EXPERIMENTAL SEEDSPOTTING TRIALS WITH BLACK SPRUCE ON UPLAND CUTOVERS

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ABSTRACT

Experimental seedspotting trials for two successive years with untreated, coated, pelleted, and encapsulated black spruce (*Picea mariana* [Mill.] B.S.P.) seeds are documented and discussed. None of the seed treatments had any significantly adverse effect on either germination or related stocking. The beneficial effect of screening was attributed to shading rather than to protection against rodents. Imbedding seeds had no advantage over sowing them on the surface. Although the evidence was not conclusive, owing to divergence in seeding dates in the two trials, late spring and late summer seeding appeared to promote better germination and stocking than midsummer and late fall seeding.

RÉSUMÉ

L'auteur a documenté et discuté des essais effectués deux ans de suite par points de graines d'Épinette noire (*Picea mariana* [Mill.] B.S.P.) non traitées, enrobées, mises en boulettes et capsulées. Aucun des traitements n'a eu d'effet adverse significatif sur la germination ou le matériel sur pied relatif. L'influence bénéfique des divers traitements fut attribuée au fait que les graines étaient préservées du soleil plutôt que protégées des rongeurs. L'ensemencement des graines sous litière n'eut aucun avantage sur l'ensemencement en surface. Bien que la preuve ne fût pas concluante, à cause des différences de dates d'ensemencement dans les deux essais, les graines semées tard à la fin du printemps et de l'été ont semblé procurer plus de succès à la germination et au matériel sur pied que les graines semées à la mi-été et à la fin de l'automne.

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INTRODUCTION

This report deals with experimental field trials with pelleted and encapsulated black spruce (*Picea mariana* [Mill.] B.S.P.) seeds on upland cutovers in the Central Plateau Section of the Boreal Forest Region (Rowe 1972). The trials were conducted on the Ontario Paper Company licence (Fig. 1) and approximately 32 km northeast of Manitouwadge, Ontario (49°8'W and 85°50'N approx.). They paralleled, roughly, controlled laboratory and greenhouse germination experiments with the same seed treatments (Fraser 1980a). Preliminary results from the first of the two trials were reported (Fraser 1975) at the Thunder Bay symposium on black spruce in 1975. The end results of both trials are documented here.

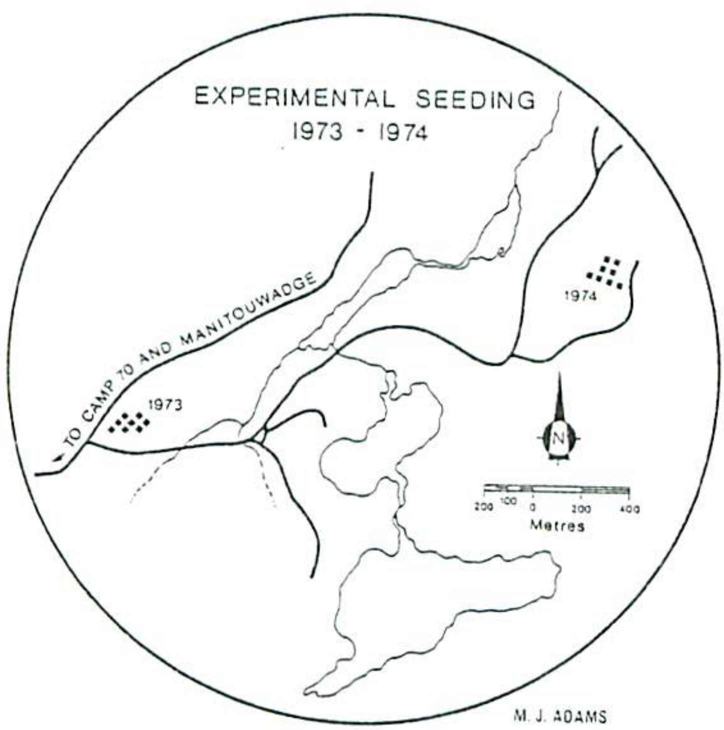

Figure 1. Location of the 1973 and 1974 experimental direct seeding trials with pelleted and encapsulated black spruce seeds.

For the sake of brevity and to avoid needless repetition readers are referred to Fraser (1975) for details on design, layout, methods and procedures for these trials. In summary, however, their objective was to determine what influence, if any, seed pelleting and encapsulation (see Fraser 1980a for details on seed treatments) had on field germination of black spruce seeded by hand onto carefully prepared seedspots consisting of a mixture of mineral soil and humus reported (Winston 1975) to be ideal for germination and survival of black spruce. Secondary considerations were screening against seed loss due to birds and/or rodents (protection), surface-sown versus imbedded seeds (seeding methods) and time of seeding.

Although the replicated Latin-square design of each trial provided for detailed factorial analyses it is doubtful whether such costly and time-consuming analyses would be more revealing than the simple Chi-square method used to analyze both germination and stocking. However, should anyone care to undertake more comprehensive analyses, all field data are filed on tape at the Great Lakes Forest Research Centre.

The 1973 experimental trial (Fig. 2) was approximately 0.5 km west of the Mooseskull 1 operational seeding trial (Fraser 1980b), on a relatively dry, upland mixedwood cutover and at least 60 m from any black spruce seed trees. Residual aspen (*Populus* sp.) and white birch (*Betula papyrifera* Marsh.) were felled to accommodate plot layout.

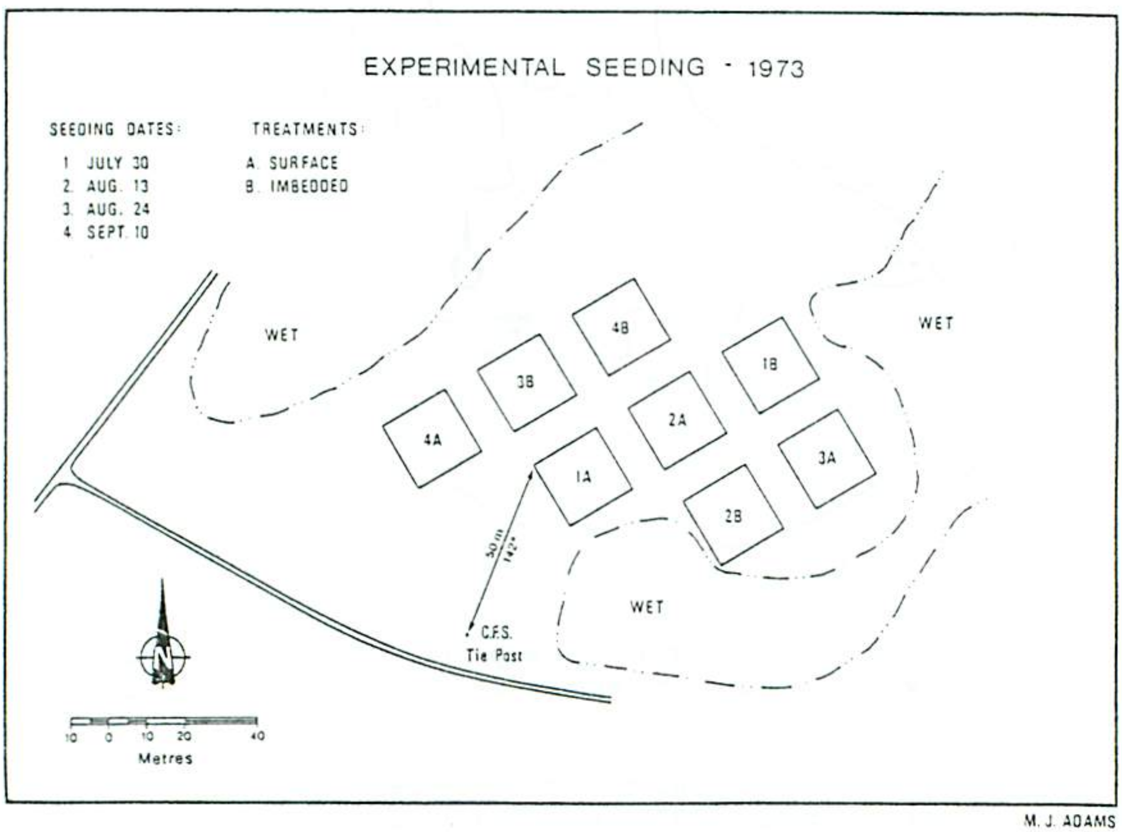

Figure 2. Latin square layout for the 1973 experimental direct seeding trials in Mooseskull Area 1.

The 1974 experimental trial area (Fig. 3) was situated about halfway between a mixedwood stand in the southeast and a pure black spruce swamp to the northwest. Here, too, the plots were more than 60 m from black spruce seed trees.

RESULTS

A tally of seedbed conditions on each seedspot was made when germination was first assessed, one month after seeding. It revealed that 98% of the seedspots in the first experiment and 97% of those in the second one were on mineral soil, on humus (partly or fully decomposed) or on a mixture of mineral soil and humus. Further, the fact that 89% and 80% of the seedspots in experiments 1 and 2, respectively, were on either mineral soil or a mixture of mineral soil and humus indicates that the hand-scalping operation was successful.

