October 8 is shown in Table 2. Overall, 310 or 31.6 per cent of 981 seedlings died. On N, 189 or 33.6 per cent died; 71 or 32.6 per cent died on M, and 50 or 24.9 per cent died on S. Slightly lower mortality occurred on R and T seedbeds than on the remaining three but this ranking was not consistent within individual exposures.

Considering all exposures as a group, mortality of 149 seedlings was attributed to damping-off, 44 to heat in combination with drought, and 19 to chewing; other mortality causes accounted for 98 seedlings (Table 3). Heat damage was greatest on the U seedbed. However, variation among seedbeds was great, as heat damage was highest on the T seedbed of exposure N, highest on the R seedbed of exposure M, and highest on the U seedbed of exposure S. There was very little difference in amount of heat mortality among exposures. Damping-off was highest on the N exposure and lowest on S. Overall, per cent damping-off mortality was lowest on the U seedbed and highest on the R seedbed. However, there was very little difference among, R, T, BNF and BSF seedbeds. Mortality from chewing was highest on the M exposure and overall, highest on the BSF seedbed.

Due to rather uniform, cool wet weather conditions mortality was fairly evenly distributed over the entire growing season (Table 4). A short peak in mortality occurred during the week of June 11 - 17 and a second, longer but with less mortality, during the period July 2 - 15. In both cases damping-off was the chief cause of mortality. This pattern was quite consistent with all exposures, except that the second peak was comprised mainly of mortality occurring on N. Consistent with weather conditions was the fact that there was no definite period of high heat mortality on any exposure.

TABLE 2

PER CENT MORTALITY OF GERMINANTS ACCORDING TO SEEDBED AND EXPOSURE
STUDY B

Exposure	Plot	Percent mortality[1] Seedbed					
		R	U	T	BNF	BSF	All seedbeds
N.	1	11.1	64.3	37.5	54.5	35.3	40.7
	4	33.3	15.6	25.7	41.5	27.8	27.7
	7	33.3	17.9	33.3	51.1	35.9	34.8
	Average 1,4,7.	30.0	23.5	31.9	48.2	33.0	33.6
M.	2	40.0	20.0	16.0	22.2	33.3	25.3
	5	—	50.0	12.5	—	35.7	28.2
	8	0.0	80.0	30.0	36.0	55.6	46.9
	Average 2,5,8.	33.3	50.0	18.4	20.3	40.3	32.6
S.	3	60.0	66.7	14.3	9.5	60.0	29.6
	6	20.0	—	23.8	20.8	32.0	25.0
	9	5.9	—	0.0	38.1	29.4	20.9
	Average 3,6,9	18.8	66.7	14.9	22.7	34.0	24.9
Average N,M,S	Average 1-9	26.5	34.2	21.0	33.8	35.3	31.6

1 Based on number of germinants

TABLE 3

MORTALITY FOR EACH SEEDBED AND EXPOSURE ACCORDING TO CAUSE - STUDY B.

		Per cent mortality[1]															
Exposure		N				M				S				Average N,M,S.			
Cause of mortality		Heat	Damping off	Chewing	Other	Heat	Damping off	Chewing	Other	Heat	Damping off	Chewing	Other	Heat	Damping off	Chewing	Other
Seedbed	R	1.6	25.0	—	3.3	16.7	—	16.7	—	6.2	6.2	3.1	3.1	4.1	17.3	2.0	3.1
	U	3.1	7.1	1.0	12.2	8.3	12.5	6.2	22.9	22.2	—	—	44.4	5.8	8.4	2.6	17.4
	T	5.4	21.1	2.7	2.7	7.9	5.3	—	5.3	2.1	8.5	—	4.2	5.2	16.7	1.8	3.3
	BNF	2.7	28.2	—	17.3	—	9.4	3.1	7.8	7.6	3.0	—	12.1	3.3	16.2	0.8	13.3
	BSF	2.8	19.3	1.8	9.2	8.1	19.4	6.4	6.4	2.1	4.2	—	27.6	4.1	16.0	2.8	12.4
	All seedbeds	3.6	20.1	1.4	8.5	6.0	11.9	4.6	10.1	5.5	5.0	0.5	13.9	4.5	15.2	1.9	10.0

[1] Expressed as a per cent of germination per seedbed.

TABLE 4

SEASONAL MORTALITY OF GERMINATION OCCURRING AT SPECIFIED PERIODS

Mortality Period	Per cent Mortality																			
	N					M					S					Average N, M & S.				
	Heat	Damping off	Chewing	Other	Total	Heat	Damping off	Chewing	Other	Total	Heat	Damping off	Chewing	Other	Total	Heat	Damping off	Chewing	Other	Total
May 28 – June 3							0.4	0.4		0.8							0.1	0.1		0.2
June 4 – June 10		0.2		0.2	0.4		1.4	1.8		3.2	0.5	0.5	0.5	1.0	2.5	0.1	0.5	0.5	0.3	1.4
June 11 – June 17		9.2	0.2	0.5	9.9	3.2	7.8	1.4	2.8	15.2	1.0	4.0		1.5	6.5	0.9	7.8	0.4	1.2	10.3
June 18 – June 24	0.4	2.1		0.2	2.7	1.4	0.9	0.4	0.4	3.1	1.0	0.5		0.5	2.0	0.7	1.5	0.1	0.3	2.6
June 25 – July 1		0.2		0.2	0.4						0.5			0.5	1.0	0.1	0.1		0.2	0.4
July 2 – July 8		2.8	1.1	1.8	5.7		0.4		0.9	1.3				1.5	1.5		1.7	0.6	1.5	3.8
July 9 – July 15		5.0		0.7	5.7		0.9		1.4	2.3	0.5			1.5	2.0	0.1	2.8		1.1	4.0
July 16 – July 22	0.2	0.4		0.7	1.3	0.4		0.4		0.8				1.5	1.5	0.2	0.2	0.1	0.7	1.2
July 23 – July 29	1.2			1.2	2.4	0.4			1.4	1.8				0.5	0.5	0.8			1.1	1.9
July 30 – Aug. 5	0.7	0.2		1.1	2.0				0.4	0.4	1.0			1.0	2.0	0.6	0.1		0.9	1.6
Aug. 6 – Aug. 12				0.5	0.5	0.4			0.4	0.8	0.5			2.5	3.0	0.2			0.9	1.1
Aug. 13 – Aug. 19	0.9				0.9				0.4	0.4						0.5			0.1	0.6
Aug. 20 – Aug. 26	0.2				0.2				0.9	0.9	0.5			1.0	1.5	0.2			0.4	0.6
Aug. 27 – Sept. 2														0.5	0.5				0.1	0.1
Sept. 3 – Sept. 9			0.2	0.2	0.4				0.4	0.4								0.1	0.2	0.3
Sept. 10 – Sept. 23				1.2	1.2				0.4	0.4				0.5	0.5				0.9	0.9

Expressed as a per cent of germination per exposure

Mortality for each week of germination is summarized in Table 5. As can be seen from the table, germination period had very little influence on subsequent mortality, with one exception. Germinants of the period May 28 to June 3 showed better survival than seedlings from any other period of substantial germination. Survival of seedlings from the peak period of germination did not appear to be significantly better than for germinants from any other period. Overall, seedlings from the period June 11-17 suffered slightly higher mortality than seedlings from any other germination period.

Mortality on 1963 and 1964 seedspots - study A. A comparison of mortality on 1963 and 1964 seedspots, for the period September 1964 to September 1965 and for the period September 1963 to September 1965, is given in Table 6. Basis for this data may be found in Appendices IV and V. This includes second- and third-year growing periods on 1963 spots and second-year growing periods on 1964 spots. From the table it appears that second-year mortality was substantially higher than third-year mortality and that winter mortality was substantially higher than mortality for the summer period. Mortality was highest on MR2 and lowest on MR1. By the end of the third year, mortality of 1963 seedlings was highest on R and U seedbeds of MR1, BNF and U seedbeds of MR2, and T seedbeds of MR3. Second-year mortality of 1964 seedlings occurred only on BNF seedbeds of MR1, was highest on BSF seedbeds of MR2 and on BNF and BSF seedbeds of MR3, although on the latter MR mortality was very low.

