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EFFECTS OF PELLETING AND REPELLENT COATING OF CONIFER SEEDS ON FEEDING BY DEER MICE

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ABSTRACT

Experiments to determine the effect of three types of pelleting processes (Moran, Asgrow, GLFRC) and two reputed rodent-repellent coatings (Arasan, R-55) on the consumption of seeds of four species of conifers (red pine [*Pinus resinosa* Ait.], jack pine [*Pinus banksiana* Lamb.], white spruce [*Picea glauca* (Moench) Voss], and black spruce [*Picea mariana* (Mill.) B.S.P.]) by deer mice (*Peromyscus maniculatus*) are documented and evaluated. Deer mice consumed more Moran-pelleted seeds than untreated seeds of all four conifer species, but consumed fewer Asgrow-pelleted and GLFRC-pelleted black spruce seeds than untreated black spruce seeds. The Arasan coat reduced consumption of black spruce seeds under all experimental conditions but the R-55 coat reduced consumption of black spruce seeds only when alternative, and presumably more desirable, seeds were present.

RÉSUMÉ

Documentation et évaluation d'expériences en vue de déterminer l'effet de trois procédés de granulation (Moran, Asgrow, CRFGL) et de deux enduits anti-rongeurs réputés (Arasan, R-55) sur la consommation des graines de 4 essences conifférales (pin rouge [*Pinus resinosa* Ait.], pin gris [*Pinus banksiana* Lamb.], épinette blanche [*Picea glauca* (Moench) Voss], et épinette noire [*Picea mariana* (Mill.) B.S.P.]) par les souris à pattes blanches (*Peromycus maniculatus*). Les souris blanches ont consommé plus de graines traitées par le procédé Moran que de graines non traitées de toutes les 4 essences conifférales, mais moins de graines d'épinette noire traitées par les procédés Asgrow et CRFGL que de celles non traitées de la même essence. L'enduit Arasan a réduit la consommation de graines d'épinette noire sous toutes les conditions expérimentales, mais l'enduit R-55 n'en faisait autant que lorsqu'il y avait d'autres graines probablement plus désirables.

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INTRODUCTION

Fraser (1974) gave the rationale for pelleting and coating conifer seeds[2] and presented a comprehensive review of the literature on those and other seed treatments. The effects of those treatments on germination have been reported (Fraser 1975, 1980; Fraser and Adams 1980).

Recent studies suggest that predation of black spruce (*Picea mariana* [Mill.] B.S.P.) seeds is minimal on recent clearcuts of upland black spruce in northern Ontario (Martell and Merritt 1979); that deer mice, the most abundant small mammals on those sites, do not include conifer seeds in their diet (Martell and Macaulay 1981); and that deer mice do not actively search for black spruce seeds or jack pine (*Pinus banksiana* Lamb.) seeds but, rather, encounter them by chance while searching for other foods (Martell 1979). However, because pelleting and coating change the shape, size and/or odor of the seeds, they may affect the degree of feeding by small mammals. No tests of the response of small mammals to pelleted seeds have been reported and tests of the effectiveness of coating seeds with repellents are equivocal. Radvanyi (1970) reported on a new chemical repellent, R-55, which he found in laboratory trials to be better than 95% effective in preventing deer mice (*Peromyscus maniculatus*) from feeding on white spruce (*Picea glauca* [Moench] Voss) seeds. However, Crouch and Radwan (1971), using a different bioassay procedure, did not find R-55 to be effective in preventing deer mice from feeding on Douglas fir (*Pseudotsuga menziesii* [Mirb.] Franco) seeds. Experiments with the fungicide Arasan (thiram) are equally contradictory (Armour 1963, Radwan 1970).

The present bioassay of pelleted and coated conifer seeds is complimentary to Fraser's studies of the effects of those treatments on germination (Fraser 1975, 1980; Fraser and Adams 1980).

MATERIALS AND METHODS

All seeds were supplied by the Ontario Ministry of Natural Resources. J.W. Fraser arranged for the pelleting and coating of the seeds. Both untreated and Moran-pelleted seeds of red pine (*Pinus resinosa* Ait.), jack pine, white spruce, and black spruce were tested.

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[2]In this report "pelleting" means applying material to a seed in such a way as to embed the seed in a more or less spherical pellet, and "coating" means applying a layer of material to a seed without materially altering its shape.

In addition, Asgrow-coated Moran-pelleted (hereafter referred to as Asgrow-pelleted) and GLFRC-pelleted black spruce seeds were tested. Two reputed rodent-repellent seed coatings, Arasan (Arasan + latex + aluminum flake) and R-55 (R-55 + latex + graphite), were also assessed. The pellets and the pelleting process are described by Fraser and Adams (1980) and the rodent-repellent coatings and the coating process are described by Fraser (1980).

