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PUMICE AS A MEDIUM FOR STRATIFYING TREE SEEDS

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During the past several years the State Forestry Department has stratified fairly large quantities of forest tree seeds in preparation for direct seeding experiments. Some of the difficulties encountered in the use of peat moss and sand, which are generally recognized as the basic stratification media, have led to the testing of other materials in an effort to find a more satisfactory material. Pumice from the pumice falls in the Deschutes River Basin of Central Oregon with its light weight, vesicular structure and ready availability appeared to offer those advantages over the other media.

Physical characteristics of the material were determined and compared to those of peat moss and sand. Later the material was actually employed as a stratifying medium. The results of these tests are described in the following report with some observations and comments of a general nature concerning the stratification process and the media involved.

CHARACTERISTICS OF SAND AND PEAT MOSS

According to Kimmel, Rindt and Munger,[2] the medium should be thoroughly mixed with the seeds. Enough material should be used to separate all seeds from each other. A moisture content should be maintained just below the point where free water can be squeezed from the material.

It generally has been found that most effective results can be expected by storing the stratified seed in a room in which a constant temperature can be maintained for a period of approximately 6 weeks. To obtain the best results the temperature should remain a few degrees below that necessary to produce germination. For Douglas-fir, true firs and ponderosa pine 35° Fahrenheit was found to be satisfactory. The minimum temperature should remain above the freezing point to permit water absorption and normal biological processes.

Sand

1. Water must be added throughout the stratification period to maintain even moisture distribution since it will settle to the bottom of the containers.

2. The high density of sand presents a problem in storage and handling where large quantities of seed are involved.

3. The removal of sand from the seeds is a time consuming process unless special facilities are provided.

4. After washing the sand from the seed, they must be surface dried before seeding through mechanical equipment. This drying is essential when seeds are to be disseminated from aircraft hoppers. The drying process after washing increases the risk of loss through early germination, where seeds must be held for additional

periods at normal out-door temperatures. This factor is critical in aerial seeding since unsuitable flying weather often necessitates delays in seeding after seeds are removed from cold storage facilities.

Vern E. McDaniels, Oregon Forest Nursery Superintendent, states that although he now prefers and uses sand exclusively as a stratification medium, the great weight, the necessity for tending during the stratification period and the problem of seed removal are highly undesirable qualities.

Some of the advantages of sand are that it can be readily obtained in sterile form and the seed can be extracted and cleaned without insurmountable difficulties.

Peat Moss

1. The peat moss commonly available may often contain seeds of undesirable weed species.

2. The possibility of molding and heating is always present. In advertent interruption of refrigeration which permits the temperature to rise for even brief periods generally results in molding and subsequent heating. Most of the losses of seed occur from premature germination of the seeds due to the effect of higher temperatures rather than by direct attack of the fungi.

Reduction of the temperature below freezing fails to arrest the mold development on the interior of the stratifying trays after its inception. The mixture may often be frozen on the exterior without affecting the molding and heating process within. To prevent complete loss of seed under these circumstances it is generally necessary to remove the seeds from the medium and to re-stratify in sand.

3. Peat moss must be constantly tended to maintain an even distribution of moisture.

4. Removal of the seeds after the completion of the stratifying period is costly and time consuming. It is very difficult to clean the stratified seed sufficiently to permit sowing with most mechanical equipment. It is virtually impossible to obtain the degree of freedom from extraneous materials necessary to permit trouble-free seeding from aerial disseminating devices.

Peat moss has several desirable characteristics, among these are its light weight and its ability to absorb and maintain a large quantity of water. It readily relinquishes its moisture to the stratified seed. It is readily available in large quantities as a standard commercial product.

COMPARATIVE ANALYSIS OF PUMICE, PEAT MOSS AND SAND

Pumice is an extremely light porous stone of volcanic origin present in great quantities in the Deschutes River Basin of Central Oregon. It occurs in natural form in wide ranges of particle sizes. It is chemically inert and completely sterile when removed from sub-soil strata.

Williams in his "The Geology of Crater Lake National Park"[3] describes the pumice falls as follows: "Pumice falls - Fine-grained, well-sorted fragments of pumice. Individual grains angular to sub-angular and nearly uniform in size, averaging 1.2 mm to 2.4 mm. Smaller fragments are generally mineral grains, white to light gray when fresh, weathering to light yellow. Pumice grains very light, highly vesicular, porphyritic; phenocrysts of feldspar, hornblende, hypersthene, augite and magnetite. Grains strong and resist crushing. Deposit 6 feet thick thinning toward edge."

