Quantity and Germinability of *Oryzopsis hymenoides* Seed in Lahontan Sands

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Abstract

The location, quantity, and germinability of seed (caryopses) reserves of *Oryzopsis hymenoides* (R. & S.) Ricker in the soil were investigated at 4 locations in the Carson Desert of western Nevada. Numerous germinable seeds were recovered from the surface 15 cm of Lahontan sands. There was no clear relation between the number of seeds and depth of burial. On sites with pronounced dunes more seeds were found in the dune sands than in the interspaces. Seeds were recovered with and without evidence of sand abrasion of the indurate lemma and paleas. Seeds without wear marks were much more highly germinable (80%) than the more numerous seeds with wear marks (6%). The germinable seed reserve consisted of seeds that germinated without pretreatment when incubated at 20° C; a much larger portion that required dissection to remove the indurate lemma and palea; and a fraction with embryo dormancy that had to be overcome with gibberellin enrichment of the germination substrate. Large numbers of opened, empty lemma and palea were found in the sands. Rodent enhancement of the germination of *Oryzopsis hymenoides* seeds appears to be a more valid hypothesis than mechanical abrasion from saltation.

Oryzopsis hymenoides (R. & S.) Ricker is the predominant herbaceous species in many plant communities at lower elevations of pluvial lake basins of the Great Basin. This perennial bunchgrass reaches its greatest abundance on sandy soils or on active dune areas. In the northern Carson Desert large areas of relatively pure stands of *Oryzopsis hymenoides* grow on Lahontan sands (Billings 1945, 1949). This geologic formation is derived from sand-textured sediments that were dumped by rivers into the pluvial Lake Lahontan during the Pleistocene and since have been transported by winds across what is now a desert landscape (Morrison 1964).

Oryzopsis hymenoides seeds (caryopses) are highly polymorphic, but all forms are generally dormant (Huntamer 1934). The nature of the dormancy has been attributed to the persistent lemma and palea and pericarp that inhibit oxygen transfer to the embryo (Huntamer 1934, Fendall 1964, Clark and Bass 1970, Shaw 1976, and McDonald and Khan 1977). The lemma and palea have to be removed and the pericarp pricked in order for the seeds to germinate (Plummer and Frischknecht 1952).

Considering the nature of the dormancy, 3 hypotheses have been offered to explain how dormancy is broken in the natural environment. The first hypothesis postulates that temperature fluctuations and microbial degradation cause the lemma and palea to split and allow germination (Stoddart and Wilkinson 1938). The second hypothesis takes into account the affinity of this grass for sandy soils and suggests that the relatively small and dense seeds of this species move along the surface of the sands by saltation until the lemma and palea are broken by the abrasive action of the sand grains (e.g. Robertson 1977). The third hypothesis, as recently proposed by McAdoo et al. (1983), is that the collecting, manipulating, and caching of seeds by rodents enhances the natural establishment of *Oryzopsis hymenoides*.

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One of the few completed studies of natural seedling establishment of *Oryzopsis hymenoides* determined that 85% of successful *Oryzopsis hymenoides* seedlings emerged from depths of 3 to 7 cm in Lahontan sands (Kinsinger 1962). Considering the relatively small size of the seeds (5 mm diameter), emergence from greater than 5 cm is surprising (Young et al. 1969).

Our purposes were to estimate the quantity and location of *Oryzopsis hymenoides* seeds in Lahontan sands and to study the germinability of recovered seeds to determine the natural means by which the inherent dormancy of the seeds is overcome.

Materials and Methods

Field studies were conducted in the northern Carson Desert about 80 to 100 km northeast to east of Reno, Nev., (latitude 39° 45′ N, longitude 119° 0′ W). Billings (1945) described the general vegetation, soils, and climate of the Carson Desert. We chose 4 sites with similar potential plant communities growing on Lahontan sands (Table 1). The sites differed in the density of *Oryzopsis hymenoides* plants. Frenchman's Station (military bombing range) was in near pristine condition with no grazing; Desert Queen Valley was occasionally grazed by cattle; Summit was moderately grazed; and Eagle Valley was severely grazed. Based on the closest stations with long-term weather records (Lovelock and Fallon, Nev.) and the gauges that we maintained on the sites, annual precipitation is estimated at greater than 100 mm, but consistently less than 120 mm.

The Lahontan sands *(Typic tropopsaments)* have a decided microtopography with dunes and interspaces. The dunes rise less than 0.5 m above the interspaces. We stratified our sampling based on this microtopography. At each location, in September 1977, we selected a relatively uniform area and laid out 4, 50 by 50-m blocks in a randomized design. In each block, open-bottom metal boxes 32 by 32 cm were driven into the sands to a depth of 15 cm. The inside surfaces of each box were divided into segments by horizontal lines every 2.5 cm to facilitate sampling. The sand was carefully removed in 2.5-cm deep increments and placed in bags for transportation to the laboratory. A box was randomly located in an interspace and dune in each replication for a total of 8 samples at each location on each sampling date. The samples were spread on paper on greenhouse benches to air dry and screened through a 0.99-mm screen to recover all *Oryzopsis hymenoides* seeds and seed parts.

The 15-cm maximum sampling depth was based on the soil depth in the most shallow interspace soils. The Lahontan sands range from 15 to 100 cm deep, but are deeper on dunes. The texture is rather uniformly 94 to 96% sand with 4 to 6% silt and clay. The pH in the soil profile ranges from 8.0 to 8.9. Because of the low silt and clay contents and the nearly complete lack of soil structure, seeds were easily recovered by screening.