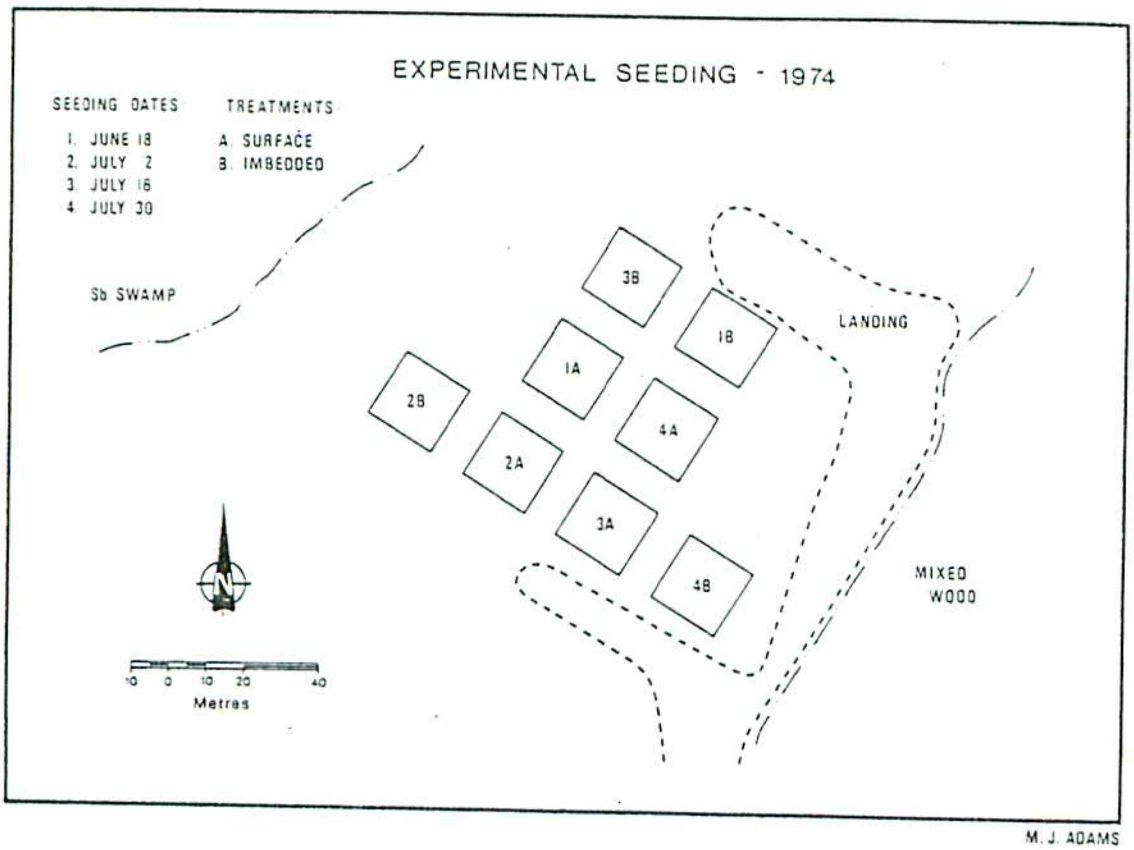

Figure 3. Latin square layout for the 1974 experimental direct seeding trials in the Mooseskull Area 2.

There were grids of 24 and 23 seedtraps, approximately 60 cm x 60 cm, on the first and second experimental areas, respectively. Since only four black spruce seeds (two of them empty) were caught in the traps on the first area, and only five (four of them empty) on the second area it is assumed that all black spruce germinants recorded on the seedspots were from the experimental seeding.

Tables 1 and 3 summarize germination from experimental trials 1 and 2, respectively, and Tables 2 and 4, respectively, summarize stocking from the same trials. These tables are found in the Appendix. Percentages in these tables have been rounded off to the nearest whole percent (which accounts for minor inconsistencies in the data) but indications of statistically significant differences ($p = 0.05$) are based on Chi-square tests using actual values.

In Figures 4-11, treatments between which there is no statistically significant difference have been averaged to simplify graphical presentation and interpretation. For example, percent stocking for the control treatment at successive assessments was 40, 36, 38, 38, and 38% (Table 1). Since there was no significant difference ($p = 0.05$) among these, the mean value, 38%, is plotted for the control value in Figure 4.

The decision to present the results of these trials as subsections on germination and stocking under each experiment rather than by germination and stocking with the experiments as subsections was strictly arbitrary.

Experimental Seeding No. 1 (1973)

Germination: Figure 4 is a series of bar diagrams comparing mean percent germination by seed treatments, protection, method of seeding and date of seeding (in each instance combining all other treatments). The contention is that these means illustrate the results of treatment difference quite adequately. As germination at each of the three assessments is based on the number of germinants (seedlings) at that time, and as it is unlikely that mortality occurred within the first month, the fall 1973 data are probably a true indication of mean germination at that assessment. Thereafter, the data probably indicate the end result of mortality and/or additional germination. This reasoning applies to all four charts on germination and also to those on stocking. Although only three assessments are illustrated here, the data on which Figures 4 and 5 are based (Table 1) tend to support the contention (Fraser 1976, 1980c) that black spruce seeds lose their ability to germinate 10 to 16 months after they are sown.

Initially (fall 1973), but only in a relative sense, Moran-pelleted (MP) and Asgrow-coated (AC) seeds germinated significantly better than control (C), Asgrow-pelleted (AP) and FMC encapsulated seeds (F_1)[1]. By spring 1974, germination was still significantly better from AP than from F_1 seeds, and significantly poorer from both than from C, MP and AC seeds among which there was no difference. One year after seeding, germination from F_1 seeds was as good as from AP seeds, but still not as good as from C, MP and AC seeds.

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[1]In the F_1 treatment single seeds were enclosed in a cavity at the centre of a vermiculite tablet. In the F_2 treatment (second trial) single seeds were imbedded at the centre of identically sized one-piece tablets (Fraser 1980a).

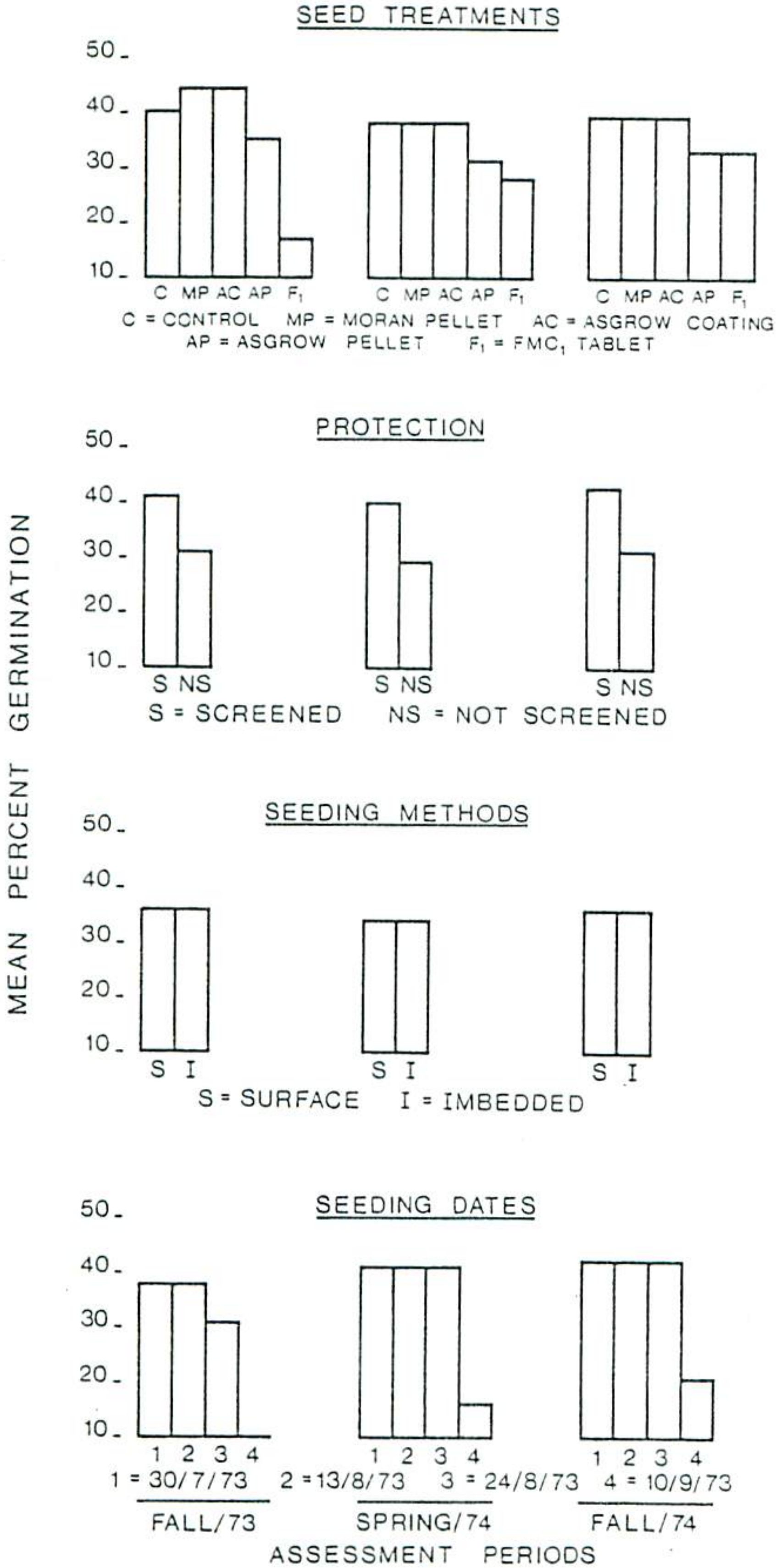

Figure 4. Mean percent germination of black spruce seeds by seed treatment, protection, seeding method and seeding dates, one, nine and twelve months after seeding.

