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RODENTS AND FIELD SOWING

By C. P. Willis

November 19, 1912.

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The study was started on the Wenatchee National Forest after observing serious injuries to seed spots by rodents boring into them and eating the seed sown. A series of tests was carried on on this Forest with the aim of obtaining some substance so repulsive to white-footed mice that seed treated with it would not be molested when sown in the field. Mice were kept in captivity for the tests, and were fed untreated and treated seed each day. The following is the summary of these tests:

Wenatchee Tests with Caged Mice (See file copy of progress report.)

The following table shows the substances tested with white-footed mice, and the value of each according to percentage of good seed left untouched.

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By C. P. Willis

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University of
California

Wind River Tests with Saged Mice and Chipmunks:

Substance used in treatment	Per cent of seed left	Number of seed left for different mice			
		Mouse 7	Mouse 8	Mouse 9	Mouse 10
Zenoleum and sulphur	60	30	56	110	90#
Zinc chlorida	56	0	72	110	
Iodoform	54	76#	50#		36#
Nux vomica	44	60	74		5#
Napthalene	43	7#	42		78#
Tincture of iron	19		20		
Glycerated asafoetida	14	0	30		
Tannic acid	16	0		35	
Carbolic acid	6	6			
Powdered sulphur	2	2			
Zenoleum solution	2	2			
Tobacco solution					
Copper sulphate	1	1			
Lime and sulphur	0	0			
Borax	0	0			
Glycerine soap	0	0			
Mercuric chloride	0		0		
Belladonna	0	0			
Tincture red pepper	0		0#		
Quinine	0	0#			

#150 treated and 150 untreated seed were each day fed. All were Douglas fir seed, but two different lots were used. In one lot a count of 500 seed showed 105 out of 150 had kernels. This lot was used where the # is not given. The other lot had 97 good seed out of 150 and this was used where a # is given after the figure.

It is thought that the test was severe and that where 40% or 50% of the treated seed were eaten in the cage that few or none would have been touched in the field. This is merely a supposition based upon the following facts: The mouse was in each case confined to a small space; he was underfed; the treated seed was easier to reach than the untreated seed in the cage.

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The mouse was in each case confined to a small space; he

where 40% or 50% of the treated seed were eaten in the

the figure.

XXXXXX of 500 seed was used. 10% of the seed was used for the control.

0000 0001 0010 0011 0100 0101 0110 0111 1000 1001 1010 1011 1100 1101 1110 1111
 0000 0001 0010 0011 0100 0101 0110 0111 1000 1001 1010 1011 1100 1101 1110 1111

[illegible]

10	10	Carbon sulphur
00	00	Sulfur and carbon

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
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Wind River Tests with Caged Mice and Chipmunks:

Tests similar to the Wenatchee ones were a few months later carried on at the Wind River Nursery.

Zinc chloride, which was next to the best substance tried on the Wenatchee Forest, failed absolutely. Two tests were made with different mice, and in each case all the treated seed were eaten.

Iodoform, the third best substance on the Wenatchee, was not used in the same form as previously, but in the way it was used it failed. Instead of putting the iodoform on the seeds, it was placed on the surface of the earth in which seed was buried. One-fourth teaspoonful was sprinkled over soil in a box 5" x 6" in size, but seed buried 1-1/4" under it were smelled and dug up.

Napthalene, fifth best on the Wenatchee, was used as in the case of iodoform -- placed on the surface of soil in which seed was buried, instead of on the seed as formerly. In the form used last it failed.

Nux vomica, iodoform, starch, and flour, made into a pellet 3/8" to 1/2" in diameter, inclosing 10 seed, was only fairly efficient. Of 6 pellets, two fed to each of three mice, 3 were nibbled, 1 broken to pieces, and the seed eaten, and 2 were left untouched.

The only conclusion which can be made is that

Wind tunnel tests with eggs and chipmunks:

Tests similar to the Venetian ones were a few

months later carried out on the Wind River Nursery.

Since the eggs were next to the nest and

distance varied on the Venetian tests, it was

Two tests were made with different distances, and in each case

All the treated seeds were eaten.

Today, the third best substance on the Venetian

ones, was returned in the same form as previously, but in

the way it was used as a bait. Instead of putting the

iodoform on the seeds, it was placed on the surface of the

earth in which seed was buried. One-fifth teaspoonful

was sprinkled over soil in a box 5" x 6" x 12", but seed

buried 1-1/4" under it were smelted and dug up.

Naphthalene, fifth best on the Venetian, was

used as in the case of iodoform. It was placed in the surface of

soil in which seed was buried, instead of on the seed as

formerly. In the form used last it failed.

