DIRECT SOWING OF TREATED MAMANE SEEDS: AN INEFFECTIVE REGENERATION TECHNIQUE

Paul G. Scowcroft
U. S. Forest Service
Pacific Southwest Forest and Range Experiment Station
Institute of Pacific Islands Forestry
Honolulu, Hawaii 96813

Most of you are familiar with the mamane (Sophora chrysophylla) and mamane-naio (Myoporum sandwicense) forest ecosystems of the Mauna Kea Forest Reserve. I need not recount the history of this reserve--you know it as well as I. Suffice it to say that feral herbivores have been major contributors to the degradation of these ecosystems.

Since 1970, the number of feral sheep (Ovis aries) has averaged 1500 animals. Mouflon sheep (Ovis musimon) have totaled 200 to 300 head. And feral goats (Capra hircus) have numbered about 150 to 200 animals. Today, the number of browsing animals in the mamane and mamane-naio ecosystems is about 1/20th of what it was in the mid-1930's.

Despite these relatively small populations, regeneration of mamane has not occurred in some areas while in others it has occurred at a slower rate than I would expect. This situation would probably persist even if all browsing pressure were eliminated. Such has been the case within several sheep exclosures, two of which are 15 years old. Elimination of browsing pressure within the exclosures has not been followed by an increase in mamane seedlings. Regenerating such areas with mamane would, therefore, involve the planting of seedlings and/or direct sowing of seeds (i.e., artificial regeneration). In my opinion, these efforts would fail if sheep still roamed the area.

If browsing pressure is eliminated from the ecosystems, thus making artificial regeneration of mamane a practical management option, information about successful regeneration methods will be needed. The study reported here deals with artificial regeneration by direct seeding. The objective was to determine the effect of seed coat treatment and sowing depth on mamane seedling emergence, survival, and growth under field conditions.

The 1-ha Wailuku River sheep exclosure located at 2750 m elevation on the east flank of Mauna Kea (Fig. 1) was selected for the experiment because mamane regeneration was lacking in a nearby exclosure built in the early 1960's.

METHODS

Old mamane seed pods were collected from Hale Pohaku, 2750 m elevation. Seeds were extracted by hand and sorted to remove damaged ones. Intact seeds were kept in sealed plastic bags at room temperature until sowing.

The two factors examined in this study were seed coat treatment and sowing depth. Four seed coat treatments were tested:

1. Acid soak: Seed immersed in concentrated sulfuric acid for 60 minutes.
2. Sanded: Seed abraided between two sanding blocks for about 1 minute.
3. Hot water soak: Seed immersed in water at 100°C and allowed to soak until the water reached room temperature (overnight).
4. Control: Seed not treated.

Seeds were sown at six depths: broadcast over the surface, spot sown at 1.3 cm, and at every 2.5 cm thereafter to a depth of about 11 cm.

Three blocks, each divided into four plots, were laid out within the Wailuku exclosure. Seed coat treatments were randomly assigned to the plots in each block. Plots were further divided into six subplots each and sowing depths were randomly assigned to them (split-plot design.). Movement of surface sown seeds was restricted by means of buried hardware cloth around the perimeter of the appropriate subplot.

Eighty treated seeds were sown in each subplot during the first week of March 1974 when the upper 13 cm of soil were moist to sight and touch. Seed spots were made by inserting a reinforcing rod to the desired depth. Spacing was 10 by 10 cm. Only one seed was sown in each spot after which soil was poured into the hole and lightly tamped.

As seedlings emerged, numbered plastic markers were stuck nearby in the ground. The condition and height of each seedling were recorded.

Weekly measurements were made for the spring test to the 15th week after sowing. Thereafter, measurements were made every 4 weeks through the 54th week when the test was terminated.

Differences in seedling emergence, survival, and height due to seed coat treatment and sowing depth were examined by standard ANOVA techniques and multiple range tests using appropriate transformations. In addition, height-age regressions were fitted to the data and the coefficients were compared.

RESULTS

None of the seed sown on the soil surface germinated during the test. Therefore, I did not include this sowing depth in the analyses.

Seedling emergence

Analysis revealed that both seed coat treatment and sowing depth significantly ($p<0.01$) affected seedling emergence. Significant interaction was also detected.

Table 1 shows the results of comparisons of means. Several conclusions can be drawn from these:

1. At all depths except 1.3 cm, emergence was significantly greater for acid and sanded treatments than for control and hot water.