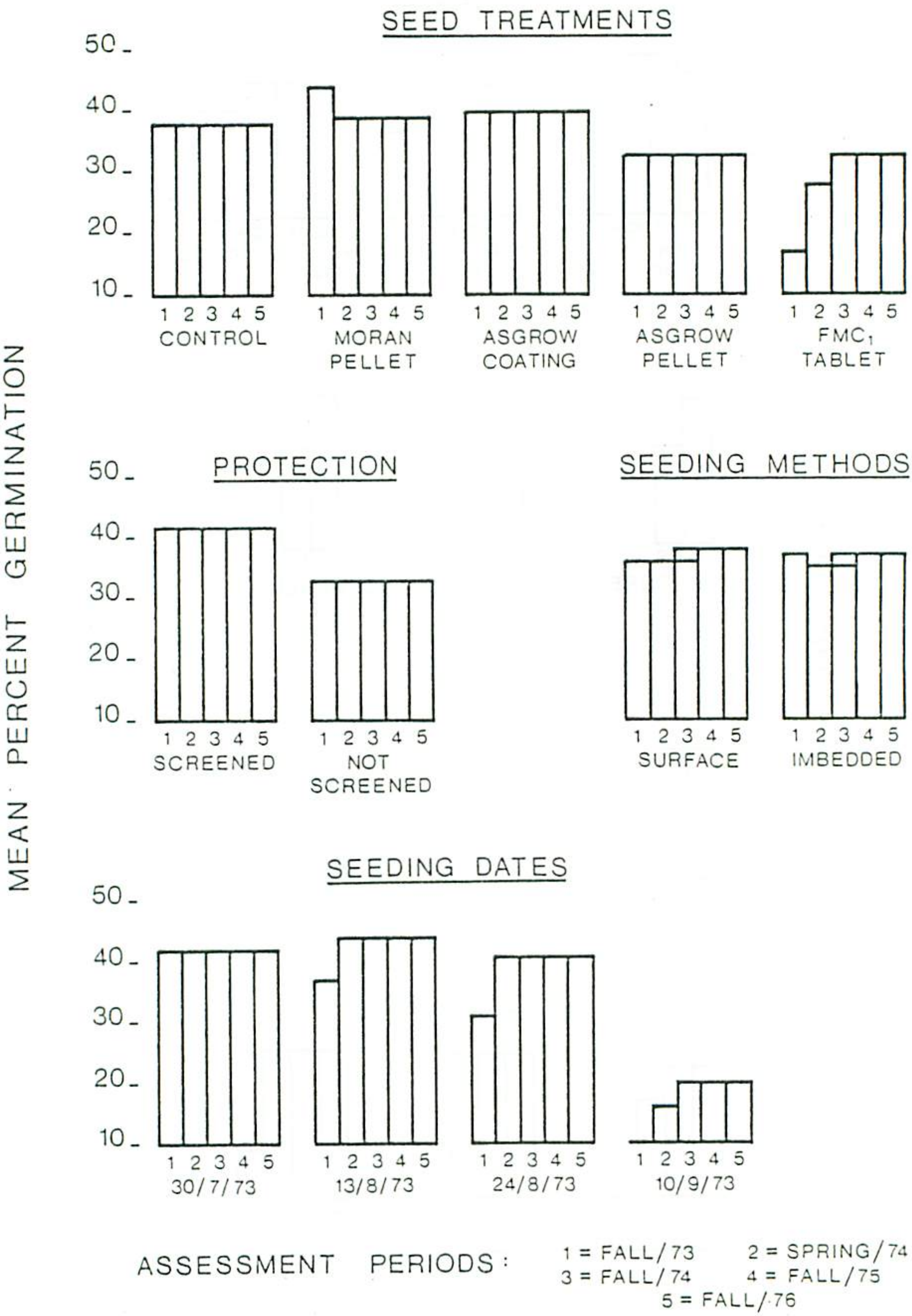

Figure 5. Mean percent germination of black spruce seeds by seed treatment, protection, seeding method and seeding date on five successive assessments.

Germination was significantly better on screened than on unscreened seedspots at the first assessment and remained so, but there was no difference in germination from surface-sown versus imbedded seeds.

Initially there was better germination from seeds sown by August 13, but by the following spring, and thereafter, there was no significant difference in germination from seeds sown from July 30 to August 24. Germination from seeds sown after August 24 was significantly poorer than from those sown earlier.

Figure 5, covering five assessments, illustrates more clearly the relationship between mean percent germination and time, i.e., subsequent assessments. Aside from some initial, overwinter mortality in the MP germinants the germination pattern for C, MP, AC, and AP treatments did not vary. The exception was the F_1 treatment where there was significantly more germination up to and including the third assessment (fall 1974) but none thereafter.

The pattern of better germination on screened versus unscreened seedspots in Figure 4 is confirmed in Figure 5, as is the pattern of equally good germination (relatively) from surface-sown and imbedded seeds. The statistically significant overlapping treatments have no real practical significance. Following the germination/seeding-date relationships beyond the third assessment (Fig. 5) merely confirms that although there was no germination beyond the first year after seeding, neither was there any significant mortality.

<u>Stocking</u>: Initially (fall 1973) there was no significant difference in stocking (87%+) among the C, MP, AC, and AP treatments but they were all significantly better than the stocking (54%) on the F_1 treatment (Fig. 6). However, by late spring 1974, there was a significant reduction in stocking on all but the F_1 treatment, where it actually increased significantly. At that time stocking on all treatments still exceeded the 60% level for desirable stocking (Robinson 1974)[2], but within a year (fall 1975) stocking had deteriorated to within the marginal stocking range on all but the F_1 treatment where it remained slightly above the desirable stocking level.

Initially (fall 1973), stocking was equally good (80%+) on screened and unscreened seedspots, but by spring 1974 it had decreased significantly on both, and stocking was significantly better on the screened seedspots. By fall 1975, stocking had deteriorated even further but still met the desirable criterion (60%) on screened seedspots whereas it was only marginal on unscreened seedspots.

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[2]Hereafter desirable stocking means 60% or more, marginal stocking means 40% to 60% and < 40% is failure (from Robinson 1974).