All deer mice used in the experiments were born in the laboratory to wild-caught parents and were at least 6 months old at the time of the trials. During the experiments, temperature was maintained at 18-20°C and approximately 50 ft-c (1 ft-c = 10.764 lx) of artificial light were available on a 13 h light/11 h dark photoperiod. In order to screen the deer mice for non-seedeaters, each animal was given a dish of jack pine and black spruce seeds, in addition to mouse chow, prior to testing. All animals ate the seeds under those conditions.

In experiments 1 and 2 the deer mice were housed separately in 18 x 28 cm polypropylene mouse cages with wood shavings on the bottom, and were provided with commercial mouse chow and water *ad libitum*. In Experiment 1 each animal was given a 15.5-cm-diameter petri dish containing 25 seeds of a single treatment each night for four nights. The seeds not consumed were counted each morning. In Experiment 2 the procedure was identical, except that the number of seeds was increased to 50 per night. Red pine was not tested in Experiment 2 because of a shortage of seeds. A total of 14 test animals were used and each seed treatment was tested on five animals. Each test animal received the seed treatments in random order and no animal received the same seed treatment in both experiments.

The procedure in Experiment 3 was similar to that described by Martell (1979). The test animals were housed in a 1.5 x 3.0 m pen with 5 cm of peat moss on the floor. Each pen contained a nest box with commercial mouse chow and water *ad libitum*. A 12-point grid, with 37.5 cm spacing between adjacent points, was established in one end of the pen. All points were at least 37.5 cm from a pen wall. A 15.5-cm-diameter petri dish was placed on top of the peat moss at each point. The 12 treatments were assigned to the 12 petri dishes at random for each night of the test, and five seeds of a given treatment were placed in the assigned dish each night. A single deer mouse was placed in a pen and was allowed three days to familiarize itself with the pen. On the first day of the test, seeds were placed in the selected petri dishes. The number of seeds removed from each dish was recorded the following day and new seeds were placed in the dishes in a new random pattern. Each of 22 deer mice used was tested for four nights.

RESULTS

Experiment 1

Deer mice ate essentially all of the seeds offered them from all treatments except the Arasan coat (Table 1). The proportion of Arasan-coated black spruce seeds consumed was significantly less than that for untreated black spruce seeds, and the proportion of Arasan-coated seeds consumed declined significantly ($X^2 = 63.11$, $p < 0.001$) over the four nights of the test.

Table 1. Proportion of untreated, pelleted, and repellent-coated conifer seeds consumed by deer mice on four consecutive nights when 25 seeds per night were offered. (Sample size in parentheses).

Species	Treatment	Night 1 (125)	2 (125)	3 (125)	4 (125)	Total (500)
Red pine	control	100.0	100.0	100.0	100.0	100.0 a[a]
	Moran pellet	100.0	100.0	100.0	100.0	100.0 a
Jack pine	control	100.0	100.0	100.0	100.0	100.0 a
	Moran pellet	100.0	100.0	100.0	100.0	100.0 a
White spruce	control	100.0	100.0	100.0	100.0	100.0 a
	Moran pellet	100.0	100.0	100.0	100.0	100.0 a
Black spruce	control	100.0	100.0	99.2	98.4	99.4 a
	Moran pellet	100.0	100.0	100.0	100.0	100.0 a
	Asgrow pellet	100.0	100.0	100.0	98.4	99.6 a
	GLFRC pellet	100.0	100.0	99.2	100.0	99.8 a
	Arasan coat	100.0	96.0	87.2	70.4	88.4 b
	R-55 coat	100.0	100.0	100.0	97.6	99.4 a

[a]Treatments with the same letter are not significantly different from each other at the $p = 0.05$ level.

Experiment 2

Deer mice ate essentially all of the seeds offered them from all treatments except the untreated white spruce and the Arasan coat (Table 2). The proportion of untreated white spruce seeds consumed was significantly less than that for all other treatments, except the Arasan coat, and was significantly less ($X^2 = 7.15$, $p < 0.01$) than the proportion of untreated white spruce seeds consumed in Experiment 1. The proportion of Arasan-coated black spruce seeds consumed was

significantly less than that for untreated black spruce seeds, and the proportion of Arasan-coated seeds consumed declined significantly (X^2 = 144.61, $p < 0.001$) over the four nights of the test. The proportion of Arasan-coated seeds consumed in Experiment 2 was significantly less (X^2 = 141.11, $p < 0.001$) than that in Experiment 1, and the decline over the four nights of the test was more rapid in Experiment 2 than in Experiment 1. The proportion consumed from all other treatments was not significantly different between the two experiments.

Table 2. Proportion of untreated, pelleted, and repellent-coated conifer seeds consumed by deer mice on four consecutive nights when 50 seeds per night were offered. (Sample size in parentheses).