Two weeks, iodoform, naphthalene, and flour, made

into a pellet 3/8" to 1/2" in diameter, including 10 seeds.

was only fairly efficient. Of 6 pellets, two fed to each

of three mice, 3 were killed, 3 when to pellets, and

the seed eaten, and 2 were left unfed.

The only conclusion which can be made is that

the Wenatchee tests were not as severe as was thought, and that the ideal substance is yet to be discovered.

Various other pellets, pastes, etc., were tried and among them only one form of one mixture gave satisfactory results so far as protection goes. This was a pellet composed of equal parts of tannic acid powder, tincture red peper, tincture of belladonna, and enough flour to make thick paste, the whole enclosing ten seeds and being about 1/2" in diameter and four sided. The pellets were used twice with one mouse, once with two other mice, and once with two different chipmunks, and in all cases formed perfect protection. The seed could hardly be sown in such form, however, as it undoubtedly would take too long to germinate, so this substance is not practical. The same mixture in paste form was of 50% (approximately) value, failing absolutely in one of two cases. The omission of one of the poisons seemed to nullify the protective value.

After tests in the treating of seed with repulsive substances had been carried to this point, it seemed best to try other methods of protection. Accordingly seed was enclosed in screen wire cylinders, about 1" high and 1/3" in diameter, with two thicknesses of wire as protection to the seed, since it was soon found that the mice could nibble the seed when but a single thickness was used.

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Cage tests indicated that this was sufficient protection to the seed. To give further tests, a nursery bed frame was made mouse proof, spots representing seed spots were sown over the ground surface enclosed, a couple of mice were turned into the area, and the results following were obtained:

Results of P & S No. 7:

There were seed spots in the experimental bed. These differed from one another in the seed being encased in cartridges of screen wire, or not so encased; in different sizes and forms of the cartridges; in different depths of covering; and in different number of seed per spot, as well as firming the covering soil or leaving it loose.

Encasing seed in screen cartridges is not efficient protection. Many of the cylinders were dug up, others were exposed by the mouse digging around them, while seed was extracted in two instances by the mouse gnawing the top of the cylinder and reaching the seed in this way without digging up the cartridge. It does not seem that the cartridges could be used even if they gave better protection, for the stems and roots of the seedlings do not extend vertically, and consequently are more apt to pierce the sides of the cylinder passing through

late tests indicated that this was sufficient protection to the seed. To give further tests, a nursery bed frame was made some 100 ft. long, and the seed was sown over the ground surface and covered, a couple of inches deep, with the soil, and the results following were obtained:

Results of P. & S. No. 2:

There were seed sown in the experimental bed. These differed from one another in the seed being sown in cartridges of various sizes, or not at all, in different places and forms of the cartridges, in different depths of covering, and in different number of seed per foot, as well as in the covering soil or leaving it loose.

Provision was in some cartridges is not at all of great protection. Many of the cylinders were the same, others were exposed by the horse digging around them, while seed was extracted in two instances by the horse gnawing the top of the cylinder and reaching the seed in this way without digging up the cylinder. It does not seem that the cartridges could be used even if they were better protection for the stems and roots of the seedlings to not stand vertically, and consequently one more apt to place the sides of the cylinder around the seed.

the wire mesh, than to miss the wire by passing through the openings of the cartridge.

The ordinary method of seed spotting, 30 seeds to the spot, 1/2" covering of soil, either firmed or loose, gave as good results as any other method tried, but nevertheless suffered greatly through the mouse damage.

Notes on the Smelling Powers of Mice: It seems he must have smelled

In the last experiment seed was sown at depths of 1-1/2" and 2-1/2" in some of the tests. Part of the seed in the 1-1/2" sowing was dug up, while the surface soil on one of the 2-1/2" spots was nosed. It is obvious, therefore, that mice can smell seed even through 2-1/2" of soil. Since deeper sowing than 1-1/2" would make the coming up of the plants very uncertain, it is not possible to sow seed deep enough to prevent their detection by rodents.

In cage tests a box 5" x 6" x 1-1/2" was filled with soil, seed sown at a depth of 1-1/4" in it, and iodoform or naphthalene spread over the surface. The following instances show that mice detected the seed despite the strong smell of the substance sprinkled over the surface. (Only the first time the box was put in a given mouse's cage is considered, since on repeating such a test there is a chance memory rather than sense of smell would cause the mouse to dig.)

seed by mice, or whether the -6- is accompanying the mulch merely hid the evidence of damage. There appeared to be a strong probability, however, that the smell of vegetation -- in mulching -- might be strong enough and of the right nature

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enough to prevent their detection by rodents.