These qualities indicated that it might provide a more satisfactory medium for stratification than either peat moss or sand, since the wide range in particle size permit the use of fractions slightly larger or smaller than seeds to be stratified thus enabling ready extraction by screening.

Laboratory tests were conducted to determine the physical characteristics of the material and to compare them with the characteristics of other media. The physical data for the three materials are included in the tables which follow.

Density and Water Holding Characteristics

Table I

Medium	Oven Dry Wt. per Cu. ft.*	Weight of H_2O per Cu. ft.	Total Wet Weight	% H_2O Content**
Peat Moss	6.75 lbs.	39.04 lbs.	45.78 lbs.	579.23
Sand	88.77 lbs.	24.27 lbs.	113.04 lbs.	27.35
Pumice	27.16 lbs.	27.06 lbs.	54.22 lbs.	99.69

*Weights are avoirdupois to reflect relative ease of handling.
**Percentage based on oven dry weight and weight of water contained at

Weight per cubic foot of peat moss was at best only an estimate due to the difficulty in determining the volume of the material which is readily compressible. The weight indicated above was for one cubic foot in which the material was compressed to the approximate density used for stratification. As may be noted in the table the moisture holding capacity of peat moss is considerably greater than that of sand or pumice while its weight is only a fraction of that of either. There appeared to be no significant difference between the total amount of moisture retained by the sand and the pumice material. However, the pumice tested was of selected particle size, slightly smaller than the smallest viable ponderosa pine seed: (4 millimeters) and contained no interpartical moisture while the sand depended entirely upon the interparticle space for its moisture retaining ability. All materials were completely saturated for several hours and all free moisture drained off before weighing.

Table No. II indicates the relative amount of moisture absorbed by seeds placed in the materials and the percentage of germination after three and six weeks stratification.

Germination Tests

Table II

Medium	Stratification period	Dry Weight Pinus Ponderosa Seeds 100	Wet Weight 100 Seeds	*Weight of H_2O Absorbed	Duration of Germ Test	Percent Germination
Peat Moss	3 wks.	5.83 gms.	6.22 gms.	1.39 gms.	70 days	74
	6 wks.	5.08 gms.	6.81 gms.	1.73 gms.	56 days	81
Sand	3 wks.	4.87 gms.	6.70 gms.	1.83 gms.	50 days	70
	6 wks.	5.13 gms.	7.11 gms.	1.98 gms.	62 days	66
Pumice	3 wks.	4.96 gms.	6.73 gms.	1.77 gms.	57 days	69
	6 wks.	5.06 gms.	7.23 gms.	2.17 gms.	67 days	78

*Sufficient water was added to each tray at two week intervals to bring the gross weight to the original measure.

The days indicating the duration of the germination tests are numbered from the time the seeds were placed in the test medium. There are not enough samples to justify a quantitative comparison of the effect of the media on the viability of the seed after stratification.

Water Relinquishing Characteristics

Table III

Time Elapsed After Saturation	Weight of H_2O Held by Medium			Weight of Water Lost and Percent of Loss					
	Peat Moss	Sand	Pumice	Peat Moss		Sand		Pumice	
- -	585 gms.	389 gms.	642 gms.	**Wt.	*%	**Wt.	* %	**Wt.	* %
7 days	474	201	489	111	19.0	188	48.3	153	23.8
14 days	365	108	349	220	38.0	281	72.2	293	45.6
20 days	280	43	262	305	52.2	346	88.9	380	59.2
29 days	191	26	224	395	67.5	363	93.3	408	65.1
36 days	150	26	190	435	74.4	363	93.3	452	70.4
43 days	116	26	157	469	80.2	363	93.3	485	75.5
50 days	85	26	125	300	85.5	363	93.3	517	80.5

*Percentage based on weight of water at saturation point and total water lost.
**Weight in grams.

The table above indicates the quantity and percent of water loss through evaporation by each media at approximately one week intervals. The materials were stored during the test in a room where a 35° F. temperature and a 70% relative humidity were maintained. The oven dry weights of the samples were as follows: Peat moss - 101 gms.; Sand - 1422 gms; and Pumice - 644 gms.