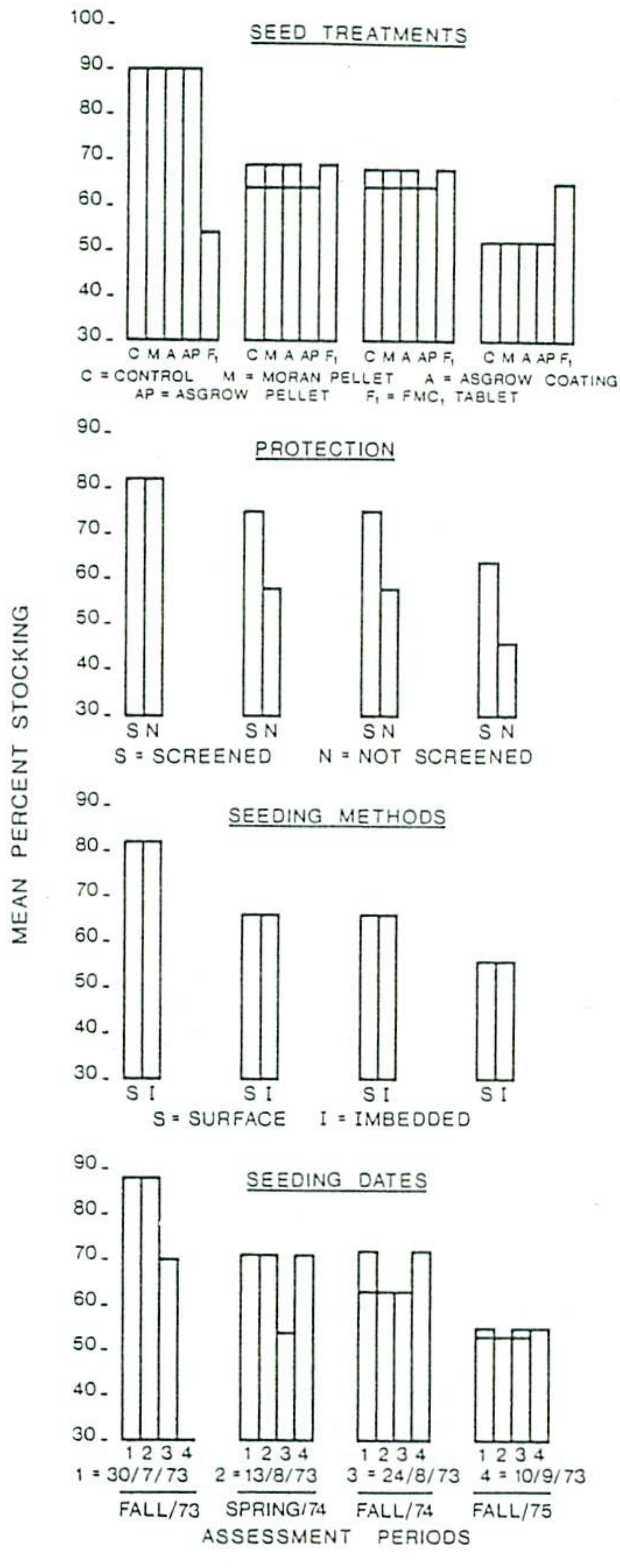

Figure 6. Mean percent stocking by seed treatment, protection, seeding method and date of seeding one, nine, twelve and twenty-four months after seeding.

There was no significant difference in stocking from surface-sown and imbedded seeds at any time. Initially, stocking was better than 80%, but within a year it had deteriorated to slightly better than desirable stocking, and the following year it deteriorated still further to within the marginal stocking range.

There were undoubtedly some inconsistencies in the seeding-date data because the first assessment was conducted too soon after the fourth (September 10, 1973) seeding for any germination to have occurred. Initially, stocking from the late July and early August seedings was equally good (87%+), and was significantly better than stocking from the mid-August seeding. By the following spring (1974), when stocking from the fourth seeding date was assessed for the first time, stocking from the first three seeding dates had worsened significantly but still exceeded the desirable level. By fall (1974) stocking had improved somewhat but one year later it had deteriorated until it was only marginally acceptable and there was no practical difference in stocking among the seeding dates.

Figure 7 illustrates somewhat more clearly the deterioration in stocking with time. The pattern is almost identical for the C, AC and AP seed treatments, i.e., excellent stocking (80%+) initially, decreasing significantly the first winter, remaining static during the summer, decreasing significantly again the second winter and remaining static thereafter--at least over the next winter/summer cycle. For the MP treatment, stocking, which initially was as good as it was on the C, AC and AP treatments, deteriorated significantly the first winter and then remained static. For the F_1 treatment, the stocking pattern was reversed, with stocking increasing significantly before the second assessment (spring 1974) and remaining static until the fall of 1976. Although it decreased significantly before the final assessment (fall 1976) it was the only treatment desirably stocked three years after seeding.

The stocking patterns with time are identical for screened and unscreened seedspots and for surface-sown and imbedded seeds, i.e., initially excellent stocking deteriorating significantly the first and second winters after seeding but not thereafter.

Stocking according to when the seeds were sown follows the same pattern of initially excellent stocking (first and second dates) to good stocking (third and fourth dates). Stocking from the first and second seedings deteriorated significantly during the first and second winters but not thereafter, while stocking from the third seeding deteriorated during the first winter, after which it remained static. Stocking from the fourth seeding deteriorated significantly only during the second winter, probably because of the anomaly of no recorded stocking in the fall of 1973, which was due to lateness of seeding.

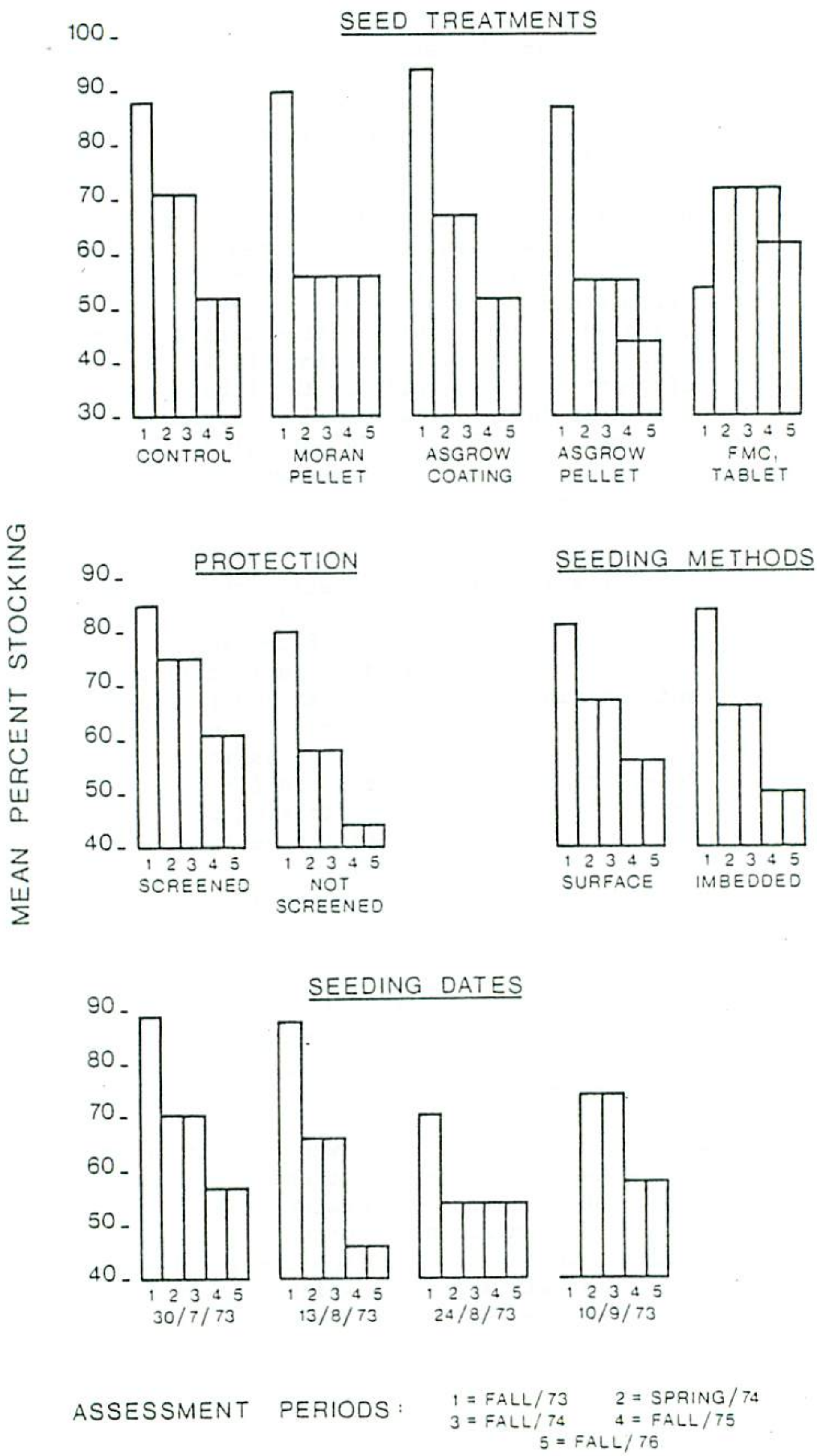

Figure 7. Mean percent stocking by seed treatment, protection, seeding method and date of seeding on five successive assessments.

Experimental Seeding No. 2 (1974)

Germination: If we bear in mind that this second trial excluded AC treatment because there was not enough seed, but included a second FMC-encapsulation treatment (FMC_2 or F_1)[3], germination patterns in this trial (Fig. 8) were generally similar to those in the first trial and, like them, consistently below 50%. In this instance, however, MP seeds germinated significantly better (relatively) than those from any other treatment, initially and thereafter; C and AP seeds germinated equally well and significantly better than F_2 seeds which, in turn, germinated better than F_1 seeds. Again, although there was only a slight increase in germination from MP, C and AP seeds between the first and second assessment, there was a significant increase in germination from F_1 and F_2 seeds during this period, and none thereafter from any treatment (Fig. 9). Presumably all seeds capable of germinating had done so by the spring of 1975.

Here, as in the first trial, germination was significantly better on screened than on unscreened seedspots, but in this trial there was a significant increase in germination on both between the first and second assessments, but none thereafter.

Germination patterns from surface-sown versus imbedded seeds differed from those in the first trial only at the first assessment (fall 1974) when there was more germination from surface-sown than from imbedded seeds. By the second assessment there was a significant increase in germination from imbedded seeds, but thereafter, seeding method had no effect on germination.