TABLE 5

SEASONAL MORTALITY OF GERMINATION OCCURRING AT SPECIFIED PERIODS — STUDY B

Germination period	Per cent mortality occurring to October 8[1]							
	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
May 28 - June 3	17	23.5	40	17.5	45	11.1	102	15.7
June 4 - June 10	163	37.4	112	33.3	114	27.2	389	33.9
June 11 - June 17	99	37.4	17	70.6	16	37.5	132	41.7
June 18 - June 24	33	18.1	3	0.0	2	0.0	38	15.8
June 25 - July 1	52	38.5	4	25.0	1	0.0	57	36.8
July 2 - July 8	124	33.8	16	25.0	6	50.0	146	33.6
July 9 - July 15	35	22.8	9	33.3	4	25.0	48	25.0
July 16 - July 22	20	35.0	5	40.0	3	33.3	28	35.7
July 23 - July 29	5	20.0	1	0.0	4	50.0	10	30.0
July 30 - August 5	8	37.5	3	33.3	3	33.3	14	35.7
August 6 - August 12	—	—	6	16.7	—	—	11	9.1

1 Expressed as a per cent of periodic germination.

TABLE 6

A COMPARISON OF SEASONAL MORTALITY ON 1963 AND 1964 SEEDSPOTS – STUDY A

Period of mortality

Seedbed	Seedspot yr.	MR1 Sept. 1964 to May, 1965	MR1 May, 1965 to Sept., 1965	MR1 Sept. 1964 to Sept. 1965	MR1 Sept. 1963 to Sept. 1965	MR2 Sept. 1964 to May, 1965	MR2 May, 1965 to Sept. 1965	MR2 Sept. 1964 to Sept. 1965	MR2 Sept. 1963 to Sept. 1965	MR3 Sept. 1964 to May, 1965	MR3 May, 1965 to Sept. 1965	MR3 Sept. 1964 to Sept. 1965	MR3 Sept. 1963 to Sept. 1965	Average MR123. Sept. 1964 to May, 1965	Average MR123. May, 1965 to Sept., 1965	Average MR123. Sept. 1964 to Sept. 1965	Average MR123. Sept. 1963 to Sept. 1965
		Percent mortality[1]															
R	1963	0.0	0.0	0.0	50.0	—	—	—	—	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.3
	1964	—	—	—		—	—	—		—	—	—		—	—	—	
T	1963	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	3.9	2.0	5.8	29.0	2.3	1.2	3.5	23.4
	1964	0.0	0.0	0.0		10.9	9.8	19.6		4.7	1.2	5.9		6.7	4.0	10.4	
U	1963	0.0	0.0	0.0	50.0	60.0	0.0	60.0	57.1	0.0	0.0	0.0	23.1	17.6	0.0	17.6	41.7
	1964	0.0	0.0	0.0		—	—	—		—	—	—		0.0	0.0	0.0	
BNF	1963	0.0	0.0	0.0	4.5	12.5	0.0	12.5	70.8	0.0	0.0	0.0	17.9	1.3	0.0	1.3	27.4
	1964	10.0	0.0	10.0		11.0	3.0	13.7		4.7	3.0	7.6		7.4	2.9	10.1	
BSF	1963	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.7	0.0	6.7	17.7	5.3	0.0	5.3	14.3
	1964	—	—	—		22.0	9.4	29.3		7.6	0.0	7.6		13.8	3.7	17.0	
All seedbeds	1963	0.0	0.0	0.0	10.5	9.1	0.0	9.1	40.3	2.8	0.7	3.5	22.0	3.6	0.5	3.5	22.0
	1964	5.6	0.0	5.6		13.7	6.5	19.4		5.3	1.7	7.0		8.5	3.4	11.6	

[1] Based upon seedlings remaining at the beginning of each period.

Mortality on 1964 seedspots - study B. Winter and summer mortality of 1964 seedspots is given in Table 7. Basis for this data may be found in Appendix VI. Overall, summer mortality and winter mortality were about equal, with summer mortality higher on N and S and the reverse true on M. Total second year mortality was greatest on BNF on exposure N, T in exposure M, and R in exposure S. Overall, total mortality was greatest on R.

Survival of planted stock - study A. Survival of 1963 stock after three years was generally poor on MR's 1 and 2, except on the T seedbed of MR1, and was good to excellent on MR3. (Table 8). On both MR1 and MR2 overall survival of 1963 stock was less than one-half that of 1962 stock after 3 years.

Survival of 1964 stock during the second year was good to excellent on all seedbeds and moisture regimes; after two years only the R seedbed of MR2 showed heavy mortality.

Survival of planted stock - study B. Survival of 1964 and 1965 planted stock is given in Table 9. First-year survival of 1965 stock was higher than first-year survival of 1964 stock. However, first-year survival was highest on S, the exposure with lowest survival in 1964. As in 1964, R and U seedbeds had lowest survival; although survival was excellent on all seedbeds. The only mortality of 1964 stock in 1965 occurred on the S exposure; four seedlings died.

Growth on seedspots - study A. A graphic illustration of height growth of 1962, 1963 and 1964 seedspots is given in Figure 7 and 8. Basis for this data may be found in Appendix I of this report, Appendix I of the 1964 report (Mimeo 64-MS-17) and in Appendix III of the 1965 report (Mimeo 65-MS-18.)

TABLE 7

MORTALITY ON 1964 SEEDS POTS SEPTEMBER 1964 TO SEPTEMBER 1965
STUDY B

Percent Mortality [1]												
Exposure	N			M			S			Average N.M.S.		
Period of Mortality	Sept. 1964 to May 1965	May 1965 to Sept. 1965	Sept. 1964 to Sept. 1965	Sept. 1964 to May 1965	May 1965 to Sept. 1965	Sept. 1964 to Sept. 1965	Sept. 1964 to May 1965	May 1965 to Sept. 1965	Sept. 1964 to Sept. 1965	Sept. 1964 to May 1965	May 1965 to Sept 1965	Sept. 1964 to Sept. 1965
R	0.0	0.0	0.0	0.0	16.7	16.7	0.0	60.0	60.0	0.0	28.6	28.6
T	12.5	4.8	16.7	43.8	11.1	50.0	0.0	0.0	0.0	15.9	3.8	19.0
U	0.0	5.3	5.3	0.0	0.0	0.0	—	—	—	0.0	4.2	4.2
BNF	9.4	17.2	25.0	26.1	23.5	43.5	5.9	9.4	14.7	12.4	15.4	25.8
BSF	9.1	16.7	24.2	14.3	0.0	14.3	0.0	0.0	0.0	9.1	12.5	20.4
All seedbeds	8.1	11.8	18.9	24.6	14.0	35.1	3.0	9.4	12.1	10.7	11.5	20.9

1 Based upon seedlings remaining at the beginning of each period.

TABLE 8

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

Seedbed	MR 1									MR 2								MR 3								Average MR 1,2,3							
	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. 1965	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. 1965	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. 1965	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. 1965
R	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			80.0	15	2	13.3	2	100.0			13.3	15	11	73.3	11	100.0			73.3	45	25	55.6	25	100.0			55.6
C	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			86.7	15	10	66.7	9	90.0			60.0	15	12	80.0	11	91.7			73.3	45	35	77.8	33	94.3			73.3
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			100.0	15	15	100.0	14	93.3			93.3	15	14	93.3	14	100.0			93.3	45	44	97.8	43	97.7			75.6
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	90.0	40	40	100.0	40	100.0	35	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			100.0	15	15	100.0	15	100.0			100.0	15	14	93.3	13	92.8			86.7	45	44	97.8	43	97.7			95.6
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	92.3	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			100.0	15	11	73.3	10	90.9			66.7	15	12	80.0	11	91.7			73.3	45	38	84.4	36	94.7			80.6
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			93.3	75	53	70.7	50	94.3			66.7	75	63	84.0	60	95.2			80.0	225	186	82.7	180	96.8			80.0