Species	Treatment	Night 1 (250)	2 (250)	3 (250)	4 (250)	Total (1000)
Jack pine	control	100.0	100.0	100.0	100.0	100.0 a[a]
	Moran pellet	100.0	100.0	100.0	99.6	99.9 a
White spruce	control	100.0	98.0	97.6	96.8	98.3 b
	Moran pellet	100.0	100.0	100.0	99.6	99.9 a
Black spruce	control	99.6	99.6	100.0	100.0	99.8 a
	Moran pellet	100.0	100.0	100.0	100.0	100.0 a
	Asgrow pellet	100.0	100.0	99.6	99.6	99.8 a
	GLFRC pellet	100.0	100.0	100.0	100.0	100.0 a
	Arasan coat	85.6	65.2	42.0	39.6	58.1 c
	R-55 coat	100.0	100.0	100.0	100.0	100.0 a

[a] Treatments with the same letter are not significantly different from each other at the $p = 0.05$ level.

Experiment 3

There was a significant difference in the frequency of seed consumption among untreated conifer seeds (Table 3). Black spruce seeds were consumed significantly more frequently than either red pine seeds or jack pine seeds, and white spruce seeds were consumed significantly more frequently than jack pine seeds. However, there was no significant difference among the four conifer species when the seeds were Moran-pelleted. Moran-pelleted jack pine seeds were consumed significantly more frequently than untreated jack pine seeds, but that was the only significant difference between untreated and Moran-pelleted seeds. The Asgrow-pelleted, GLFRC-pelleted, and Arasan-coated black spruce seeds were consumed significantly less frequently than untreated or Moran-pelleted black spruce seeds, but were not significantly different from

each other. The Arasan-coated black spruce seeds were consumed significantly less frequently than those of any other treatment, except the Asgrow-pelleted black spruce seeds.

Table 3. Proportion of dishes with seeds removed and mean number ($\bar{x}$ ± SE) of seeds removed per dish by deer mice. For all treatments, 88 dishes were available with five seeds each.

Species	Treatment	No. of dishes with seeds removed (%)	No. of seeds removed from dishes with at least 1 seed removed
Red pine	control	72 (81.8) b, c[a]	4.0 ± 0.16 c, d, e, f[a]
	Moran pellet	79 (89.8) a, b	4.8 ± 0.09 a
Jack pine	control	62 (70.4) c, d	3.8 ± 0.17 e, f
	Moran pellet	77 (87.5) a, b	4.4 ± 0.14 b, c
White spruce	control	79 (89.8) a, b	3.9 ± 0.14 d, e, f
	Moran pellet	80 (90.9) a, b	4.4 ± 0.12 b
Black spruce	control	81 (92.0) a	3.6 ± 0.14 f
	Moran pellet	79 (89.8) a, b	4.2 ± 0.14 b, c, d
	Asgrow pellet	58 (65.9) d, e	4.2 ± 0.16 b, c, d, e
	GLFRC pellet	59 (67.0) d	4.3 ± 0.15 b, c
	Arasan coat	46 (52.3) e	2.7 ± 0.21 g
	R-55 coat	60 (68.2) d	2.7 ± 0.18 g

[a]Treatments with the same letter are not significantly different from each other at the p = 0.05 level.

When deer mice removed seeds from dishes, they removed significantly fewer repellent-coated seeds and significantly more Moran-pelleted red pine seeds than seeds from other treatments (Table 3). There was a gradient among the other treatments with more pelleted seeds than untreated seeds removed. There was no significant difference in numbers of seeds removed among the control seeds but significantly more pelleted seeds than untreated seeds were removed for all four conifer species.

DISCUSSION AND CONCLUSIONS

Pelleting

Pelleted seeds were readily consumed by deer mice in cages (experiments 1 and 2). The pellet did not present a barrier to seed consumption; the deer mice cracked the pellet open as they would open a seed coat. When a choice in seed treatments was offered (Experiment 3), deer mice discriminated among the types of pellets. Moran-pelleted seeds were consumed as frequently as, or more frequently than, untreated seeds. However, Asgrow-pelleted and GLFRC-pelleted black spruce seeds were consumed less frequently than either untreated or Moran-pelleted black spruce seeds. When seeds were consumed, deer mice consistently ate more pelleted seeds than untreated seeds. This was possibly because the large size of the pellets relative to the untreated seeds allowed deer mice to find the remaining pellets in a dish more easily once one was encountered.