2. For the acid and sanded treatments, emergence from the 1.3 cm depth was significantly poorer than from the other depths.

3. Emergence from acid treated seed sown at the 3.8 cm depth was significantly greater than any other treatment/depth combination.

4. For the control treatment, emergence from the 3.8, 6.4, and 8.9 cm depths was significantly greater than from the 1.3 cm depth.

5. Seedling emergence from hot water treated seeds was not significantly affected by sowing depth.

Emergence began the fifth week after sowing with a single seedling, originating from an acid-soaked seed buried at 1.3 cm (Fig. 2). The two greatest seedling increments occurred between the fifth and sixth weeks; 52 new seedlings emerged from acid-soaked seed at 3.8 cm and 32 seedlings from sanded seed, also at 3.8 cm. Seedlings were not observed from the 8.9 cm and 11.4 cm depths until the 7th and 8th weeks, respectively. In both cases, sanded seed produced seedlings first.

Seedlings from hot water-treated seed emerged slowly. The first seedlings came from the 1.3 cm and 6.4 cm depths 12 weeks after sowing. The first and only seedling from the 3.8 cm depth emerged between the 30th and 34th week after sowing.

Most of the seedlings emerged between the 5th and 14th week after sowing. In the case of the acid and sanded treatments, more than 80% of the emergence was complete by the 14th week at all sowing depths.

Seedling survival

Seedling survival was low. Of the 602 seedlings that emerged, only 99 (16%) were still alive 54 weeks after sowing.

Was survival affected by sowing depth? By type of seed coat treatment? After looking at my data, I decided I could not answer these questions for the control and hot water treatments because so few seedlings emerged from these. Therefore, I only compared seedling survival between acid and sanded treatments (Table 2).

Depth at which seed were sown did not significantly affect end-of-test seedling survival. However, seedling survival was affected by type of seed coat treatment; significantly greater survival was observed for seedlings originating from sanded seed.

I examined the relationship between percent survival and week of emergence and found that survival was not dependent on week of emergence. Seedlings that emerged relatively early had just as good a chance of surviving as those that emerged later.

Another expression of survival is seedling age--that interval between the time a seedling was first seen and the time it was declared dead or the test ended. Analysis showed that seedling age was not significantly affected by week of emergence, seed coat treatment, or sowing depth.

One unexpected discovery was that some seedlings tallied as dead suddenly reemerged, one as much as 24 weeks later. Of the 602 seedlings that emerged, 57 exhibited this behavior. Thirteen of these were still alive at the end of the test, thus accounting for about 13% of the surviving seedlings.

Seedling height

Height-age regression curves were fitted to my data (Fig. 3). Comparisons of the regression coefficients for the acid seed coat treatment showed that growth was significantly greater for seedlings from the 11.4 cm depth than for those from other depths. The same was true for the sanded treatment. Regression curves for the control treatment--3.6, 6.4, and 8.9 cm depths only--were significantly different from each other with seedlings from the 6.4 cm depth growing tallest.

The effect of seed coat treatment on seedling height was not clear from my data.

The coefficients of determination (r^2) for the regressions were low. Obviously, factors other than seedling age, seed coat treatment, and sowing depth were affecting height growth.

About 70% of the seedlings died back either prior to their death or prior to the end of the study. The greatest proportion of seedlings exhibiting dieback (77%) came from the 3.8 cm depth followed in order by the 6.4 cm (71%), 8.9 cm (70%), 11.5 cm (64%), and 1.3 cm depth (47%).

DISCUSSION

The management implications of these results are clear; direct sowing is not viable regeneration technique on sites similar to the one I used. Maximum emergence was only 54%. Survival was low and height growth slow.

Compared to planting of nursery-grown seedlings, direct sowing is not effective for regenerating mamane. About the time the test began, 36 containerized seedlings with an average height of 24 cm were planted in the Wailuku exclosure. Survival was 47% in April 1978 compared to 3% for seedlings from this study. Average height of survivors was 52 cm for the planted seedlings and 31 cm for the others. Planting was clearly the superior regeneration method.

TABLE 1. Comparisons of percent seedling emergence means for each combination of seed coat treatment and sowing depth.