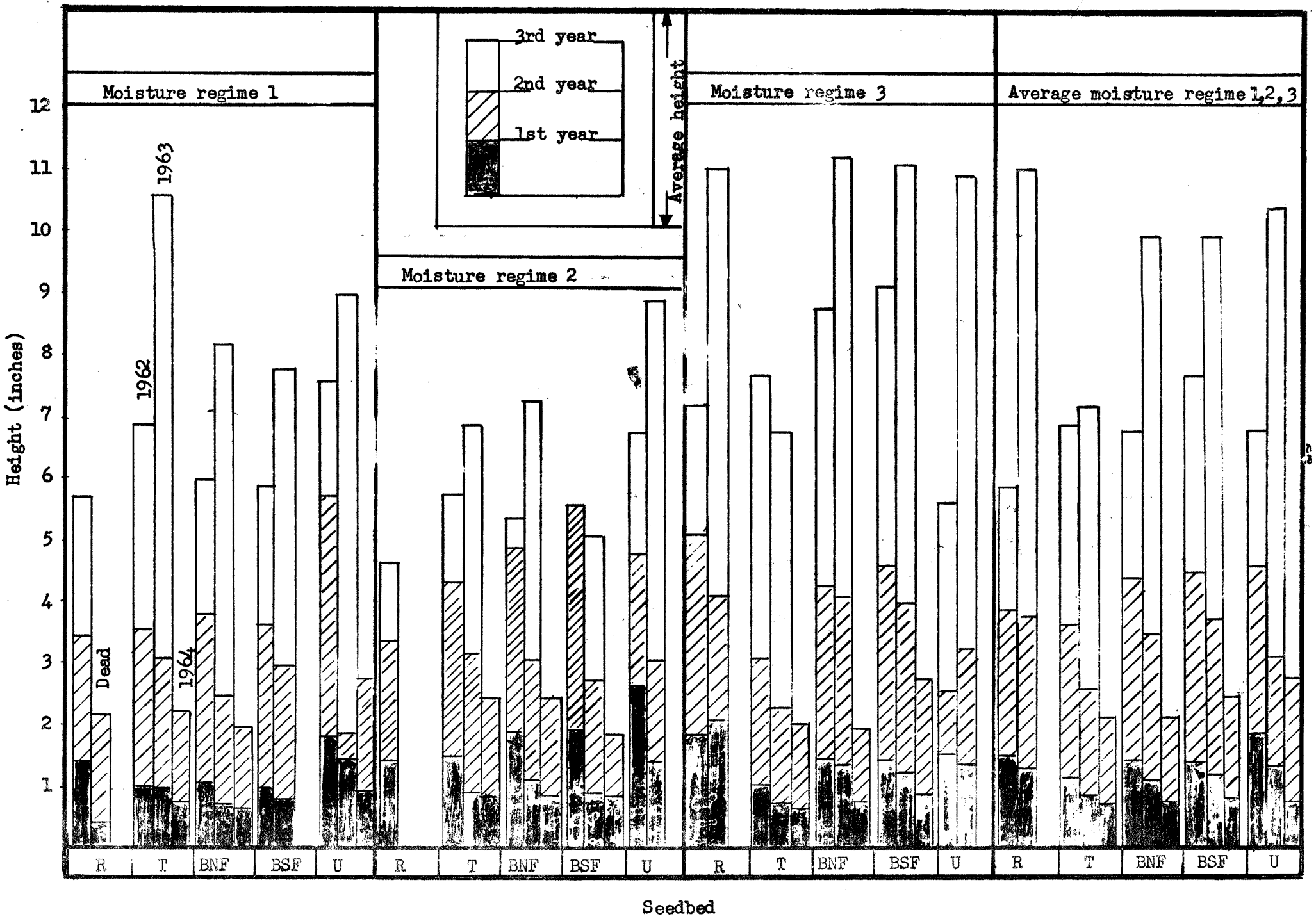
* Seedlings harvested Sept. 1964

TABLE 9

FIRST- AND SECOND- YEAR SURVIVAL OF PLANTED STOCK - STUDY B

Seedbed	Year of planting	N						M						S						Average N, M, S					
		Number planted	Seedlings remaining end of first year	First year survival - per cent	Seedlings remaining end of second year	Second year survival per cent	Per cent survival Time of planting to Sept. 1st	Number planted	Seedlings remaining end of first year	First year survival - per cent	Seedlings remaining end of second year	Second year survival per cent	Per cent survival Time of planting to Sept 1st	Number planted	Seedlings remaining end of first year	First year survival - per cent	Seedlings remaining end of second year	Second year survival per cent	Per cent survival - Time of planting to Sept 1st	Number planted	Seedlings remaining end of first year	First year survival - per cent	Seedlings remaining end of second year	Second year survival per cent	Per cent survival - Time of planting to Sept. 1st
R	1964	15	12	80.0	12	100.0	80.0	15	11	73.3	11	100.0	73.3	15	9	60.0	9	100.0	60.0	45	32	71.1	32	100.0	71.1
	1965	15	13	86.7			86.7	15	12	80.0			80.0	15	15	100.0			100.0	45	40	88.9			88.9
T	1964	15	13	86.7	13	100.0	86.7	15	14	93.3	14	100.0	93.3	15	15	100.0	15	100.0	100.0	45	42	93.3	42	100.0	93.3
	1965	15	15	100.0			100.0	15	14	93.3			93.3	15	15	100.0			100.0	45	44	97.8			97.8
U	1964	15	15	100.0	15	100.0	100.0	15	11	73.3	11	100.0	73.3	15	12	80.0	10	83.3	66.7	45	38	84.4	36	94.7	80.0
	1965	15	14	93.3			93.3	15	12	80.0			80.0	15	15	100.0			100.0	45	41	91.1			91.1
BNF	1964	15	15	100.0	15	100.0	100.0	15	14	93.3	14	100.0	93.3	15	15	100.0	14	93.3	93.3	45	44	97.8	43	97.7	95.6
	1965	15	15	100.0		100.0	100.0	15	15	100.0			100.0	15	15	100.0			100.0	45	45	100.0			100.0
BSF	1964	15	15	100.0	15	100.0	100.0	15	14	93.3	14	100.0	93.3	15	12	80.0	11	91.7	73.3	45	41	91.1	40	97.6	88.9
	1965	15	15	100.0			100.0	15	15	100.0			100.0	15	15	100.0			100.0	45	45	100.0			100.0
All seedbeds	1964	75	70	93.3	70	100.0	93.3	75	64	85.3	64	100.0	85.3	75	63	84.0	59	93.6	78.7	225	197	87.6	193	98.0	85.8
	1965	75	72	96.0			96.0	75	68	90.7			90.7	75	76	100.0			100.0	225	215	95.6			95.6

Figure 8. Average height of 1962, 1963 and 1964 seedspot seedlings for each moisture regime and seedbed - Study A.



Height on 1963 seedspots exceeded that on 1962 seedspots after three years of growth, due primarily to excellent growth in 1965. On 1962 seedspots, height was greatest on MR3. Height of 1964 seedspot seedlings lags behind height of 1962 and 1963 seedspots for an equivalent growth period (Figure 7).

Considering each seedbed and MR individually (Figure 8), on MR1, 1965 growth of 1963 stock was highest on U and T seedbeds and exceeded 4 inches on all seedbeds. Growth of 1964 stock in 1965 ranged from 1.3 to 1.8 inches.

On MR2, 1965 growth of 1963 stock was highest on U seedbeds (5.8 inches) and least on BSF seedbeds (2.3 inches). Growth on 1964 seedspots ranged from 1.0 to 1.5 inches in 1965.

On MR3, growth of 1963 stock was excellent in 1965, ranging from 4.5 inches on T to 7.6 inches on U; growth on R, BNF, and BSF was 6.9, 7.1 and 7.1 inches respectively. Growth on 1964 seedspots ranged from 1.2 to 1.9 inches in 1965.

Considering all moisture regimes combined, 1965 growth on 1963 seedspots was greatest (7.2 inches) on R and U seedbeds and least (4.6 inches) on T seedbeds. Growth on 1964 seedspots ranged from 1.5 to 1.8 inches in 1965.

Growth on seedspots - study B. Growth of 1964 and 1965 seedspots is shown in Table 10. Considering all exposures, second-year seedlings were tallest on U seedbeds and smallest on BSF seedbeds. Considering all seedbeds, seedlings were tallest on the M exposure and smallest on N.

TABLE 10

AVERAGE SEEDLING HEIGHTS. 1964 AND 1965 SEEDSPOTS - STUDY B.

Exposure	Date of establishment	Growth period (years)	R		U		T		BNF		BSF		All seedbeds	
			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)
N.	1964	2	3	2.2	18	2.5	20	2.2	24	1.6	25	1.4	90	1.9
	1965	1	44	0.9	12	0.6	125	0.5	53	0.5	10	0.6	364	0.6
M.	1964	2	5	2.3	5	3.1	8	2.3	13	2.8	6	2.5	37	2.6
	1965	1	5	1.5	22	1.0	31	0.7	51	0.9	37	0.8	146	0.9
S.	1964	2	2	2.4	-	-	23	2.4	30	2.2	4	1.6	59	2.2
	1965	1	25	1.1	3	0.8	40	0.7	50	0.7	30	0.5	148	0.8
Average	1964	2	10	2.3	23	2.6	51	2.3	69	2.1	35	1.6	186	2.1
N,M,S.	1965	1	74	1.0	91	0.7	196	0.6	154	0.7	131	0.6	658	0.7

Height growth of planted stock - study A. Growth of planted stock is illustrated graphically in Figures 9, 10, 11 and 12. Basis for the graphs may be found in Appendix II of this report, Appendix II of the 1964 report (Mimeo 64-MS-17) and in Appendix IV of the 1965 report (Mimeo 65-MS-18).

Average second-year growth of 1962, 1963 and 1964 planting stock is illustrated in Figure 9. On MR's 1, 2 and 3, second-year growth of 1964 stock was less than that of 1962 stock but greater than that of 1963 stock on all seedbeds. On MR1 second-year growth of 1964 stock was greatest on U and least on R, on MR2 greatest on U and least on BSF, and on MR3 greatest on BSF and least on T.

Average third-year growth of 1962 and 1963 stock is illustrated in Figure 10. On MR1 third-year growth of 1962 planting exceeded that of 1963 planting on all seedbeds except BSF. Height growth of 1962 planting was greatest on T and of 1963 planting was greatest on BSF. On MR2, third-year growth of 1963 planting exceeded that of 1962 planting on all seedbeds except U and BNF and was greatest on T seedbeds. Growth of 1962 planting was also greatest on T. On MR3 third-year growth of 1962 planting was much greater than that of 1963 planting on all seedbeds. Height growth of 1962 planting was greatest on T; growth of 1963 planting was greatest on BSF.

First-, second- and third-year growth of 1963 and 1964 planting stock on all seedbeds combined for each moisture regime is shown in Figure 11, and for all MR's combined for each seedbed in Figure 12.

Fig. 9. Average second year growth of 1962, 1963 and 1964 planting stock for each seedbed and moisture regime- Study A.