Since the latest seeding date in this trial is the same as the earliest seeding date in the first trial (July 30) the germination/seeding date patterns are obviously unrelated. Despite the significantly better germination initially from the latest seeding (July 30) than from the two earliest ones (June 18, July 2)--between which there was no difference--and despite the fact that the two earliest and the latest seedings resulted in significantly better germination than did the third seeding (July 16), less than 35% of all seeds germinated. Germination from all seedings increased significantly by the second assessment (spring 1975) and sufficiently so from the first two seedings in comparison with the fourth one to reverse the initial pattern, but it was still only 41% (maximum) and never improved significantly.

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[3]In the F_1 treatment single seeds were enclosed in a cavity at the centre of a vermiculite tablet. In the F_2 treatment (second trial) single seeds were imbedded at the centre of identically sized one-piece tablets (Fraser 1980a).

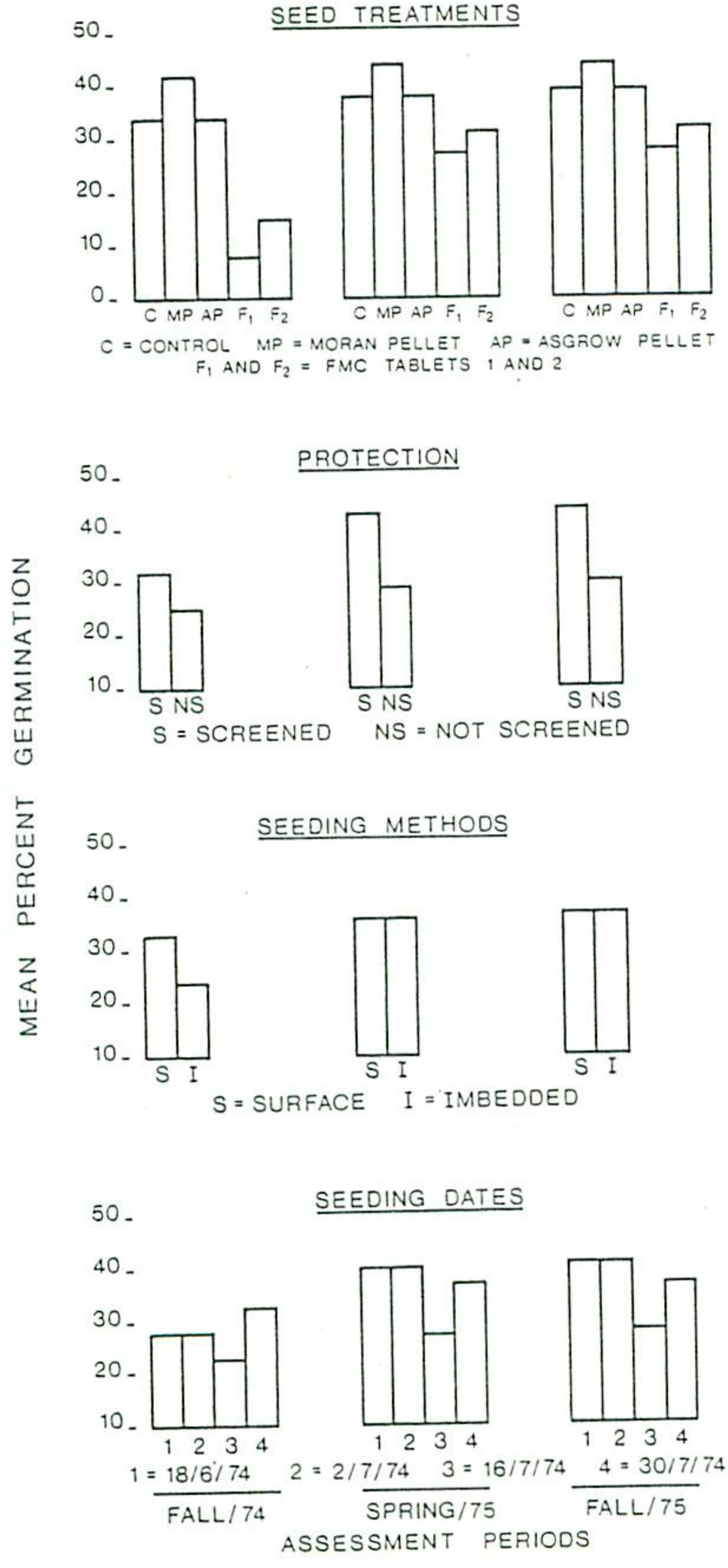

Figure 8. Mean percent germination of black spruce seeds by seed treatment, protection, method of seeding and seeding dates, one, nine and twelve months after seeding.

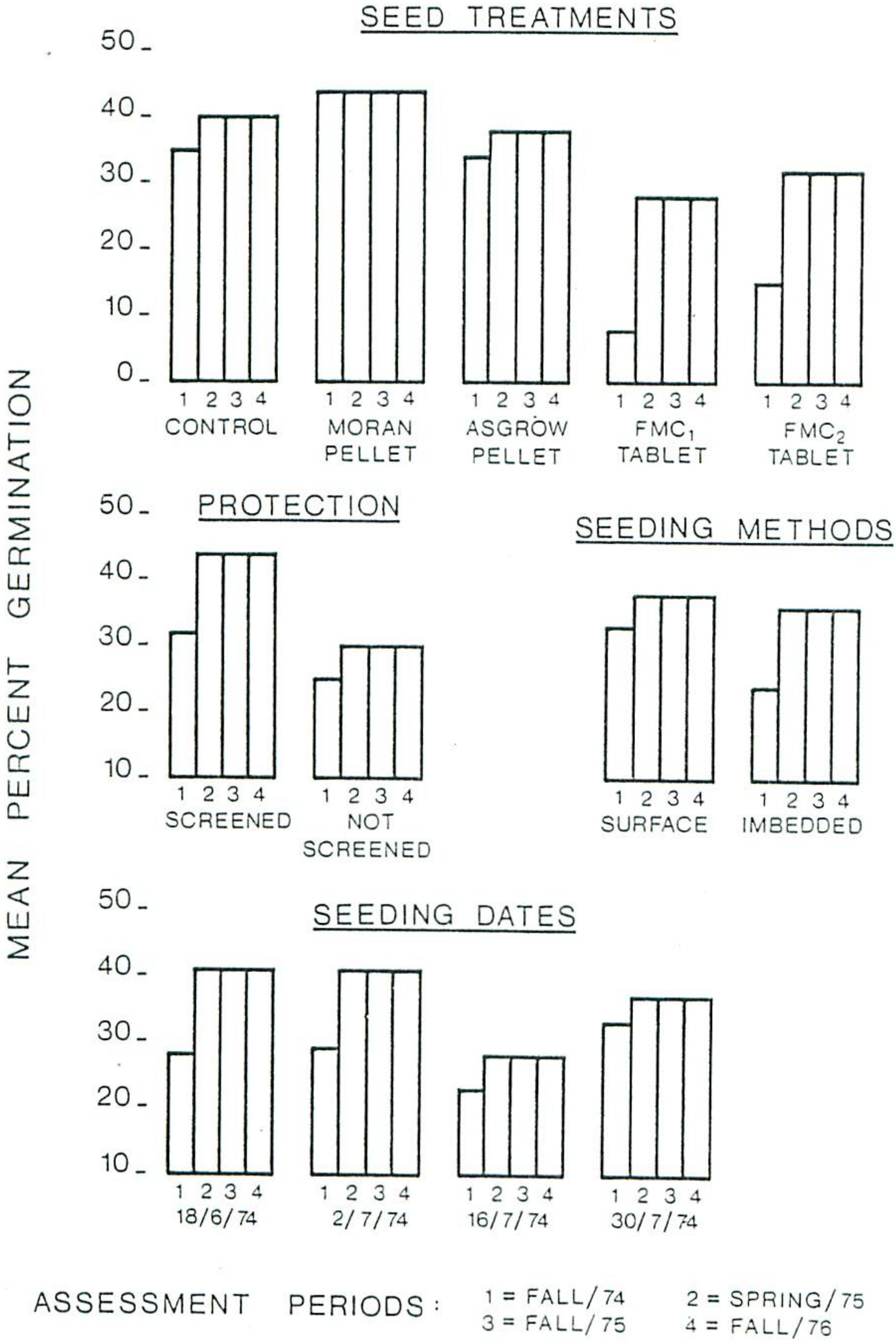

Figure 9. Mean percent germination of black spruce seeds by seed treatment, protection, seeding method and seeding date on four successive assessments.

With one exception (the MP seeds), from which germination never increased significantly beyond the first assessment, germination from the C, AP, F_1 and F_2 seeds increased between the first and second assessments but not thereafter. The most significant increase was from F_1 and F_2 seeds in that order.

The same pattern of germination, i.e., a significant increase in germination in the period between the fall 1974 and spring 1975 assessments, and none thereafter, was maintained for the screened versus unscreened, surface-sown versus imbedded seeds, and the different seeding dates.