Seed Coat	Sowing Depth				
Treatment	1.3	3.8	6.4	8.9	11.4
	Percent				
Acid	6d[1]	54a	34b	15c	15c
Sanded	3def	32b	34b	22bc	15c
Control	0g	6d	4de	3def	< 1efg
Hot Water	< 1fg	1defg	1defg	< 1fg	< 1fg

[1] Means followed by the same letter are not significantly different (Duncan's Multiple Range Test).

TABLE 2. Average percent survival of mamane seedlings by sowing depth for acid and sanded seed coat treatments.

Seed Coat	Sowing Depth (cm)					
Treatment	1.3	3.8	6.4	8.9	11.4	Average
	Percent Survival					
Acid	0	9	12	9	11	10
Sanded	33	25	24	21	20	24
Average	14	15	18	16	17	--

Figure 1--Map of Mauna Kea, island of Hawaii, showing the location of the Wailuku exclosure study site.

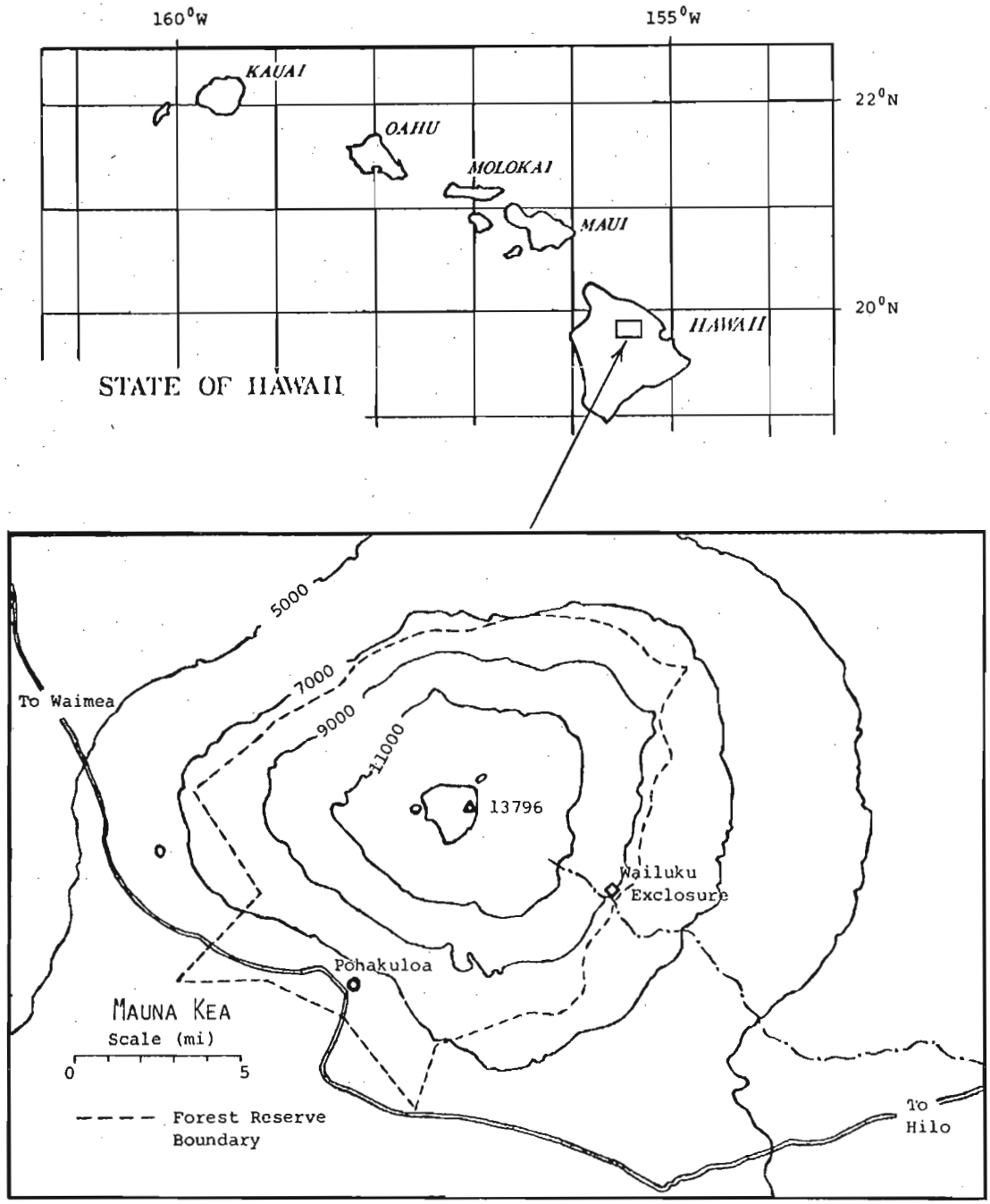


Figure 2--Cumulative number of emerged mamane seedlings over time for each sowing depth and seed coat treatment during the test period, March 7, 1974 to March 18, 1975.