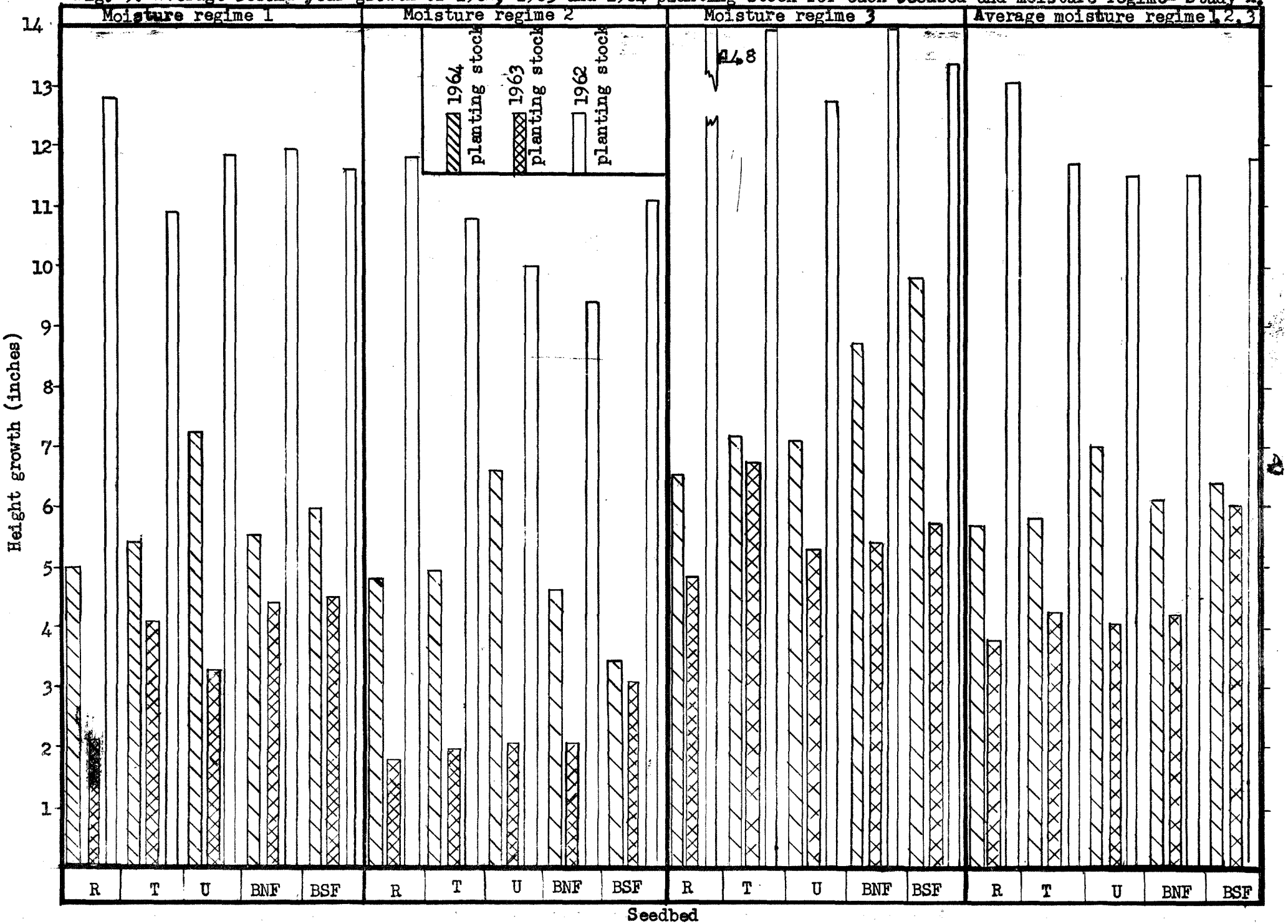


Figure 10. Average third year growth of 1962 and 1963 planting stock for each seedbed and moisture regime - Study A.

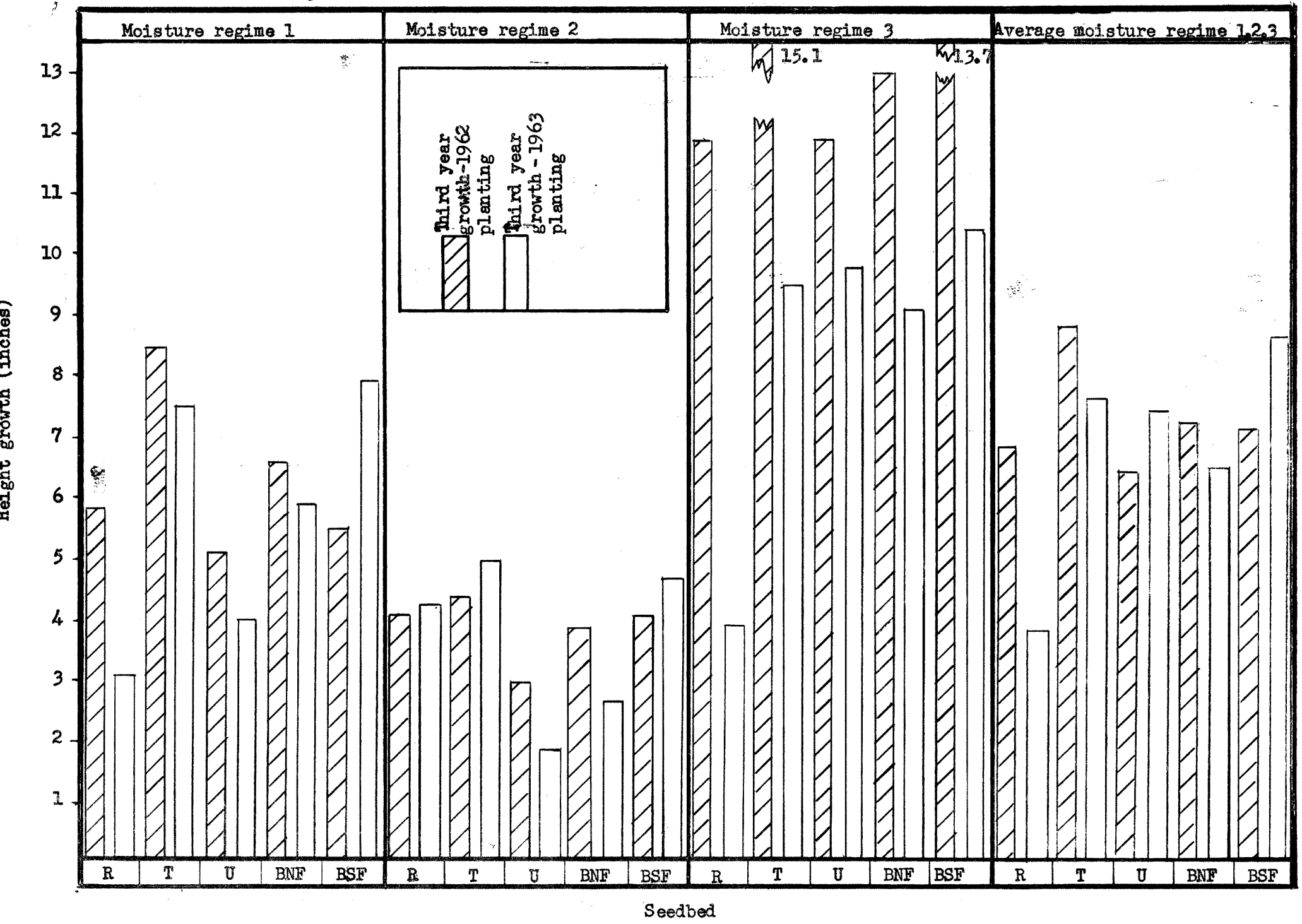
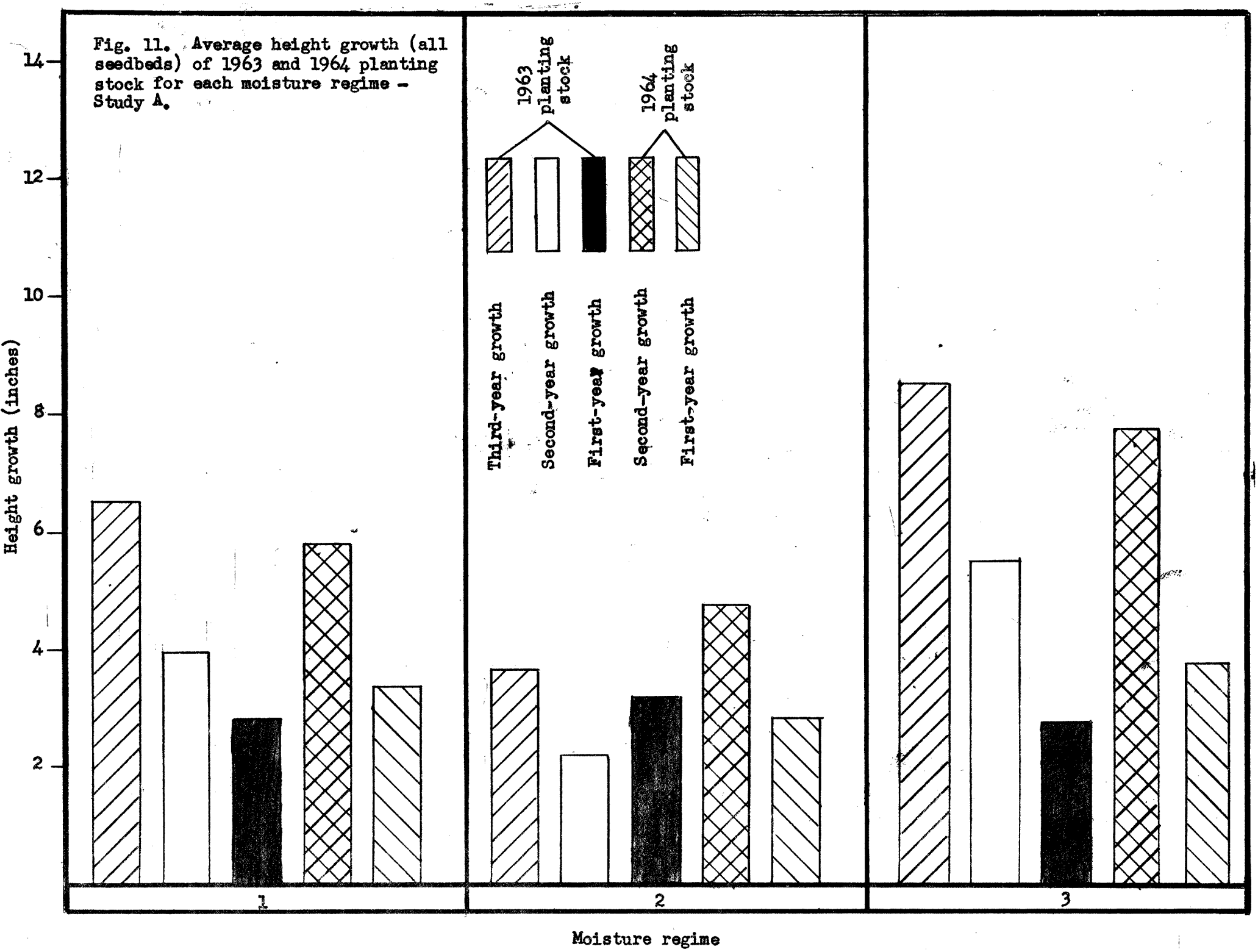


Fig. 11. Average height growth (all seedbeds) of 1963 and 1964 planting stock for each moisture regime - Study A.