Stocking: The initial stocking/seed-treatment pattern for this trial (Fig. 10) generally resembles that for the first trial, i.e., there was no significant difference in stocking among the control and pelleted treatments (C, MP and AP) (83%). Stocking was significantly better than that from the F_2 treatment (64%), which was itself significantly better than that from the F_1 treatment (45%). By the spring of 1975 there was a significant increase in stocking from F_1 seeds so that it was as good as that from F_2 seeds (64%), and more than satisfied the criterion for desirable stocking. It was significantly better than stocking from C, MP and AP seeds, which had decreased significantly to the marginal level. Stocking remained almost static until the third year after seeding (fall 1976) when it had deteriorated to below the failure level regardless of seed treatment.

The stocking/protection pattern in this second trial differed from that in the first trial in that initial stocking, equally good on screened and unscreened seedspots, was about 10% lower than it was in the first trial. By the spring of 1975 stocking on both had decreased significantly, but by then it was significantly better on screened than on unscreened seedspots (desirable stocking versus marginal stocking). There was no appreciable change by the fall of that year, but one year later (fall 1976), although screened spots were still significantly better stocked than unscreened ones, neither was even marginally stocked (cf. first trial where stocking on screened spots was above the desirable level).

Unlike stocking in the first trial, which was no different from surface-sown and imbedded seeds throughout the trials, stocking in the second trial was significantly better initially from surface-sown seeds, and in both trials it was above the desirable level. By the following spring (1975) the pattern was reversed: stocking from both surface-sown and imbedded seeds had decreased, but was significantly better from imbedded seeds. Although there was little if any additional change that year, stocking deteriorated the following year until "imbedded" seedspots were barely marginally stocked and stocking on "surface-sown" seedspots was well below the failure level.

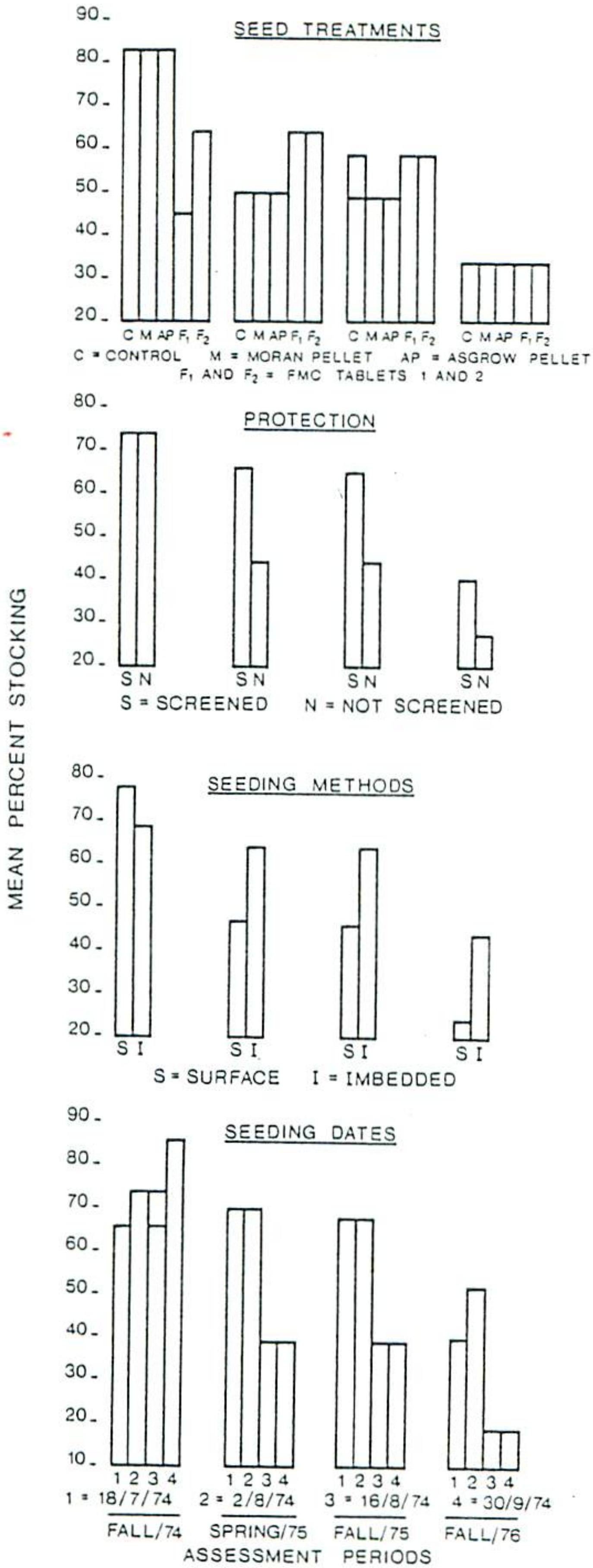

Figure 10. Mean percent stocking by seed treatment, protection, seeding method and date of seeding, one, nine, twelve and twenty-four months after seeding.

Stocking relative to seeding date was quite inconsistent at the first assessment (fall 1974) (Fig. 11) as might be expected from the spread in seeding dates, but by the spring of 1975 the pattern of equally good stocking (60%+) from the first two seedings was established. This was significantly better than that from the statistically equal but much poorer (<40%) last two seedings. This pattern held for 1975, but one year later (fall 1976), although stocking from the third seeding was significantly better than that from the first, second and fourth seedings, it was no better than marginal on any of them.

Despite the occasional anomalies (FMC_1 and FMC_2), stocking, initially well above desirable levels regardless of seed treatment, deteriorated each winter following seeding until by the fall of 1976 it was only marginal or a failure.

The stocking/protection patterns in both trials were remarkably similar, i.e., initially (fall 1974) both screened and unscreened seedspots were more than desirably stocked, with screened seedspots significantly better stocked than unscreened ones; by the fall of 1976, after stocking had deteriorated significantly for two winters, it was only marginal on screened spots and below the failure level on unscreened spots.

Stocking from surface-sown seeds, initially better than 78%, had deteriorated significantly to the failure level by the fall of 1976. Stocking from imbedded seeds, though initially significantly poorer than that from surface-sown seeds, was still desirable and remained so until the significant decrease during the second winter reduced it to just within the marginal range.

Stocking from the two earliest seedings was desirable initially and until the fall of 1975 in relation to time of seeding, but before the next fall (1976) it had deteriorated to the marginal level. Stocking from the second of the first two seedings was always significantly better than that from the earliest seeding. Initially (fall 1974) stocking from the two later seedings was as good as (third seeding) or significantly better (fourth seeding) than it was from the first two seedings, but deteriorated rapidly thereafter until it was only marginal by the fall of 1975 and a failure by the fall of 1976.

DISCUSSION AND CONCLUSIONS

This report has documented *mean* percent germination and percent stocking by individual treatments when all other treatments are combined. Since only one seeding date, July 30, is common to both trials, combining all seeding dates to arrive at means for other treatments confounds them to a considerable degree. However, this "broad-brush" treatment is revealing enough to support some reasonable conjectures.