In case tests a box $5\frac{1}{2}$ " x $6\frac{1}{2}$ " x $1\frac{1}{2}$ " was filled with

soil, seed sown at a depth of $1\frac{1}{4}$ " in it, and tumbled over

repeatedly spread over the surface. The following instances

show that mice detected the seed despite the strong smell of

the substance sprinkled over the surface. (Only the first

time the box was put in a given mouse's cage is considered,

since on repeating such a test there is a chance memory

rather than sense of smell would cause the mouse to dig.)

to deaden the smell of the seeds, and to prevent their detection. To test this point the following experiment was made:

With Mouse 11 two moth balls (naphthalene) were crushed and put on the soil surface. The first night the mouse dug into the box, but only went to a depth of $1\frac{1}{2}$ ", and therefore did not reach the seed, though it seems he must have smelled them: With Mouse 12 a similar test was carried on, but in this case one-fourth teaspoonful of iodoform was put in the surface. In one night 45% of the seed in the box were dug up. Again, with Mouse 13 a test similar to that with Mouse 11, except that the naphthalene was placed in a layer over the seed instead of on the ground surface, was carried on. Approximately 50% of the seed were eaten in one night.

In the field seed spotting on Pilot Knob (P & S 2) most of the spots were mulched and a few were left unmulched. Signs of mouse damage were very evident in the unmulched spots, and apparently almost absent in the mulched ones. Two spots mulched in the mouse-proof nursery bed already mentioned apparently were not dug into. No seedlings came up in these spots, however, and it therefore is not known whether the mulching actually prevented the detection of the sown seed by mice, or whether the debris accompanying the mulch merely hid the evidence of damage. There appeared to be a strong probability, however, that the smell of vegetation -- in mulching -- might be strong enough and of the right nature

With House 11, two moth balls (naphthalene) were crushed and put on the soil surface. The first night the moths did not go into the box, but only went to a depth of 1/2 inch. There-fore did not reach the seed, though it seems they must have smelled them. With House 12 a similar test was carried on, but in this case one-fourth teaspoonful of iodoforn was put in the surface. In one night 45% of the seed in the box were dug up. Again, with House 13 a test similar to that with House 11, except that the naphthalene was placed in a layer over the seed instead of on the ground surface, was carried on. Approximately 50% of the seed were eaten in one night. In the field seed spotting on Pilot Knob (P. S. 2) most of the spots were mulched and a few were left unmulched. Signs of mouse damage were very evident in the unmulched spots, and apparently absent in the mulched ones. Two spots mulched in the mouse-proof nursery had already gotten on and apparently were not dug into. No seedlings came up in these spots, however, and it therefore is not known whether the mulching actually prevented the detection of the sown seed by mice, or whether the debris accompanying the mulch merely hid the evidence of damage. There appeared to be a strong probability, however, that the smell of vegetation in mulching -- might be strong enough and of the right nature

to deaden the smell of the seeds, and so prevent their detection. To test this point the following experiment was made:

Results of P & S No. 8:

A nursery bed similar to that of P & S 7 was made mouse proof and sown to 46 seed spots, each with 30 seeds covered 1/2". Ten spots were left unmulched, and various sorts and amounts of mulch were used on the other spots. The number of seeds which germinated per spot indicated the efficiency of the mulch in protecting during the period the spots were exposed to the attack of a mouse turned into the bed.

The mulch did not prove effective protection, but it apparently had a slightly beneficial effect, at least when its depth was over 3/4". The following is a comparison of mulched spots with layers of mulch 3/4" to 1-1/2" deep, and unmulched spots. There were ten of each.

Class	Seedlings per spot	Spots with seedlings
Mulched	Min. 0, Max. 5, Av. 1.4	50%
Unmulched	Min. 0, Max. 1, Av. .4	40%

All of the unmulched spots and 60% of the above mulched spots had been dug into by the mouse. No evidence of digging was found in four of the well-mulched spots, but it is not certain that they were unmolested. The spot

to deepen the smell of the seeds, and so prevent their being
 detected. To test this point the following experiment was
 made:

Results of P & S No. 8:

A nursery bed similar to that of P & S 7 was made
 mouse proof and sown to 40 seed spots, each with 50 seeds
 covered $1\frac{1}{2}$ ". Ten spots were left unmulched, and various amounts
 and amounts of mulch were used on the other spots. The num-
 ber of seeds which germinated per spot indicated the effi-
 cacy of the mulch in protecting during the period the
 spots were exposed to the attack of a mouse turned into the
 bed.

The mulch did not prove effective protection, but
 it apparently had a slightly beneficial effect, at least
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 of mulched spots with layers of mulch $\frac{3}{4}$ " to $1\frac{1}{2}$ " deep, and
 unmulched spots. There were ten of each.