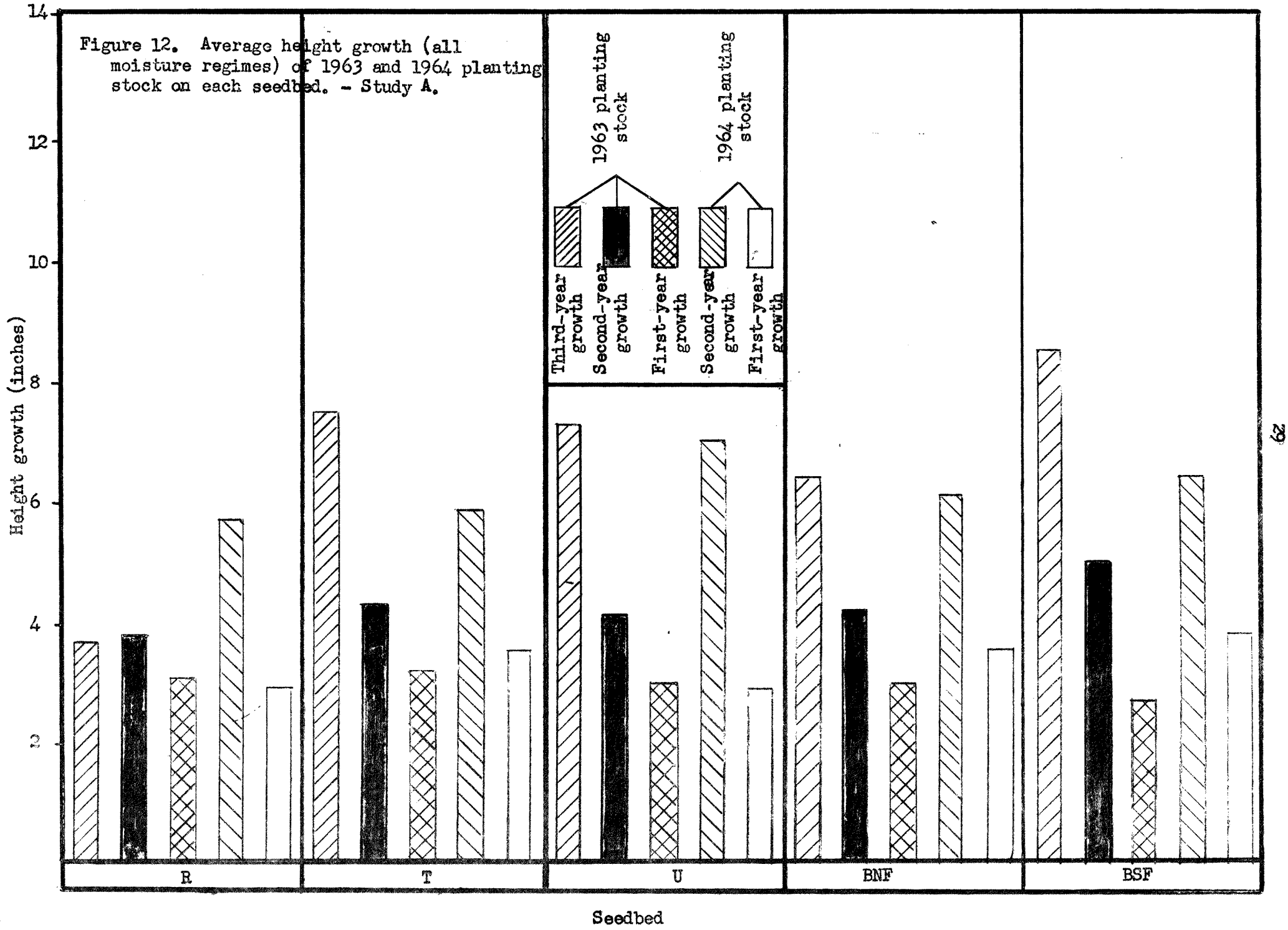


Figure 12. Average height growth (all moisture regimes) of 1963 and 1964 planting stock on each seedbed. - Study A.
1963 planting stock
1964 planting stock
Third-year growth
Second-year growth
First-year growth
Second-year growth
First-year growth
Height growth (inches)
14
12
10
8
6
4
2
R
T
U
BNF
BSF
Seedbed

Height growth of planted stock - study B. Height of 1964 and 1965 planted stock is illustrated in Figure 13. Basic data for the figure may be found in Appendix III. In 1964, height growth of 1964 stock was greatest on N exposure except for the BNF seedbed, where growth was greatest on the M exposure. In 1965, height growth of 1964 stock was greatest on the M exposure on all seedbeds and total height of all seedlings was greatest on seedbeds of the M exposure. For 1965 stock, height growth on all seedbeds was greatest on the S exposure. As in 1964, planting heights varied among exposures but height at time of planting did not seem to affect height growth; tallest seedlings did not always exhibit greatest growth.

Root-collar diameter and oven-dry seedling weights of 1962 seedlings - study A. Weights and diameters of seedspot seedlings and planted stock are given in Tables 11, 12, 13 and 14.

Considering all seedbeds, oven-dry weight of seeded stock (Table 11) is highest on MR1 and lowest on MR2. Considering all moisture regimes, oven-dry weight of seeded stock is highest on R and lowest on T seedbeds. For planted stock (Table 12), oven-dry weight is greatest on MR3 and lowest on MR2. By seedbed, weight was greatest on BSF and least on R.

Unlike the 1964 results, in 1965 there was very nearly a direct correlation between oven-dry seedling weight and root-collar diameter. The few discrepancies were very small.

Browsing of seedlings - study A. Browse damage to seeding and planting stock is shown in Table 15. Stock of 1963 and 1964 planting origin was severely browsed except 1964 stock on MR1. Seedspots were less severely affected with heavy damage occurring to 1963 seedspots on MR2 and light damage on 1963 spots on MR3 and 1964 spots on MR2. No browsing occurred on seedspots on MR1.

TABLE 11

AVERAGE OVEN-DRY SEEDLING WEIGHTS. 1963 - SEEDSPOT SEEDLINGS - STUDY A

Moisture regime	Oven-dry seedling weights (grams) Seedbed					
	R	T	U	BNF	BSF	All seedbeds
1	1.8*	6.3	0.6	2.4	6.0	3.4
2	–	2.6	1.5	1.6	0.8	2.1
3	5.0	1.5	4.3	3.7	3.6	3.0
All moisture regimes	4.4	2.3	3.3	3.1	3.4	2.9

*1 seedling only

TABLE 12

AVERAGE OVEN-DRY SEEDLING WEIGHTS. 1963 PLANTING - STUDY A

Moisture regime	Oven-dry seedling weights (grams) Seedbed					
	R	T	U	BNF	BSF	All seedbeds
1	5.4	24.6	7.5	17.2	22.0	19.5
2	3.6	10.0	7.2	3.9	5.7	6.4
3	14.3	22.1	25.6	22.0	31.4	23.5
All moisture regimes	11.5	20.5	19.1	15.9	23.8	18.8

TABLE 13

AVERAGE ROOT COLLAR DIAMETER 1963 SEEDSPOT SEEDLINGS - STUDY A.