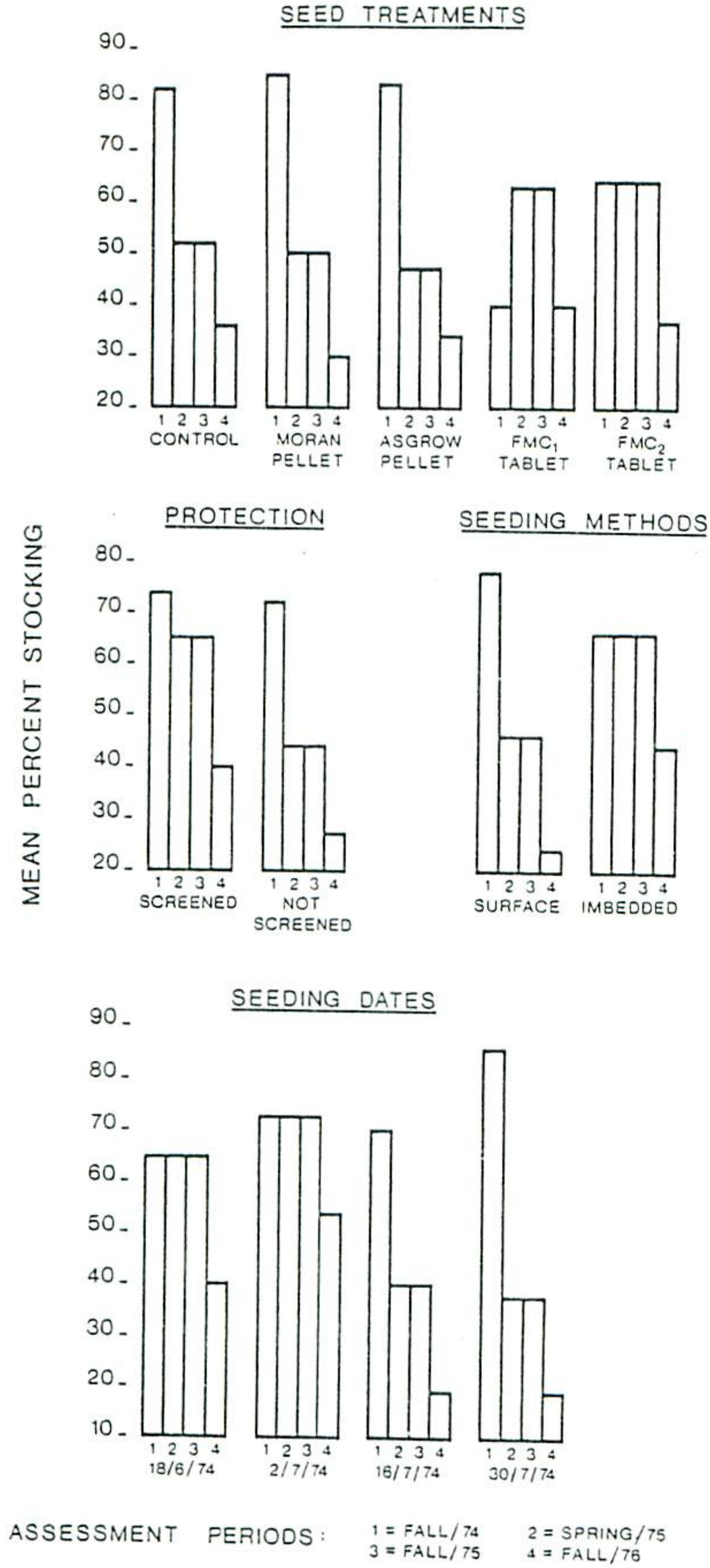

Figure 11. Mean percent stocking by seed treatment, protection, seeding method and date of seeding on four successive assessments.

Consideration of seed treatments in both experiments can be narrowed considerably by eliminating the encapsulation treatments. Simply put, there was initially less germination and poorer stocking from encapsulated seeds than from all other seed treatments. By the following year, although germination had increased to a certain degree, and stocking had improved quite considerably (to the desirable level), it was really no better than the best stocking obtained from the other treatments. In any case, by the time of the final assessments FMC had discontinued the single-seed encapsulation process,[4] making even these results irrelevant as far as practical forest management is concerned.

The one common denominator in the germination/seed-treatment patterns, if we bear in mind the elimination of the Asgrow-coating in the second trial, is the better germination from Moran-pelleted seeds than from control and Asgrow-pelleted seeds. This hardly underwrites the use of Moran-pelleted seeds, when we consider the poor germination results from this and from all other treatments including the control. It merely indicates that none of the coating and pelleting treatments had any adverse effect on field germination of black spruce seeds.

Since stocking was universally well above the level for desirable stocking initially (fall 1973), except for the encapsulated-seed treatments, and was only marginal in the first trial and a failure in the second, it is clearly not related to seed treatment.

There is little doubt that screening promoted better germination and, after the first assessment on each trial, better stocking. This might have been due to protection against rodents, etc., mainly insofar as germination is concerned, and possibly against browsing insofar as stocking (survival) is concerned. Studies conducted by the Canadian Wildlife Service indicated that the considerable numbers of different species of rodents on the cutovers did not constitute a hazard to seedspotting of black spruce.[5] Screening probably promoted better germination and survival (and hence better stocking) by virtue of the shade it provided against excessive heat and/or (indirectly) drought. The important point is that even the screened spots were no better than marginally stocked after two years.

Aside from initially better germination from surface-sown seed in the second trial, the method of seeding had no impact on germination. In the first trial the method of seeding had no impact on stocking until the third year, when stocking, though marginal, was significantly better from surface-sown seeds. Conversely, in the second trial, stocking was significantly better from surface-sown seeds

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[4]Personal communication, W.L. Marlow.

[5]Personal discussions with Dr. A. Martell, Canadian Wildlife Service, 204 Range Road, Whitehorse, Yukon Territories.

only initially, and thereafter was significantly better from imbedded seeds. The relevancy of this is questionable in view of the fact that, two years after the seeding, stocking from surface-sown seed was below the failure level and only marginal from imbedded seed.

The data on germination relative to time of seeding tend to be inconsistent and anomalous because the dates of the first, second, third and fourth seedings in the two trials are so widely divergent. Any comparison on the basis of the one common seeding date, July 30, would hardly be credible since it is the earliest seeding date in the first trial and the latest one in the second trial. If the significantly (and not unexpectedly) poorer germination is excluded from the unusually late September seeding in the first trial, seeds sown from July 30 to August 24 germinated equally well--albeit poorly--by spring of the following year.

In the second trial the same general germination pattern was maintained, i.e., germination from the two earliest seedings was better initially than it was from the two later seedings. That germination from the last seeding (July 30) was better than from the previous one (July 16) indicates that seeding in mid-July may have coincided with deleterious moisture/temperature conditions which may have improved subsequently.

Although the evidence from these particular trials is not conclusive there is some justification for inferring that, insofar as germination is concerned, seeding up to the end of June and during the month of August may be as effective as seeding in July and after the beginning of September--or even more so.

If we make liberal allowances for the widely divergent seeding dates in the two trials there is still some suggestion that, initially at least, better stocking resulted from earlier seeding. The implication is that the earlier the seeding the better the resultant stocking. However, this is hardly substantiated by the indication (Tables 2 and 4) that within three years of seeding (actually two years in the second trial) the initially excellent stocking was at best only marginal and in two instances was a dismal failure.

In summary:

If we exclude the FMC-encapsulation treatment, because it is no longer available and because it tended to delay and depress germination initially (which may or may not be undesirable, depending upon weather conditions), field germination and resultant stocking from Moran-pelleted, Asgrow-coated, and Asgrow-pelleted black spruce seeds was, for all practical purposes, as good as or better than it was from untreated seeds. The conclusion is that wherever coating or pelleting facilitates or is otherwise potentially advantageous in direct seeding, black spruce seeds may be so treated for immediate use without prejudicing field germination or resultant stocking.

Screening of seedspots undoubtedly promoted better germination, survival, and resultant stocking of black spruce. Since the Canadian Wildlife Service studies indicated that rodents were not significantly hazardous to seedspotting of these cutovers, the conclusion is that screening, rather than providing protection against a nonexistent hazard, simply created a more favorable environment for black spruce germination and survival. From this one can hypothesize that direct seeding may be more successful on newly site-prepared older cutovers where the vegetation regrowth/ingrowth is as good as screening or better in creating favorable environments for germination and survival of direct-seeded black spruce.

Imbedding black spruce seeds, to simulate covering of surface-sown seeds, e.g., as they conceivably could be covered by simple modifications to mechanical seeders, was neither advantageous nor disadvantageous in comparison with sowing them on the surface of seedspots.

More conjecturally, the apparent ultimate advantages of relatively better germination and stocking from earlier than from later seeding may be more the product of variations in climate and/or microclimate than of time of seeding as such. Unfortunately, owing to the discontinuous weather records on these areas (Fraser 1980) one can only speculate about this.

In view of the abysmal failure of the operational seeding trials (Fraser 1980b) where no attempt was made to create the seedbed conditions prescribed by Winston (1975), germination on these experimental trials was commendably good. The initial stocking was not only desirable but was well in excess of what one must have to begin with in order to ensure that stocking remains desirable some years hence. This, in the author's opinion, was due primarily to the creation of suitable seedbeds on the hand-scalped spots and, to a lesser degree, to shading by screening. However, even with 80%+ stocking to begin with, three years later it was no better than marginal. It seemed to be static then but would undoubtedly deteriorate somewhat in the future.

The first reasonable inference from the above is that more careful attention to site preparation to create more of those conditions reputed to favor black spruce germination and survival (Winston 1975), coupled with protection against extreme heat and drought, will promote successful black spruce regeneration (stocking) from direct seeding. The second is that the initiation of even better than desirable stocking is of little consequence if, subsequently, it deteriorates to or below the marginal level within a few years.

If we assume (although the assumption is not always warranted) the use of viable seeds from the correct seed zone (local provenance), at least three things have militated against successful direct seeding of black spruce in the past and, to a considerable extent, still do so. They are inadequate site preparation (quality and quantity), microclimatic extremes in the seedbed associated with excessive exposure, and the traditional "one-shot" application of seed dictated too frequently by convenience rather than by biological considerations. The results of the experimental trials documented herein and of some operational trials reported elsewhere (Fraser 1980b) supported by experience and observations of the author and numerous other federal, provincial and industrial foresters, indicate the following procedure for increasing the likelihood of direct seeding black spruce successfully on clearcut boreal forest uplands:

> *Cutovers should be left undisturbed for several (?) years* following clearcutting until vegetation regrowth and/or ingrowth is well enough established to ameliorate soil moisture and temperature conditions, particularly at or a few centimetres below the surface.
>
> *Late spring site preparation should be by prescription (?)* and should be based on conditions most likely to promote good germination and survival of black spruce on uplands.
>
> *Local-provenance seed should be sown*[6] *immediately (?)* after site preparation and annually thereafter for at least three (?) years.

The question marks above indicate where definitive information is lacking. If we assume the logic of letting cutovers "age" before site preparing them for direct seeding, *how many* years should elapse between harvesting and site preparation so that potential advantages of shading from vegetation are not offset by disadvantages of competition?

