Effect of a soil wetting agent on germination of four important British Columbia conifers

The hydrophobic peat mixes currently used in container nursery soil mixes in British Columbia would be almost unworkable without a surfactant to render them wettable. However, since there have been suggestions that surfactants may have side effects that may not be beneficial to plant growth, is the continued use of Soil Wet justified? Yes, concludes D. G. EDWARDS (Pacific Forest Research Centre, Canadian Forestry Service, Victoria, B.C.) for he found negligible side effects when Soil Wet was used as prescribed. He describes here his investigations.

Influence d'un agent mouillant du sol sur la germination de quatre conifères importants de la Colombie-Britannique. *Au laboratoire, la germination de quatre conifères ne fut pas affectée par "Soil Wet", un agent mouillant du sol, en solutions variant jusqu'à 0.1%. A cette concentration, l'auteur n'observa pas d'effets phytotoxiques sur les dimensions des semis; cette dernière étant plus élevée que celle prescrite pour la production de semis en godets. A 0.1%, i.e., à la concentration recommandée par le manufacturier pour la préparation du sol en général, on observa une diminution de la germination de l'épinette de Sitka de 46%, celle du pseudotsuga, du pin à feuilles tordues et de l'épinette blanche variant de 5 à 11%. A 0.1%, la longueur des radicelles mesurées à la fin du test de germination s'avérait plus courte chez le pseudotsuga et les deux épinettes concernées.*

The introduction of surfactants, including wetting agents, is one of many innovations in plant cultivation in recent years. The ability of these compounds to render hydrophobic soils wettable (Osborn *et al.* 1964) and to conserve water in the root zone of plants (Moore 1966) has resulted in increasing use of a wide variety of agents, especially non-ionic surfactants. Scepascenko *et al.* (1970) found two Soviet surfactants had favorable effects on the field germination of *Acer, Tilia* and *Robinia* seeds. Matthews (1971) prescribed the use of Soil Wet[1], classified as an alkyl aryl polyethoxy ethanol, at the rate of 0.5 gal/2500 gal water (0.002%) in the preparation of the soil mix and in subsequent irrigation of conifer seedlings grown in small containers in British Columbia. The large scale use of wetting agents, without prior testing of their effects on tree species, was questioned by Burridge and Jorgensen (1971). Working with Soil Wet and another non-ionic surfactant, Aqua-gro[2] (a 50/50 mixture of a polyoxyethelene ether and ester), they found both germination percentage and root growth of nine tree species varied inversely with the concentration of the surfactants; solutions weaker than 0.4% were not tested.

Whereas the use of Soil Wet, or any other surfactant, is not confined to container nurseries, over 10 million containerized conifer seedlings have been raised in British Columbia and a further 13 million are planned for 1973, following the implementation of Matthews' (1971) prescription. Although no obvious detrimental effects on seedling production had become apparent prior to 1972 (Kinghorn, personal communication), when this study was undertaken, the report by Burridge and Jorgensen (1971) was cause for concern. It seemed prudent, therefore, to investigate the phytotoxicity of Soil Wet, in relation to the prescribed use in British Columbia, on the germination and initial seedling growth of several important conifers.

[1]Trademark, Plant Products Co. Ltd., Port Credit, Ontario.
[2]Trademark, Aquatrols Corp., Camden, New Jersey. Trade names included to identify products. No endorsement is implied by the Canadian Forestry Service.

Materials and methods

Germination tests were carried out on modified Jacobsen germinators comprising 150-mm (6-in) diameter plastic dishes, approximately 25-mm (1-in) deep, containing 125-mm (5-in) diameter trays supported about 18 mm (0.75 in) above the bottom. The seeds were placed on 125 mm circles of filter paper and irrigated with the test solution by means of a wick through the centre of each tray; 150 ml of solution were placed in each dish, and additions made to maintain the level. An inverted glass funnel was placed over the seeds and the dishes were then placed in the germination room. An alternating temperature regime of 30°C (day) and 20°C (night), and an 8-h photoperiod under fluorescent lamps, intensity approximately 3228 lux (300 ft-c), was maintained. Each test comprised 6 samples each of 100 unstratified seeds and lasted 28 days; ungerminated seeds were subjected to a cutting test. Germinants were counted daily using the international seed testing rules (International Seed Testing Association 1966).

Seeds of four important British Columbia conifers, Douglas-fir *(Pseudotsuga menziesii* (Mirb.) Franco), lodgepole pine *(Pinus contorta* (Dougl.)),