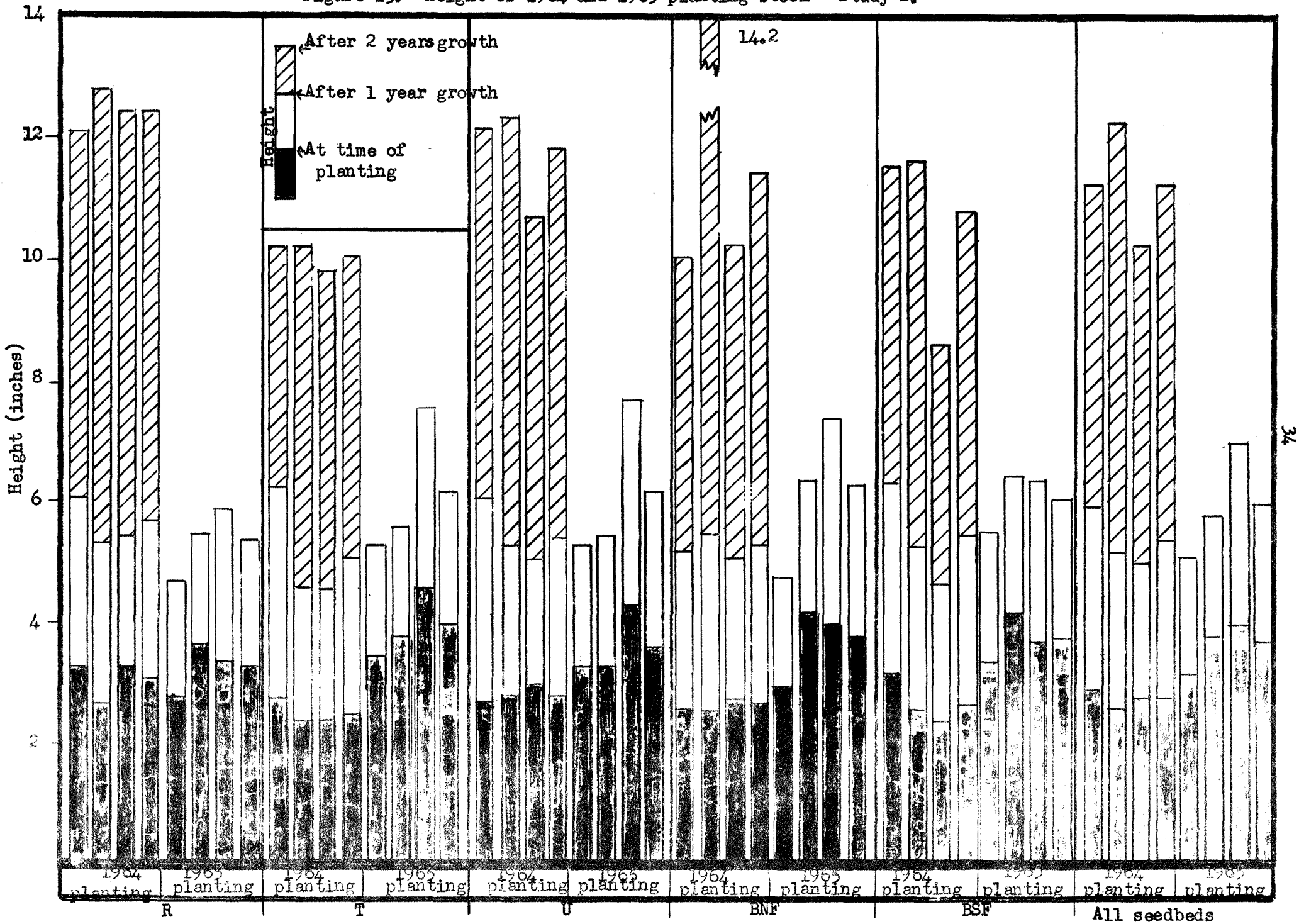
Moisture regime	Root-collar diameter (cm) Seedbed					
	R	T	U	BNF	BSF	All seedbeds
1	0.35	0.52	0.21	0.35	0.46	0.39
2	–	0.39	0.36	0.36	0.30	0.37
3	0.52	0.27	0.45	0.42	0.44	0.38
Average 1,2,3.	0.50	0.33	0.40	0.40	0.42	0.38

TABLE 14

AVERAGE ROOT-COLLAR DIAMETER. 1963 PLANTING - STUDY A.

Moisture regime	Root-collar diameter (cm.) Seedbed					
	R	T	U	BNF	BSF	All seedbeds
1	0.60	0.94	0.59	0.77	0.83	0.83
2	0.64	0.69	0.75	0.58	0.62	0.65
3	0.93	0.88	0.98	0.94	1.03	0.96
Average 1,2,3.	0.84	0.87	0.87	0.80	0.90	0.85

Figure 13. Height of 1964 and 1965 planting stock - Study B.



Most browsing occurred during winter and mice and deer are probable agents.

Soil temperature, 1964 - study B. For a period of 146 days, from June 6 to September 28 inclusive, maximum and minimum temperatures were recorded from 1000 - 1800 hours continually on each seedbed and plot. Seasonal extreme temperatures and critical temperature times are presented in Table 16. Because temperatures were recorded by thermocouples, higher extremes than in 1964 were expected. However, seasonal extremes were quite similar in 1964 and 1965 due primarily to cooler, wetter weather in 1965.

Total number of temperature minutes $\geq 120^{\circ}F$ for the M and S exposures was quite similar and far exceeded the total for the N exposure. On the N exposure temperatures did not exceed $120^{\circ}F$ on T and BNF seedbeds and total time was highest on BSF. On M, temperatures on BNF did not exceed $120^{\circ}F$ and total time was highest on U, though quite similar to BSF and R. On S, all seedbeds experienced critical temperatures, although BNF and T recorded a very low total. Total time was highest on BSF. Over all exposures, seedbeds in order of decreasing total critical temperature minutes were BSF, R, U, T, BNF.

Average maximum air temperature for the period June 6 to September 28 was $73.3^{\circ}F$; maximum air temperature was $97.7^{\circ}F$. The period of above $90^{\circ}F$ temperature lasted for only 3 days. Otherwise air temperatures rarely exceeded $85^{\circ}F$.

TABLE 16

SEASONAL EXTREME SOIL SURFACE TEMPERATURES AND TOTAL TIME ≥ 120°F FOR EACH SEEDBED AND EXPOSURE

STUDY B

Seedbed	Seasonal Maximum (°F)				Average Time ≥120°F (minutes)			
	Exposure				Exposure			
	N	M	S	N.M.S	N	M	S	N.M.S.
BSF	144.9	154.8	157.8	157.8	893	5,747	9,621	16,261
U	131.2	149.2	137.3	149.2	224	6,862	1,358	8,445
R	138.2	148.3	158.4	158.4	365	4,776	6,087	11,229
T	<120.0	133.2	129.0	133.2	—	727	251	978
BNF	<120.0	<120.0	124.0	124.0	—	—	41	41
				Total	1,482	18,112	17,358	36,954

Precipitation, 1965 - study A. Total precipitation for each of the 3 moisture regimes (Table 17) was higher than in 1962, 1963 and 1964 and was 57 (MR2) to 75 (MR1) per cent above the 21 year average for the area.

Precipitation, 1965 - study B. Precipitation for the Study B area is given in Table 18. Total for the collection period was 68 per cent above normal.

Solar radiation - study B. Difficulties were experienced with the actinograph and incomplete records only were obtained. They are not presented in this report. I believe that all minor difficulties have now been rectified and a complete record should be obtained for the 1966 study period.

Soil moisture - study B. Field capacity and permanent wilting point of study - B soils are given in Table 19.

TABLE 19
FIELD CAPACITY AND PERMANENT WILTING POINTS - STUDY B

Seedbed	Depth (inches)					
	1/2		1-1/2		3	
	Field capacity (%)[1]	Permanent wilting point (%)	Field capacity (%)	Permanent wilting point (%)	Field capacity (%)	Permanent wilting point (%)
U	51.3	-	21.4	1.9	21.4	1.9
R	21.4	1.9	24.4	2.4	21.0	5.3
T	21.4	1.9	21.4	1.9	21.4	1.9

[1] Per cents based on oven-dry weights

TABLE 17

PRECIPITATION DURING THE PERIOD

MAY 12 TO SEPTEMBER 29 1965 STUDY A

Precipitation (inches)					
Collection period	Total	MR1	MR2	MR3	21 year avg. Sprague
May 12-18		0.40	0.67	0.52	
19-25		0.62	0.65	0.76	
26-31		0.21	0.32	0.42	
	May 12-31	1.63	1.64	1.70	1.18
June 1		0.03	0.06	0.08	
2-8		2.20	1.74	1.68	
9-16					
17-23		0.50	0.49	1.03	
24-30		2.25	1.74	2.15	
	June	4.98	4.03	4.94	2.99
July 1-7		3.15	2.11	1.88	
8-14		0.90	0.84	0.39	
15-21		1.60	0.42	0.65	
22-28		0.08	0.20	0.10	
29-31		0.37	0.76	0.62	
	July	6.10	4.33	3.64	2.76
August 1-3		0.36	0.76	0.62	
4-11		0.14	0.05		
12-18		0.37	0.34	0.22	
19-25		0.32	0.57	0.54	
26-31		0.74	0.99	1.18	
	August	1.93	2.71	2.56	2.36
September 1-7		2.28	2.44	2.41	
8-15		0.89	0.75	0.91	
16-22		0.38	0.45	0.43	
23-29		1.02	0.79	0.82	
	September	4.57	4.43	4.57	1.61
	May 13-September 29	19.21	17.14	17.41	10.90

Average all moisture regimes 17.92

TABLE 18

PRECIPITATION DURING THE PERIOD

MAY 20 TO SEPTEMBER 26, 1965 STUDY B

Precipitation (inches)				
Collection period	Total	Casella recording gauge	Bedl gauge	21 year avg Sprague
May 20-27		0.76	0.73	
28-31		0.68	0.64	
	May 20-31	1.44	1.37	0.78
June 1-3		0.53	0.49	
4-10		1.08	1.06	
11-17				
18-24		0.50	0.44	
25-30		2.10	2.19	
	June	4.21	4.18	2.99
July 1-8		3.09	3.10	
9-15		0.90	0.93	
16-22		1.34	1.36	
23-29		0.09	0.10	
30-31		0.24	0.24	
	July	5.66	5.73	2.76
August 1-5		0.57	0.61	
6-12		0.21	0.21	
13-19		0.30	0.35	
20-26		0.20	0.14	
27-31		0.55	0.55	
	August.	1.83	1.86	2.36
September 1-2		0.23	0.25	
3-9		2.10	2.15	
10-16		0.79	0.79	
17-23		1.24	1.24	
24-26		0.24	0.24	
	September 1-26	4.60	4.67	1.61
Total	May 20 - September 26	17.74	17.81	10.52

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

Study A - MR1 -	Tetralopha robustella	- webworm
	Trichiosoma triangulum	- sawfly
Study A - MR3 -	Tetralopha robustella	- fall webworm
	Aphidae	- aphid sp.
Study B - 1964 area -	Argyrotaenia tabulana	- needle miner
	Tetralopha robustella	- webworm
	Phenacaspis pinifolia	- pine needle scale
	Choristoneura pinus	- jack pine budworm
Study B - 1965 area -	Tetralopha robustella	- webworm
	Choristoneura pinus	- jack pine budworm

None of the above species have done serious damage but collections will be continued on the study-B areas to check the development of infestations of Tetralopha robustella and Choristoneura pinus, which do not commonly infest young pine.