Class	Seedlings per spot	Spots with seedlings
Mulched	Min. 0, Max. 5, Av. 1.4	50
Unmulched	Min. 0, Max. 1, Av. .4	40

All of the unmulched spots and 60% of the above
 mulched spots had been dug into by the mouse. No evidence
 of digging was found in four of the well-mulched spots,
 but it is not certain that they were unmolested. The spot

having the highest number of seedlings (5) had certainly been dug into.

Extent of Damage in Field Sowing: where 1-1/2" of soil covered

Area No. 1 of the field sowing was devoted to determining how seriously mice and chipmunks damage seed spots. One-fourth of the spots were caged with wire screens, preventing rodent digging, and the others left uncaged. Half of the area had the seed covered 1/2", and the remainder had 1-1/2" of earth over the sown seed.

Germination was very poor and for this reason no conclusive results were obtained. On the area, comprising 1/6 acre, 15 white-footed mice and 6 chipmunks were trapped. From the looks of the seed spots it was judged that 98% of the damage done was caused by white-footed mice and 2% by chipmunks. In the 1/2" sowing, 96% of the spots had been dug into at the end of 11 days, while 76% of the 1-1/2" sowing had been similarly damaged in the same time. These figures apply, of course, to the uncaged spots; there was no damage in the caged ones, since the screens proved very efficient protection. The germination results are not very suggestive, owing to the general poorness of germination. Even in the protected spots and the shallow sowing it was very poor. The number of seedlings per caged and per uncaged spot differed little. Of the caged spots, 60% had no germination

Having the highest number of seedlings (5) had certainly

best results.

Extent of damage in field sowing:

Area No. 1 of the field sowings was devoted to de-

termining how seriously mice and chipmunks damage seed spots

One-fourth of the spots were sown with wheat, 1/4

with corn, 1/4 with soybeans, and the other half unsown.

Of the area had the seed increased 1/2", and the remaining

1/2" of the area was sown with seed.

Germination was very poor and for this reason no

definitive results were obtained. On the area, comparing

1/4 area of white-footed mice and 1/4 area of chipmunks were trapped

from the blocks of the seed spots it was judged that 90% of

the damage done was caused by white-footed mice and 10% by

chipmunks. In the 1/2" sowing, 90% of the spots had been

into a mass of 10 days, while 10% of the 1/2" sowing

remained relatively damaged in the same time. These figures ap-

ply, of course, to the sowing of spots; there was no damage

in the sowing, since the sowing was very efficient

protection. The germination results are not very satisfac-

tory to the general poor germination. Even in the

protected spots and the shallow sowing it was very poor.

The number of seedlings per seed and per sowing spot dif-

fered little. Of the sowing spots, 60% had no germination

while 71% of the uncaged spots were without seedlings. The most seedlings per spot were in an unprotected spot. Germination was almost an utter failure where 1-1/2" of soil covered the seed.

On P & S No. 3, at least 82%, and probably more, of the seed spots had been dug into by mice or similar animals, when examination was made July 22, 1912, a month and a half after sowing.

On P & S No. 4, a count on the north slope showed 86% dug into and one on the south slope showed ⁸⁷97% of the spots certainly dug into by rodents. The time of sowing and of examination were similar to P & S No. 3.

On P & S No. 5, where the spots were made with a tamp, and were 3" in diameter and 1" to 2" deep, a count on the north slope showed at least 73% dug into by rodents, and one on the south slope showed 76% molested.

Results of Poisoning 20-30 Acres in Spring, and Sowing Seed in Fall:

P. & S. No. 6 is an experiment in poisoning to rid a small tract of rodents so that seed could safely be sown on it. The trial failed. The area was poisoned with strychnine-treated wheat on June 15, 1912. The wheat was poisoned by Dr. Dearborn of the Biological Survey, and was distributed partly by him and partly under his direct supervision. To

while 7% of the unweeded spots were without seedlings. The most seedlings per spot were in an unprotected spot. Germination was almost an utter failure where 1-1/2" of soil covered the seed.

On P & S No. 3, at least 62% and probably more of the seed spots had been dug into by mice or a similar animal, when examination was made July 22, 1912, a month and a half after sowing.

On P & S No. 4, a count on the north side showed 8% dug into and on the south side 9% of the spots certainly dug into by rodents. The time of sowing and of examination were similar to P & S No. 3.

On P & S No. 5, where the spots were made with a tamp, and were 3" in diameter and 1" to 2" deep, a count on the north slope showed at least 75% dug into by rodents, and one on the south slope showed 70% molested.