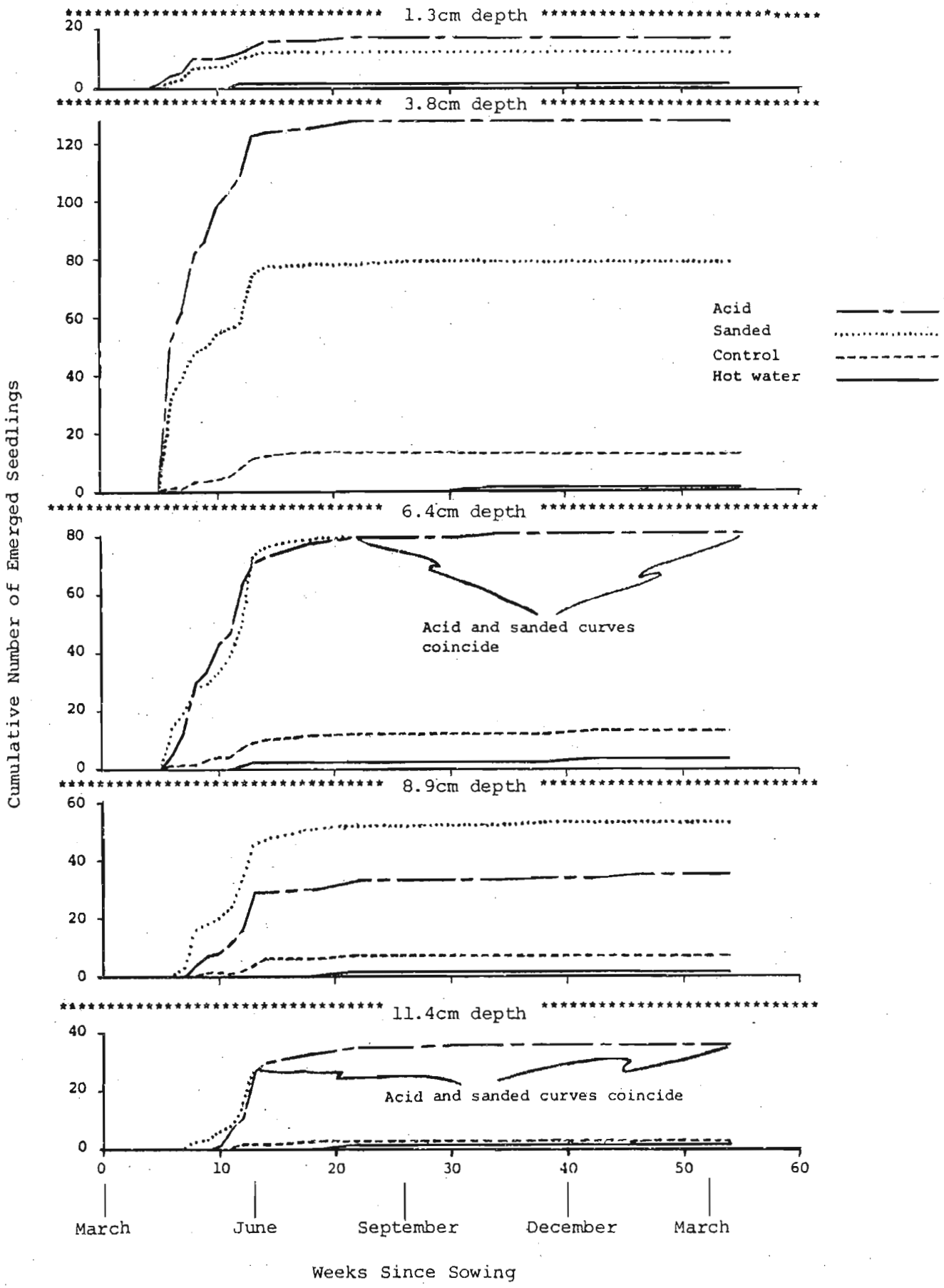
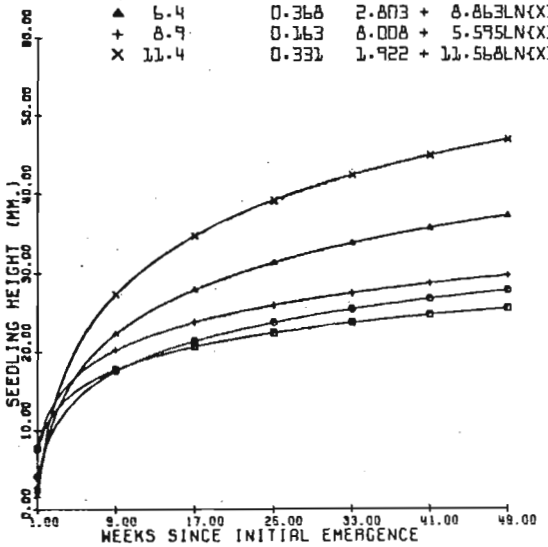