The pellets showed essentially no repellent effectiveness[3] in the cage trials. In the pen trial, Moran-pelleted jack pine was -43% effective, Moran-pelleted red pine was -31% effective, and Moran-pelleted white spruce and black spruce were -15% effective. However, Asgrow-pelleted black spruce was +17% effective and GLFRC-pelleted black spruce was +12% effective. In other words, Moran pelleting of conifer seeds increases the consumption of those seeds by deer mice, while Asgrow pelleting or GLFRC pelleting of black spruce seeds reduces their consumption to a moderate degree. For a given type of seed, the size and shape of the three types of pellets are similar, but the Moran and GLFRC pellets use different pelleting media and the Asgrow pellet is a Moran pellet coated with Asgrow Lite-Coat. The differences among the pellet types in their consumption by deer mice may be related to odor rather than to size, because deer mice use odor in seed selection (Howard and Cole 1967, Howard *et al.* 1968, Jennings 1976, Martell 1979).

On the basis of the trials described, Moran pelleting is considered an unacceptable practice for operational seeding because of the likelihood of increasing the seed consumption by small mammals, but Asgrow pelleting and GLFRC pelleting are considered to be acceptable practices and may have a beneficial effect in reducing seed consumption by small mammals. Fraser and Adams (1980) concluded that Moran pelleting of white spruce, jack pine, and red spruce seeds and Asgrow pelleting of black spruce seeds were unacceptable practices because of the adverse effect on germination. However, they also concluded that Moran pelleting and GLFRC pelleting of black spruce seeds were acceptable practices and

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[3]repellent effectiveness = (% untreated seeds consumed -% treated seeds consumed)/% untreated seeds consumed.

warranted serious consideration in operational seeding "*if* the potential advantages outweigh the likelihood of delayed and/or depressed germination and *if* provision is made to counteract these adverse effects, i.e., by sowing more seeds, earlier." In view of those findings and the findings of the present study, only GLFRC pelleting of black spruce seeds seems to warrant consideration in operational seeding.

Repellent Coating

Only the Arasan-coated black spruce seeds showed any reduction in consumption in the cage trials (experiments 1 and 2). Taste may have been a factor because consumption declined more rapidly and to a lower level when the number of seeds offered per night was increased. When a choice of seed treatments was offered (Experiment 3), the Arasan-coated black spruce seeds were consumed significantly less frequently than either the R-55-coated black spruce seeds or the untreated black spruce seeds. The R-55 coated seeds were also consumed significantly less frequently than the untreated seeds. When seeds were consumed, deer mice ate significantly fewer Arasan and R-55-coated black spruce seeds than untreated black spruce seeds. The repellent effectiveness of the Arasan coat in the three experiments was 11%, 42%, and 57%, respectively. The R-55 coat showed essentially no repellent effectiveness in experiments 1 and 2, but was 44% effective in Experiment 3.

Crouch and Radwan (1971) and, presumably, Radwan (1970) conducted cage trials of repellent-coated Douglas-fir seeds similar to those in experiments 1 and 2. In those trials, as in the present experiments, R-55 was ineffective in reducing seed consumption by deer mice (Crouch and Radwan 1971). However, Arasan was also reported to be ineffective (Radwan 1970), although the actual results of the trials have not been published and therefore it is not known if the seed treatments were similar. Radvanyi (1970) used a test procedure which was more similar to that used in Experiment 3 than that used in experiments 1 and 2. He found that the R-55 coat was better than 95% effective in reducing the consumption of white spruce seeds by deer mice when the coat was fresh but that the effectiveness declined rapidly with prolonged (1-5 months) weathering. In the present trials the R-55 coating was only 44% effective in reducing the consumption of black spruce seeds by deer mice, less than half the effectiveness reported by Radvanyi. The seeds used in the present trials had been stored for various periods, but had not been weathered. It is possible that the repellent qualities of the R-55 coat decreased with storage, thereby accounting for the difference in effectiveness observed in the present trial and that observed by Radvanyi. Storage, however, was not a factor in Crouch and Radwan's (1971) trials. Also, the Arasan coat used in the present trials had been stored for a prolonged period.

The results of the present trials suggest that the Arasan coat is an effective repellent under all conditions and that its effectiveness increases with increasing exposure of deer mice to it. The R-55 coat, on the other hand, is ineffective under some conditions, but may be effective under conditions of operational seeding *if* alternative, preferred foods are available. I would therefore recommend only the Arasan coat for direct seeding of black spruce under operational conditions where a rodent repellent is needed.

Fraser (1980) reported that neither the Arasan coat nor the R-55 coat had any appreciable adverse effect on germination of black spruce seeds, except at low temperatures. However, he also noted that since the experiments had begun, the manufacturing of R-55 has been discontinued and Arasan 42S is no longer available. Because those potential rodent repellents are no longer available, it is indeed fortunate that other experiments (Martell 1979, Martell and Macaulay 1981, Martell and Merritt 1979) suggest that consumption of conifer seeds by deer mice is not a serious problem on upland black spruce clearcuts in northern Ontario.

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