Mortality - Microclimate Relationships - Study B.

Cool, wet weather reduced the incidence of heat mortality. The heat mortality which did occur usually occurred during periods of high temperature accompanied by low rainfall. Often the effects of high temperature appeared to be off-set by high rainfall.

Damping-off accounted for most mortality on each exposure. The first peak occurred June 11 - 17; over 1 inch of rain fell during the week preceding this period. Most mortality occurred on N, the shaded

exposure, and accompanied the peak germination period (June 4 - 17) on this exposure. Mortality on M was also high while on S, very little mortality occurred and 80 per cent of the mortality occurred on the cool, damp T seedbed. No damping-off mortality occurred on S after June 24.

In the second peak of damping-off mortality, July 2 - 15, most mortality occurred on N. The peak period was accompanied by 4 inches of rain and also corresponded to the second peaks of germination on N(22%) and M(7%). No new germination occurred on S.

WORK PROPOSED, 1966 - STUDY A.

Measurements

Total height and height growth of 1964 planted and seeded stock will be recorded in September of 1966.

Mortality of all planted and seeded stock will be recorded in May and September of 1966.

All 1964 stock will be harvested in September of 1966 and root collar diameters and oven-dry weights obtained.

Precipitation will be recorded by means of three Beal-type rain gauges located on each of MR's 1, 2 and 3.

WORK PROPOSED, 1966 - STUDY B.

Plot Layout

Nine permanent plots will be systematically located on a scarified and cut east-west strip located on Sec. 26, Twp. 1, Rge. 13 (Figure 14). Plots and sub-plots will be laid out as in 1965, and the area will be fenced.

Seeding and Planting

(a) Seeding - Each of the five seedbed conditions (R, U, T, BSF, BNF) will contain three 1-by 1-foot seedspots. Each spot will be sown with 50 seeds. Seed will be treated with endrin-arasan compound which contains fungicidal as well as rodent-and bird-repellent properties. To prevent washing, a small barrier will be placed on the downslope side of each seedspot.

(b) Planting - Five 2-year-old seedlings will be planted on each seedbed condition.

Each seeding and planting sub-plot will be one milacre in size.

Seeding and planting will be carried out in spring as soon as seasonal conditions are satisfactory.

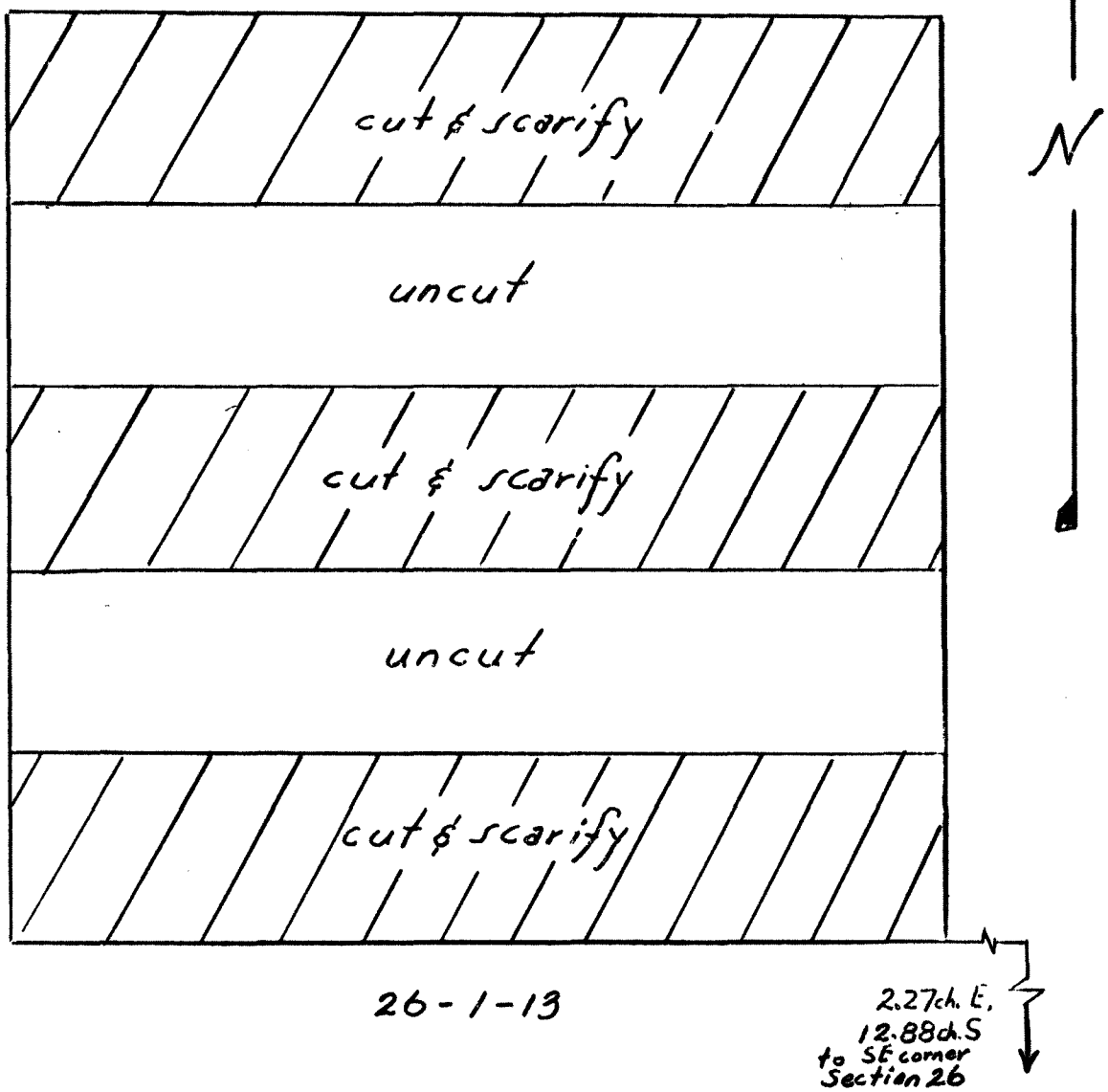
Seed viability will be tested before seeding.

FIGURE 14

MS 222 Area Sprague-3

1965-66 Cutting

1 inch = 2 chs.



Measurements

(a) Seeding and planting. Observations of germination and mortality on seedspots will be made weekly except during peak periods of germination and mortality, when daily observations will be made. Location of germination and mortality will be marked on the plots with colored plastic toothpicks, using one color for each week of germination and red for mortality. Dead seedlings will be examined by the Forest Pathology Laboratory and suspected cause of mortality will be recorded.

Planted material will be observed weekly and mortality recorded. Mortality of 1964 and 1965 seeded and planted stock will be recorded in May and September of 1966.

At the end of the 1966 growing season, height growth and total height of seedlings and planted stock on all 1964, 1965 and 1966 plots will be measured. All 1964 stock will be harvested in September of 1966 and root-collar diameters and oven-dry weights obtained.

(b) Temperatures. Air and soil-surface temperatures will be recorded by means of copper-constantan thermocouples and two 24-point potentiometric strip-chart recorders.

One thermocouple will be placed on each seedbed of each plot. The thermocouple junctions will be covered by a thin layer of surface material.

A thermistor probe will be used to obtain temperatures at 1-1/2- and 3-inch depths. These measurements will be taken daily within 2 to 3 hours after sunrise and between 4:00 and 5:00 p.m. CDT to obtain readings as near as possible to the maximum and minimum respectively (Shaw, 1955).

(c) Soil moisture. Soil samples from surface, 1-1/2- and 3-inch depths will be collected 1, 5, and 10 days after rainfall, and every 5 days thereafter (when applicable). Samples will be analyzed for moisture content.

Infiltration rates will be determined using methods employed by Burns (1952). Depth of penetration will also be measured.

(d) Precipitation. Precipitation will be measured by means of a Cassela siphon recording rain gauge and supplemented by three Beal-type rain gauges.

(e) Solar radiation. Daily solar radition will be recorded by means of a Robitzsch-Fuess, Model 58d bimetallic actinograph.

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. Collections will be made on June 25, July 25 and August 25.

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.

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APPENDIX I

AVERAGE SEEDLING HEIGHTS

1962, 1963 and 1964 SEEDSPOTS

STUDY A.