FIGURE 3 --SEEDLING HEIGHT OVER TIME FOR EACH SOWING DEPTH WITHIN A GIVEN SEED COAT TREATMENT DURING THE SPRING TEST.

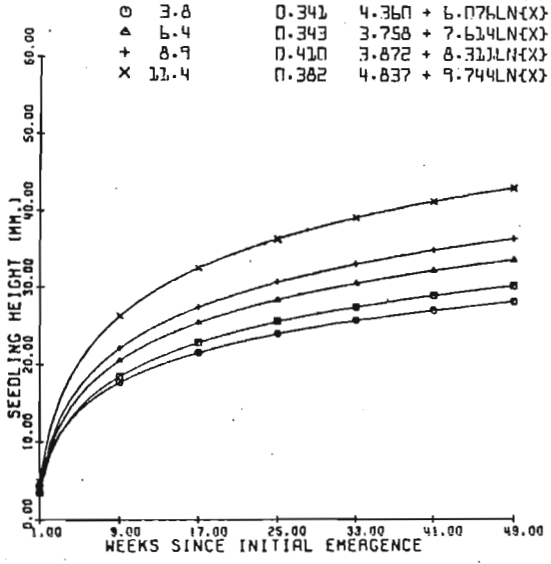
ACID

SOWING DEPTH (CM)	R^2	EQUATION
1.3	0.263	7.744 + 4.589LN(X)
3.8	0.310	4.223 + 6.088LN(X)
6.4	0.368	2.803 + 8.863LN(X)
8.9	0.163	8.008 + 5.595LN(X)
11.4	0.331	1.922 + 11.568LN(X)



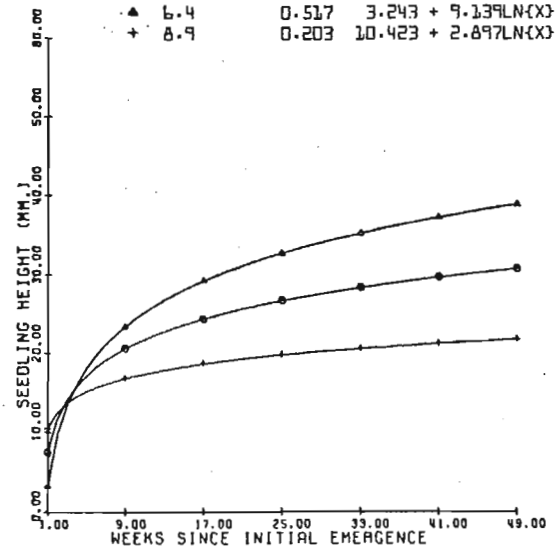
SANDED

SOWING DEPTH (CM)	R^2	EQUATION
1.3	0.507	3.488 + 6.831LN(X)
3.8	0.341	4.360 + 6.076LN(X)
6.4	0.343	3.758 + 7.614LN(X)
8.9	0.410	3.872 + 8.311LN(X)
11.4	0.382	4.837 + 9.744LN(X)



CONTROL

SOWING DEPTH (CM)	R^2	EQUATION
3.8	0.205	7.459 + 5.970LN(X)
6.4	0.517	3.243 + 9.139LN(X)
8.9	0.203	10.423 + 2.897LN(X)



HOT WATER

SOWING DEPTH (CM)	R^2	EQUATION
3.8	0.147	7.285 + 1.840LN(X)
6.4	0.001	10.838 + 0.141LN(X)