What is the correct, or at least the best, prescription for site preparation to promote germination and survival on black spruce on upland clearcuts? It is already becoming apparent from Fleming's[7] work that there may be considerable latitude in Winston's (1975) "ideal" seedbed, which indicates that foresters must be constantly aware of new developments and prepared to incorporate them in the site-preparation stage of direct seeding.

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[6]Long-overdue cooperative field trials between the Great Lakes Forest Research Centre and the Ontario Ministry of Natural Resources' Kapuskasing District to determine optimum rates of direct seeding black spruce continue to be delayed by the critical shortage of black spruce seed in OMNR's Northern Region.

[7]R. Fleming, Forestry Officer, Great Lakes Forest Research Centre, Sault Ste. Marie, Ontario. Project GLC-04-129. "Scarification and prescribed seeding trials for black spruce on upland boreal forest cutovers".

Should seeds be sown immediately following site preparation--perhaps even as an integral feature of the site-preparation operation? Should site-prepared areas be seeded annually thereafter, and if so, at what rate and for how many years? Will changes occurring in the "receptivity" of the seedbed during the intervening year(s), confound the outcome of the successive seedings (favorably or unfavorably)?

In conclusion, the sharp division between proponents and opponents of direct seeding as a regeneration alternative for black spruce must have been obvious to participants in the Timmins symposium on direct seeding, or to anyone familiar with its proceedings. The concept may be somewhat less controversial today, owing to its considerable economical potential and to exploratory work at the Great Lakes Forest Research Centre. However, a vastly greater commitment of research resources is imperative to obtain and document evidence to resolve the controversy once and for all and to demonstrate whether direct seeding can or cannot be a successful management alternative for regenerating upland black spruce cutovers.

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APPENDIX

Table 1. Mean percent germination by seed treatment, protection, seeding method and seeding date of black spruce seeds hand-seeded onto prepared seedspots in 1973.

	Experimental Seeding--Area 1--1973				
Seed treatment	Fall/73	Spring/74	Fall/74	Fall/75	Fall/76
Control	40 a	$_{1}$36 a	$_{1}$38 a	$_{1}$38 a	$_{1}$38 a
Moran pellet	$_{1}$44 a	$_{1}$37 b	$_{1}$39 a b	$_{1}$40 a b	$_{1}$40 a b
Asgrow coating	$_{1}$44 a	$_{1}$40 a	$_{1}$41 a	$_{1}$42 a	$_{1}$42 a
Asgrow pellet	35 a	$_{2}$ 31 a	$_{2}$ 33 a	$_{2}$ 33 a	$_{2}$ 33 a
FMC tablet	17	$_{2}$ 28	$_{2}$ 33 a	$_{2}$ 33 a	$_{2}$ 33 a
Protection					
Screened	41 a	40 a	43 a	43 a	43 a
Not screened	31 a	29 a	31 a	31 a	31 a
Seeding method					
Surface-sown	$_{1}$35 a	$_{1}$35 a	$_{1}$37 a b	$_{1}$38 b	$_{1}$38 b
Imbedded	$_{1}$37 a	$_{1}$34 b	$_{1}$36 a b	$_{1}$37 a	$_{1}$37 a
Seeding date					
July 30/73	$_{1}$40 a	$_{1}$41 a	$_{1}$42 a	$_{1}$43 a	$_{1}$43 a
August 13/73	$_{1}$37	$_{1}$42 a	$_{1}$44 a	$_{1}$44 a	$_{1}$44 a
August 24/73	31	$_{1}$39 a	$_{1}$41 a	$_{1}$42 a	$_{1}$42 a
September 10/73		16	19 a	20 a	20 a

There is no significant difference ($p = 0.05$) between values with the same subscript numeral(s) in any given column, or between those with the same lower case letter(s) in any given line.

Table 2. Mean percent stocking by seed treatment, protection, seeding method and seeding date from black spruce seeds hand-seeded onto prepared seedspots in 1973.

	Experimental Seeding--Area 1--1973				
Seed treatment	Fall/73	Spring/74	Fall/74	Fall/75	Fall/76
<u>Control</u>	$_{1}$88	$_{2}$ $_{1}$72 a	$_{2}$ $_{1}$70 a	$_{1}$54 b	$_{2}$ $_{1}$51 b
Moran pellet	$_{1}$90	$_{2}$ $_{1}$62 a	$_{2}$ $_{1}$62 a	$_{1}$54 a	$_{2}$ $_{1}$50 a
Asgrow coating	$_{1}$94	$_{2}$ $_{1}$67 a	$_{2}$ $_{1}$67 a	$_{1}$54 b	$_{2}$ $_{1}$51 b
Asgrow pellet	$_{1}$87	$_{2}$ 58 a	$_{1}$58 a	$_{1}$48 a b	$_{2}$ 40 b
FMC tablet	54	$_{1}$75 a	$_{2}$ 76 a	65 a b	$_{1}$60 b
<u>Screening</u>					
Screened	$_{1}$85	75 a	75 a	64 b	58 b
Not screened	$_{1}$80	58 a	58 a	46 b	42 b
<u>Seed placement</u>					
Surface-sown	$_{1}$81	$_{1}$66 a	$_{1}$68 a	$_{1}$57 b	54 b
Imbedded	$_{1}$84	$_{1}$67 a	$_{1}$65 a	$_{1}$54 b	47 b
<u>Seeding date</u>					
July 30/73	$_{1}$89	$_{1}$71 a	$_{2}$ $_{1}$69 a	$_{2}$ $_{1}$60 b	$_{1}$54 b
August 13/73	$_{1}$88	$_{1}$70 a	$_{2}$ 62 a	$_{1}$48 b	$_{1}$44 b
August 24/73	70	54 a	$_{2}$ 59 a	$_{2}$ 42 a	$_{1}$48 a
September 10/73		$_{1}$72 a	$_{1}$75 a	$_{2}$ 61 b	$_{1}$56 a

There is no significant difference ($p = 0.05$) between values with the same subscript numeral(s) in any given column, or between those with the same lower case letter(s) in any given line.

Table 3. Mean percent germination by seed treatment, protection, seeding method and seeding date of black spruce seeds hand-seeded onto prepared seedspots in 1974.

	Experimental Seeding--Area 2--1974			
Seed treatment	Fall/74	Spring/75	Fall/75	Fall/76
Control	$_{1}35$	$_{1}39$ a	$_{1}40$ a	$_{1}40$ a
Moran pellet	42 a	44 a	44 a	44 a
Asgrow pellet	$_{1}34$	$_{1}38$ a	$_{1}38$ a	$_{1}38$ a
FMC_1 tablet	8	27 a	28 a	28 a
FMC_2 tablet	15	31 a	32 a	32 a
Protection				
Screened	32	43 a	44 a	44 a
Not screened	25	29 a	30 a	30 a
Seeding method				
Surface-sown	33	$_{1}37$ a	$_{1}38$ a	$_{1}38$ a
Imbedded	24	$_{1}35$ a	$_{1}36$ a	$_{1}36$ a
Seeding date				
June 18/74	$_{1}28$	$_{1}40$ a	$_{1}41$ a	$_{1}41$ a
July 2/74	$_{1}29$	$_{1}41$ a	$_{1}41$ a	$_{1}41$ a
July 16/74	23	27 a	28 a	28 a
July 30/74	33	37 a	37 a	37 a

There is no significant difference (p = 0.05) between values with the same subscript numeral(s) in any given column or between those with the same lower case letter(s) in any given line.

Table 4. Mean percent stocking by seed treatment, protection, seeding method and seeding date from black spruce seeds hand-seeded onto prepared seedspots in 1974.

	Experimental Seeding--Area 2--1974			
Seed treatment	Fall/74	Spring/75	Fall/75	Fall/76
<u>Control</u>	$_1$82	$_1$52 a	$_2$ $_1$52 a	$_1$36
Moran pellet	$_1$85	$_1$51 a	$_1$49 a	$_1$30
Asgrow pellet	$_1$83	$_1$48 a	$_1$47 a	$_1$34
FMC_1 Tablet	45 b	$_2$ 65 a	$_2$ 61 a	$_1$35 b
FMC_2 Tablet	64 a	$_2$ 64 a	$_2$ 64 a	$_1$37
<u>Screening</u>				
Screened	$_1$75	66 a	65 a	40
Not screened	$_1$72	44 a	44 a	27
<u>Seed placement</u>				
Surface-sown	78	47 a	46 a	24
Imbedded	69 a	64 a	64 a	44
<u>Seeding date</u>				
June 18/74	$_2$ 62 a	$_1$68 a	$_1$66 a	40
July 2/74	$_1$77 a	$_1$72 a	$_1$70 a	54
July 16/74	$_2$ $_1$70	$_2$ 40 a	$_2$ 40 a	$_1$19
July 30/74	86	$_2$ 38 a	$_2$ 38 a	$_1$19

There is no significant difference ($p = 0.05$) between values with the same subscript numeral(s) in any given column, or between those with the same lower case letter(s) in any given line.