Date of seedspot establishment	Growth period (years)	MR	Plot	R		U		T		BNF		BSF		All seedbeds		
				Number seedlings	Avg. ht. (inches)	Number Seedlings	Avg. ht. (inches)	Number seedlings	Avg. ht. (inches)	Number seedlings	Avg ht. (inches)	Number seedlings	Avg. ht. inches	Number Seedlings	Total ht. inches	Avg. ht. (inches)
1964	2	1	10	—	—	—	—	2	2.7	4	2.1	—	—			
1963	3		1	—	—	1	8.9	3	6.4	5	6.9	—	—			
1962	3		4	—	—	—	—	12	4.8	19	5.7	17	6.0			
1964	2	1	11	—	—	—	—	—	—	3	1.9	—	—			
1963	3		2	—	—	—	—	3	16.2	3	7.4	—	—			
1962	3		5	1	5.6	—	—	20	8.4	12	5.6	16	7.2			
1964	2	1	12	—	—	5	2.7	1	1.2	2	1.4	—	—			
1963	3		3	—	—	—	—	2	8.4	13	8.7	2	7.7			
1962	3		6	—	—	7	7.5	4	4.9	15	6.3	11	4.1			
1964	2	Average MR 1		—	—	5	2.7	3	2.2	9	1.9	—	—	17	36.8	2.2
1963	3			—	—	1	8.9	8	10.5	21	8.1	2	7.7	32	278.8	8.7
1962	3			1	5.6	7	7.5	36	6.8	46	5.9	47	5.8	137	847.5	6.2
1964	2	2	13	—	—	—	—	1	2.4	3	1.7	1	1.7			
1963	3		4	—	—	1	8.5	6	8.9	3	8.7	3	5.8			
1962	3		1	1	3.3	—	—	26	6.0	14	5.1	13	5.2			
1964	2	2	14	—	—	—	—	35	2.4	54	2.4	27	1.8			
1963	3		5	—	—	—	—	10	7.5	1	6.2	1	4.0			
1962	3		2	1	2.9	1	6.6	27	6.2	27	4.8	10	6.3			
1964	2	2	15	—	—	—	—	1	3.0	7	2.3	1	2.2			
1963	3		6	—	—	1	9.0	9	4.6	3	6.0	2	4.4			
1962	3		3	8	5.0	—	—	21	4.7	24	4.4	12	5.1			
1964	2	Average MR 2		—	—	—	—	37	2.4	64	2.4	29	1.8	130	293.4	2.3
1963	3			—	—	2	8.8	25	6.8	7	7.2	6	5.0	40	267.6	6.7
1962	3			10	4.6	1	6.6	74	5.7	65	4.7	35	5.5	185	973.4	5.3
1964	2	3	16	—	—	—	—	11	1.3	19	1.7	—	—			
1963	3		7	—	—	4	12.4	39	5.8	24	10.2	6	12.8			
1962	3		7	5	4.5	4	4.3	47	7.1	41	7.7	43	7.8			
1964	2	3	17	—	—	—	—	41	2.8	44	2.3	35	3.0			
1963	3		8	2	14.9	4	8.3	5	13.0	6	14.5	10	13.2			
1962	3		8	4	10.4	1	10.2	60	8.0	47	9.4	60	9.9			
1964	2	3	18	—	—	—	—	27	1.2	37	1.6	14	2.1			
1963	3		9	3	8.3	2	12.6	5	7.3	11	11.2	13	8.4			
1962	3		—	only 8 plots in 1962												
1964	2	Average MR 3		—	—	—	—	79	2.0	100	1.9	49	2.7	228	486.3	2.1
1963	3			5	10.9	10	10.8	49	6.7	41	11.1	29	11.0	134	1265.4	9.4
1962	3			9	7.1	5	5.5	107	7.6	88	8.6	103	9.0	312	2594.3	8.3
1964	2	Average MR 1.2&3		—	—	5	2.7	119	2.1	173	2.1	78	2.4	375	816.5	2.2
1963	3			5	10.9	13	10.3	82	7.1	69	9.8	37	9.8	206	1811.8	8.8
1962	3			20	5.8	13	6.7	217	6.8	199	6.7	185	7.6	634	4415.2	7.0

APPENDIX III

SEEDLING HEIGHTS

1964 AND 1965 PLANTING

STUDY B.

1964 planting - height after one growing season												
	A		T		U		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)
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
	Growth 1965											
N	12	6.1	13	4.0	15	6.1	15	4.8	15	5.2	70	5.3
M	11	7.5	14	5.6	11	7.1	14	8.7	14	6.3	64	7.0
S	9	7.0	15	5.2	9	5.6	14	5.1	11	3.9	58	5.2
Avg. N,M,S.	32	6.8	42	4.9	35	6.3	43	6.1	40	5.3	192	5.8
	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	10.7	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
1965 planting - height at time of planting												
N	15	2.8	15	3.5	15	3.3	15	3.0	15	3.4	15	3.2
M	15	3.7	15	3.8	15	3.3	15	4.2	15	4.2	15	3.8
S	15	3.4	15	4.6	15	4.3	15	4.0	15	3.7	15	4.0
Avg. N.M.S.	45	3.3	45	4.0	15	3.6	45	3.8	45	3.8	45	3.7
	Growth 1965											
N	14	1.9	15	1.8	15	2.0	15	1.8	15	2.1	74	1.9
M	12	1.8	14	1.8	12	2.2	15	2.2	15	2.2	68	2.0
S	15	2.5	15	3.0	15	3.4	15	3.4	15	2.7	75	3.0
Avg. N.M.S.	41	2.1	44	2.2	42	2.6	45	2.5	45	2.3	217	2.3
	Height at end of first 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

APPENDIX IV

MORTALITY ON 1963 SEEDSPOTS, SEPTEMBER 1963 TO SEPTEMBER 1965

STUDY A.

APPENDIX V

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

	No. seedlings Sept. 1964	No. seedlings died Sept. 1964 - May 1965	Percent[1] mortality Sept. 1964 - May 1965	No. seedlings May 1965	No. seedlings died May 1965 - Sept 1965	No. seedlings Sept 1965	Percent mortality May 1965 - Sept 1965	No. seedlings died Sept 1964 - Sept 1965	Percent mortality Sept. 1964 - Sept 1965
	R								
MR1	—	—	—	—	—	—	—	—	—
MR2	—	—	—	—	—	—	—	—	—
MR3	—	—	—	—	—	—	—	—	—
Total	—	—	—	—	—	—	—	—	—
	U								
MR1	5	0	0.0	5	0	5	0.0	0	0.0
MR2	—	—	—	—	—	—	—	—	—
MR3	—	—	—	—	—	—	—	—	—
Total	5	0	0.0	5	0	5	0.0	0	0.0
	BSF								
MR1	—	—	—	—	—	—	—	—	—
MR2	41	9	22.0	32	3	29	9.4	12	29.3
MR3	53	4	7.5	49	0	49	0.0	4	7.5
Total	94	13	13.8	81	3	78	3.7	16	17.0
	T								
MR1	3	0	0.0	3	0	3	0.0	0	0.0
MR2	46	5	10.9	41	4	37	9.8	9	19.6
MR3	85	4	4.7	81	1	80	1.2	5	5.9
Total	134	9	6.7	125	5	120	4.0	14	10.4
	BNF								
MR1	10	1	10.0	9	0	9	0.0	1	10.0
MR2	73	8	11.0	65	2	63	3.1	10	13.7
MR3	106	5	4.7	101	3	98	3.0	8	7.5
Total	189	14	7.4	175	5	170	2.8	19	10.0
	All seedbeds								
MR1	18	1	5.6	17	0	17	0.0	1	5.6
MR2	160	22	13.8	138	9	129	6.5	31	19.4
MR3	244	13	5.3	231	4	227	1.7	17	7.0
Total	422	36	8.5	386	13	373	3.4	49	11.6

[1] Percents based on number seedlings remaining at the beginning of each period.

APPENDIX VI

MORTALITY ON 1964 SEEDSPOTS, SEPTEMBER 1964 TO SEPTEMBER 1965

STUDY B.

	No. seedlings Sept. 1964	No. died m. Sept. 1964 - May 1965	Percent mortality Sept 1964 - May 1965	No. seedlings May 1965	No. seedlings died May 1965 - Sept 1965	Percent mortality May 1965 - Sept 1965	No. seedling Sept 1965	Number seedlings died Sept 1964 - Sept 1965	Percent mortality Sept 1964 - Sept 1965
	R								
N	3	0	0.0	3	0	0.0	3	0	0.0
M	6	0	0.0	6	1	16.7	5	1	16.7
S	5	0	0.0	5	3	60.0	2	3	60.0
Total	14	0	0.0	14	4	28.6	10	4	28.6
	U								
N	19	0	0.0	19	1	5.3	18	1	5.3
M	5	0	0.0	5	0	0.0	5	0	0.0
S	—	—	—	—	—	—	—	—	—
Total	24	0	0.0	24	1	4.2	23	1	4.2
	BSF								
N	33	3	9.1	30	5	16.7	25	8	24.2
M	7	1	14.3	6	0	0.0	6	1	14.3
S	4	0	0.0	4	0	0.0	4	0	0.0
Total	44	4	9.1	40	5	12.5	35	9	20.4
	T								
N	24	3	12.5	21	1	4.8	20	4	16.7
M	16	7	43.8	9	1	11.1	8	8	50.0
S	23	0	0.0	23	0	0.0	23	0	0.0
Total	63	10	15.9	53	2	3.8	51	12	19.0
	BNF								
N	32	3	9.4	29	5	17.2	24	8	25.0
M	23	6	26.1	17	4	23.5	13	10	43.5
S	34	2	5.9	32	3	9.4	29	5	14.7
Total	89	11	12.4	78	12	15.4	66	23	25.8
	All seedbeds								
N	111	9	8.1	102	12	11.8	90	21	18.9
M	57	14	24.6	43	6	14.0	37	20	35.1
S	66	2	3.0	64	6	9.4	58	8	12.1
Total	234	25	10.7	209	24	11.5	185	49	20.9