The pumice lost moisture much less rapidly than either the peat moss or the sand. At the end of 50 days it still retained a greater quantity of water as well as a higher percentage of its original content. In addition to the quantitative tests additional experiments designed to test the capillary action in the three media were established. Materials were placed in large glass tubes, open on each end, and set in shallow trays filled with water. No quantitative check was made on the process, but the pumice rapidly became moist to all but a top layer of particles approximately one-fourth inch deep. No differences could be detected in the moisture content of the materials in the greater portion of the top as long as water was maintained in the trays.

The top layer of peat moss remained dry but the bulk of the material became and remained saturated. Evidence of but little capillary action could be detected in the sand.

Chemical Analysis of Oregon Pumice

Table IV

Element	Crater Lake Pumice		Newberry Crater Pumice
	(Pumice Fall)	(Pumice Flow)	
SiO_2	68.56	69.50	71.72
TiO_2	.58	.41	.25
Al_2O_3	14.22	15.18	13.77
Fe_2O_3	1.42	1.24	.55
FeO	1.49	1.42	1.34
MnO	.03	.03	.02
MgO	.83	.83	.52
CaO	2.35	2.08	Trace
Na_2O	5.18	4.78	4.54
K_2O	2.47	2.18	3.75
P_2O_5	.10	.21	.06
CO_2	None	None	None
H_2O	3.32	2.51	3.22
	100.55	100.37	99.74

Practical Use of Pumice for Stratification of Seeds

With foregoing data as a guide, a portion of the seed to be stratified in the spring of 1949 was placed in pumice. The general procedure was to extract the fractions of the pumice material slightly larger than the small seeds or slightly smaller than the largest seeds, in a standard seed cleaning mill. The seeds were then mixed at an approximate one to one ratio with the material and placed in five gallon cans with perforated bottoms. The cans were set in trays in which a fairly constant water level was maintained for the duration of the stratification period. To prevent the seeds from becoming completely immersed, a layer of pure pumice was placed in each container to a level above that of the water in the trays.

The moisture content of the seeds and the media was maintained by capillary action. The only water added during the entire six weeks stratification period was poured directly into the trays. Some fluctuation in the room temperature occurred but without deleterious effect.

The seeds were removed from the pumice in a "Clipper" mill seed cleaner. The seeds emerged sufficiently clean to permit seeding through any mechanical device. Since no free water was present in the medium the seeds were sufficiently dry on the exterior to permit immediate sowing.

Approximately 400 lbs. of seed were extracted from the medium in forty-five minutes.

Similar Media For Investigation

In regions where pumice is not available some light weight aggregates similar to the natural pumice are being manufactured and have a wide commercial distribution. They were not tested but may prove to be equally satisfactory as a stratifying medium. Information concerning these materials may be obtained from the following sources.

Dealers Bulletin on Light Weight Aggregates, by J. D. Alexander, published by Alexite Engineering Company, Colorado Springs, Colo.

Lightweight Aggregates for Concrete, Office of Housing Expediter, Expediter, Washington 25, D. C.

Pumice and Perlite as Industrial Materials in California, C. R. King, State Division of Mines, Dept. of Natural Resources, State of California, Ferry Building, San Francisco, California.

"Perlite Deposits Near the Deschutes River, S. Wasco County, Oregon." SMI Short Paper #16. Dept. of Geology and Mineral Industries, 702 Woodlark Building, Portland, Oregon.

SUMMARY

In 1949 after experiencing serious difficulties in the stratification of large quantities of true fir, Douglas fir and ponderosa pine seed with sand and peat moss as media, pumice was tested as a substitute. The material compares very favorably for moisture holding ability and appears to be superior to the other materials tested in many respects. Some of its other advantages are listed below:

1. It is less than 1/3 as heavy as sand.
2. It can be obtained in comparatively sterile condition.
3. It is available in large quantities at a very low cost.
4. The moisture is retained in uniform quantities throughout the medium by capillary action.
5. The seeds can be readily extracted by regulation of the particle sizes.
6. Moisture is contained within the particles, which permits adequate range of particle sizes without loss of water holding capacity.

REFERENCES

(1) Fahey, J. J., "Nonmetallic Mineral Resources of Eastern Oregon." U. S. Geological Survey Bulletin 875, 1937.

(2) Kummel, J. F., Rindt, C. A., and Munger, T. T., "Forest Planting in the Douglas Fir Region." Portland, Oregon, U.S.D.A., Forest Service, 1944

(3) Williams, Howell, "The Geology of Crater Lake National Park." Carnegie Institute Publication No. 540.