Results of Poisoning 20-50 Acres in Spring, and Sowing Seed in Fall:

P. & S. No. 6 is an experiment in poisoning to rid a small tract of rodents so that seed could safely be sown on it. The trial failed. The area was poisoned with strychnine-treated wheat on June 15, 1912. The wheat was poisoned by Dr. Dearborn of the Biological Survey, and was distributed partly by him and partly under his direct supervision. The

a bushel of wheat, 2 ounces of strychnine in the alkaloid form and 3 pints of tallow were used. (On the Mt. Hebo poisoning, Kraebel gives the following figures: To 5 gallons of wheat, 20 teaspoonfuls of strychnine and one quart of tallow. The strychnine and tallow were mixed before applying to the wheat, but this was not done in the poisoning of P & S No. 6.) (The poisoning on the Mt. Hebo area was more severe, since 1 teaspoonful instead of 1/2 teaspoonful of strychnine was used per quart of wheat.) Since the wheat was distributed at the rate of 1 bushel to 20-30 acres, 1 quart to 1-1/2 quarts was used per acre. (In the Mt. Hebo poisoning, according to Kraebel, the wheat was distributed at the rate of 2 to 3 quarts per acre.)

On July 27 most of the wheat seemed to have been eaten or carried away. One dead mouse was found; some kernels half eaten showed rodent work; some bird feathers were found near piles of wheat.

On October 26, 28 and 30, part of the area was sown to Douglas fir and western white pine. The sowing of the 26th was examined on the 28th, and one count showed 80% to 96% of the spots dug into. Another count made nearer the center of the tract showed 80% to 90% of the spots molested. This was after two nights. During the same time four mice were caught in five traps and the bait of the fifth trap had been nibbled without springing the trap. On

a bushel of wheat, 2 ounces of strychnine in the alkaloid form and 3 pints of talow were used. (On the Mt. Hebo poisoning, Knebel gives the following figures: To 5 bushels of wheat, 20 teaspoonfuls of strychnine and one quart of talow. The strychnine and talow were mixed before applying to the wheat, but this was not done in the poisoning of P. & S. No. 6.) (The poisoning on the Mt. Hebo area was more severe, since 1 teaspoonful instead of 1/2 teaspoonful of strychnine was used per quart of wheat.) Since the wheat was distributed at the rate of 1 bushel to 20-50 acres, 1 quart to 2-1/2 quarts was used per acre. (In the Mt. Hebo poisoning, according to Knebel, the wheat was distributed at the rate of 2 to 3 quarts per acre.)

On July 27 most of the wheat seemed to have been eaten or carried away. One dead mouse was found; some half eaten half eaten showed rodent work; some bird feathers were found near piles of wheat.

On October 20, 28 and 30, part of the area was sown to Douglas fir and western white pine. The sowing of the 20th was examined on the 28th, and one count showed 80% to 90% of the spots due to mice. Another count made nearer the center of the tract showed 80% to 90% of the spots noted. This was after two nights. During the same time four mice were caught in live traps and the bait of the fifth trap had been nibbled without springing the trap. On

October 30 the sowing of the 28th was examined. On a strip through the center of the tract 100% of spots where seed was covered 1/2" deep appeared to have been disturbed, while 91% of these undoubtedly had been burrowed into, since seed husks were found on them. In spots similarly placed but with seed covered 1" deep, 52% appeared to have been molested and 38% had surely been dug into, as shown by the husks of eaten seeds on the spots. As with the previous count, this damage was done during two nights after sowing. As before, in this time four mice were caught in five traps, and the bait of the fifth trap had been nibbled. The traps this time were set as near as possible to the center of the sowing area, and about in the center of the area poisoned.

It is evident, therefore, that poisoning a small area in the early summer cannot be depended upon to rid the tract of rodents to such an extent that seed can safely be sown on the place in the following fall.

October 30 the sowing of the 25th was examined. On a strip through the center of the tract 100% of spots where seed was covered 1/2" deep appeared to have been disturbed, while 91% of these undoubtedly had been burrowed into, since seed husks were found on them. In spots similarly placed but with seed covered 1" deep, 82% appeared to have been molested and 58% had surely been dug into, as shown by the husks of eaten seeds on the spots. As with the previous count, this damage was done during two nights after sowing. As before, in this time four mice were caught in five traps, and the bait of the fifth trap had been nibbled. The traps this time were set as near as possible to the center of the sowing area, and about in the center of the area poisoned.

It is evident, therefore, that poisoning a small area in the early summer cannot be depended upon to rid the tract of rodents to such an extent that seed can safely be sown on the place in the following fall.