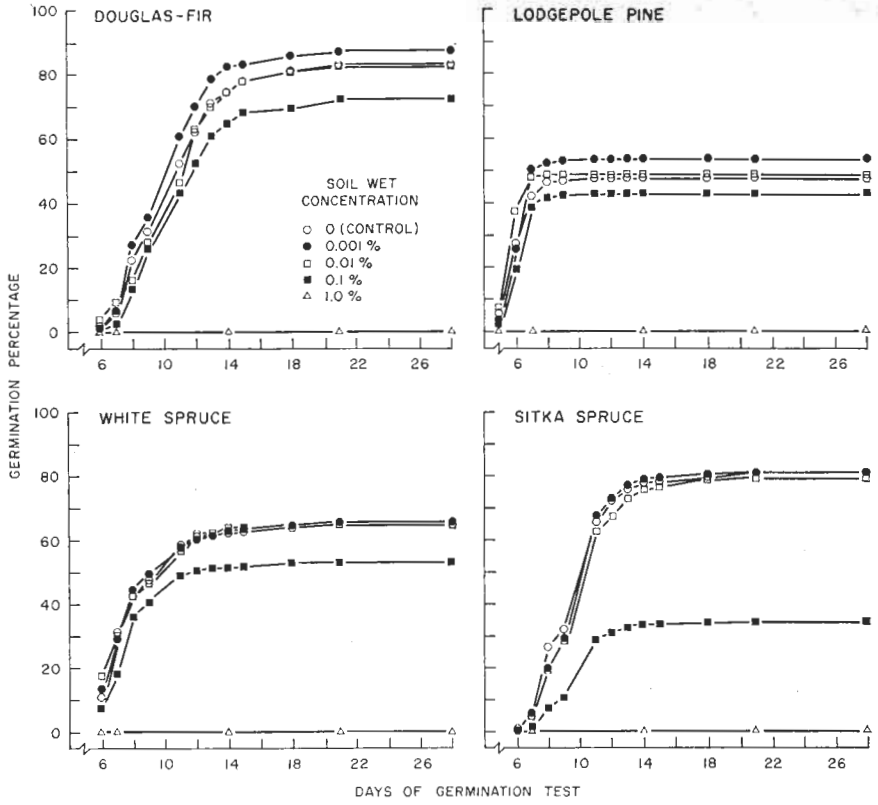

FIG. 1. Effect of Soil Wet on germination of Douglas-fir, lodgepole pine, white spruce and Sitka spruce.

white spruce *(Picea glauca* (Moench) Voss) and Sitka spruce *(Picea sitchensis* (Bong.) Carr.), were continuously irrigated throughout the germination test by five concentrations of Soil Wet, viz., 0 (control), 0.001%, 0.01%, 0.1% and 1% (volume-volume basis). A completely randomized experimental design was used, and analysis of variance and Duncan's multiple range test (Duncan 1955) were applied to real germination percentages i.e. percentages based on filled seeds) for normal germinants only (International Seed Testing Association 1966). Three parameters were used to assess the effects on germination:

1/ Days to reach 50% germination (R_{50}).
2/ Germination percentage after 28 days (GC).
3/ Germination Value (GV), described by Czabator (1962), which is calculated by the formula GV = MDG × PV where MDG (mean daily germination) is the quotient obtained by dividing the accumulated total number of germinants by the number of days of the test, and PV (peak value of germination) is the maximum quotient obtained by dividing daily the accumulated number of germinants by the corresponding number of days.

At the completion of the germination tests, 100 germinants from each test solution were taken at random; radicle length, hypocotyl length (the pigmented "stem" of the germinant, between the root collar and the base of the cotyledons) and dry weight were recorded and analysed.

Results

Germination in all four species was completely inhibited by 1% Soil Wet, and was significantly reduced by a 0.1% solution (Table 1, Fig. 1); the germination capacity of seeds irrigated with 0.01% and 0.001% solution was not significantly different from the controls. Except for the 1% solution, the first germinants were recorded between the 5th and 7th days in all tests. In addition, the cessation of germination, which occurred after 21 days in Douglas-fir and both spruces and after 9 days in lodgepole pine, was not affected by solution strength. Although R_{50} values could not be analysed since germination failed to reach 50% in several treatments (Fig. 1), GVs revealed that germination rate as well as GC had been affected (Table 1). These effects were minor however; the main influence was on GCs. Very few abnormal germinants occurred and nearly all seeds that failed to germinate became moldy during the germination test.

No phytotoxic effects on radicle length were observed in Douglas-fir, lodgepole pine and white spruce when exposed to solutions up to 0.01% (Table 1). A 0.1% solution significantly reduced radicle length in Douglas-fir and both spruces. In Sitka spruce, a 0.01% solution significantly increased radicle length. Neither hypocotyl length nor dry weight was affected in Douglas-fir, lodgepole pine and white spruce. In Sitka spruce, a significant increase in hypocotyl length resulted from exposure to 0.01% and 0.1% solutions; this was partly reflected in dry weights for this species.

Discussion

For general nursery and greenhouse soil prepara-

TABLE 1. Effect of Soil Wet concentration on germination and seedling size of four conifers

Species	Soil Wet Concentration (%)	GC(%)	GV	Length (mm)		Total wt(mg)
				Radicle	Hypocotyl	
Douglas-fir (Lot 590[1] collected 1964 Summit Lake 2400 ft).....	Control	82.8a[2]	16.5a	44.0a	31.4a	4.8a
	0.001	86.8a	18.9a	44.4a	31.5a	4.8a
	0.01	82.3a	16.2ab	43.4a	30.0a	4.8a
	0.1	72.2b	12.6b	31.6b	29.0a	4.7a
	1.0	0.0c	0.0c	—	—	—
Lodgepole pine (Lot 1791 Collected 1969 Prince George 2200 ft).....	Control	47.3ab	12.1ab	19.9a	18.0a	1.8a
	0.001	53.3a	15.2a	19.7a	17.1a	1.8a
	0.01	48.5ab	13.5a	21.1a	17.0a	1.9a
	0.1	43.5b	8.4b	19.0a	18.1a	1.8a
	1.0	0.0c	0.0c	—	—	—
White spruce (Lot 1548 Collected 1968 Prince George 4000 ft).....	Control	64.8a	13.3a	19.7a	21.0a	1.2a
	0.001	65.2a	12.1a	19.3a	21.0a	1.2a
	0.01	64.7a	12.2ab	19.6a	20.1a	1.2a
	0.1	53.2b	8.9b	17.0b	21.2a	1.2a
	1.0	0.0c	0.0c	—	—	—
Sitka spurce (Lot 1012 Collected 1966 Tofino 500 ft).....	Control	80.3a	17.6a	19.1b	25.0b	1.3b
	0.001	80.3a	17.9a	19.2b	24.3b	1.4ab
	0.01	78.8a	16.3a	22.2a	26.9ab	1.3b
	0.1	34.3b	3.5b	16.5c	27.3a	1.5a
	1.0	0.0c	0.0b	—	—	—

[1]B. C. Forest Service lot number
[2]Within each species, means followed by the same letter are not significantly different (p = .01)

tion, a solution strength of 0.1% Soil Wet (16 oz/100 gal water) is recommended by the manufacturer. When seeds were continuously irrigated with a solution of this concentration, statistically significant phytotoxicity was observed; in Sitka spruce, germination capacity was reduced by 46%, but in the other three species, the reduction was between 5% and 11%. Radicle lengths were also reduced: by 28% (of the control) in Douglas-fir, and by 14% in both spruces. No phytotoxic effects on germination or seedling size were noted in any of the four species when treated with solutions up to 0.01% concentration.

Scepascenko *et al.* (1970) suggested that stratification had reduced surfactant phytotoxicity in their study. Stratification might have reduced the phytotoxicity found at the higher surfactant concentration in this study. In many species, stratification prompts earlier germination by increasing germination rate. Seedlings are obtained sooner, so the period of seed exposure to a surfactant is shorter than for unstratified seeds. Phytotoxic effects of the surfactant on germination would, therefore, be minimized. Other conifer species might be expected to show responses similar to those reported here.

These observations on the effects of Soil Wet on germination and initial seedling growth were made in pure solutions on filter paper, and are a measure of absolute phytotoxicity of the surfactant. The filter paper is an inert medium and has no effect on the properties of the solution. In peat, sand or any other soil media, physical and chemical forces, and degradation by soil microorganisms, frequently modify the properties of solutions added to them, reducing the phytotoxic effects on the plants. Studies on such media provide measures of relative phytoxicity only. It follows that if no phytotoxic influences can be found on filter paper, it is relatively safe to assume that none will exist in the soil. Observations for any one soil mix, without the knowledge of absolute phytotoxicity provided by a filter paper test, should not be used to predict results on any other soil medium.

The filter paper test used here permitted the surfactant concentration to increase slightly over the test period, thereby providing a vigorous test of phytotoxicity. In the nursery or greenhouse, the use of surfactant solution would be limited to a number of applications over a period of time. For example, the container manual (Matthews 1971) prescribes the use of Soil Wet for the initial mixing of the soil, and then at monthly intervals to retain wettability. In between these applications, watering and fertilizing will dilute the surfactant in degrees related to the frequency of such operations. No phytotoxicity (at the concentrations prescribed in the container manual) was observed under the conditions of gradually increasing solution strength obtained in the laboratory, so it may be concluded that none will exist under nursery regimes when surfactant concentration will decrease between applications.

The results reported here differ from those of Burridge and Jorgensen (1971) primarily because these authors used a 0.4% solution, four times that recommended by the manufacturer, as their weakest Soil Wet treatment. Other notable differences include the severe phytotoxicity produced by a 1% Soil Wet solution in all species, whereas Burridge and Jorgensen obtained no less than 7% germination from any species exposed to a 3.16% solution. In the case of *Picea glauca*, used in both studies, this might be accountable in terms of seedlot differences. However, contrasts in bioassay technique, especially in the method of assessing germination, could also be related to such differences.

Practical applications

If Soil Wet is used as prescribed by Matthews (1971) for container seedling production, i.e., at

0.002% concentration, no phytotoxic effects will occur. On the basis of these results, a 5-fold increase in concentration (i.e., 0.01%) would be harmless. Such periodic use would bring seeds and seedlings into contact with the surfactant for short periods only, and errors in concentration as great as 10-20 fold might be tolerated; it is doubtful that this would pass unnoticed in mixing since, at these concentrations, there is a strong foaming action. Other products should not be substituted without similar testing; any alteration in the manufacture of Soil Wet will also require retesting.

Acknowledgments

The author is indebted to Messrs. D. G. Lund, R. G. Matthews and D. W. Taylor for their technical assistance.

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