The recovered seed material was divided into classes as follows: (a) entire seeds, (b) seeds with wear marks or holes in the lemma and palea, and (c) empty lemma and paleas. The entire seeds and with wear areas were squeezed between thumb and forefinger to see if they were empty. Empty lemmas and paleas disintegrated while filled seeds were too hard to crush. Seeds that passed this test were

Table 1. Characteristics of experimental sites.[1]

Site	Elevation (m)	Microtopography: Dune height (cm)	Microtopography: Dune extent (% of landscape)	Density: *Oryzopsis hymenoides* (plants per m^2)	Density: Shrubs (plants per 10 m^2)
Desert Queen	1,200	5	50	1.7 b	0.2 b
Summit	1,340	8	60	1.9 b	0.6 a
Eagle Valley	1,200	5	50	0.7 c	0.5 a
Frenchman	1,300	1	10	2.8 a	0.2 b

[1]Density means followed by the same letter are not significantly different at the 0.01 level of probability as determined by Duncan's multiple range test.

classed as potentially germinable and tested for germination.

Germination tests were conducted in dark germinators at 20° C. Previous laboratory experiments had established 20°C as an optimum incubation temperature in dark germinators (unpublished research USDA/ARS, Reno, Nev.). Seeds were placed on germination paper in closed petri dishes and kept moist with tap water. After 2 weeks' incubation, the germinated seeds were counted and removed. Seeds that had not germinated during this 2-week period were dissected to remove the lemma and palea and the pericarp was pricked if it was not damaged in the dissection. Dissected embryos and endosperms were returned to petri dishes and then incubated for another week, after which germinated seedlings were counted. The remaining ungerminated seeds were incubated for another week with 50 ppm of an aqueous solution of gibberellin (GA_3) added to the germination substrate.

Seed production at the Desert Queen site was excellent during the summer of 1978. To obtain an estimate of *Oryzopsis hymenoides* seed production, we bagged individual plants and clipped them at optimum seed maturity and counted the seeds.

Using the same procedures as in the original sampling, we recovered samples at the Desert Queen in August and November 1978 and April 1979.

Results

Analysis of variance revealed significant (P=0.01) differences in the number of *Oryzopsis hymenoides* seeds, type of seeds, and seed parts recovered from Lahontan sands, and the location, depth, and microtopography from which they were recovered.

Seeds without Apparent Wear Marks

Among seeds without wear marks, there was no consistent relation between numbers of apparently and actually germinable seeds, and the depth in the soil from which they were recovered (Table 2). Apparently germinable seeds were those that were firm and appeared filled. Actually germinable seeds were ones that germinated when incubated, dissected, or treated with gibberellin. Except at the Frenchman location, the samples dug from dunes were always higher in apparently and actually germinating seeds than samples recovered from the interspaces. Frenchman was the location with the least microtopographical differences between dunes and interspaces (Table 1).

Frenchman had the greatest number of seeds from interspaces (Table 2). No seeds were found in the interspaces at Eagle Valley. Recovery from interspaces at Frenchman (1.8 × 10^6 germinable seeds per hectare) was half of the maximum for the dunes at Summit and did not differ statistically from recovery from the dunes at Frenchman.

When seed numbers are combined from the dunes and interspace and corrected for the variable portion of dunes and interspaces among sites, Summit produced 2.3 × 10^6, Frenchman 1.8 × 10^6, Desert Queen 1.7 × 10^6 and Eagle Valley 0.2 × 10^6 germinable *Oryzopsis hymenoides* seeds per hectare.

Germination Characteristics—Seeds with No Apparent Wear

Of the seeds that we judged to be apparently germinable, 80% subsequently germinated (Fig. 1). Over all locations and microtopographies, 28% of the seeds that germinated did so after 2 weeks at 20° C without any pretreatment. An additional 46% germinated when the lemma and palea were removed by dissection. The remaining 26% germinated when 50 ppm gibberellin was added to the substrate.

At individual locations and microtopographies, the percentage of seeds that germinated without pretreatment varied from a high of 37% for the dune sands at Summit to zero at Eagle Valley (Fig. 1). The percentage of recovered seeds that germinated after the

Table 2. Number of apparently and actually germinable *Oryzopsis hymenoides* seeds per 2,560 cm^3 of Lahontan Sand by 2.5-cm increments in the soil at 4 locations. These seeds exhibited no wear marks or holes in their lemma and paleas.[1]

		No. of Seeds							
		Desert Queen		Summit		Eagle Valley		Frenchman	
Microtopography	Depth (cm)	Apparent	Actual	Apparent	Actual	Apparent	Actual	Apparent	Actual
Dune	0–2.5	2	1	7	6	1	0	6	5
	2.5–5.0	2	1	5	4	1	0	9	8
	5.0–7.5	1	1	5	3	1	1	1	0
	7.5–10.0	3	2	3	2	1	1	2	1
	10.0–12.5	8	7	26	20	3	2	1	0
	12.5–15.0	16	6	3	3	2	1	0	1
		32 b	28 u	49 a	38 t	9 e	5 y	19 d	15 w
Interspace	0–2.5	2	2	1	1	0	0	7	5
	2.5–5.0	2	2	2	2	0	0	2	2
	5.0–7.5	1	1	1	0	0	0	2	2
	7.5–10.0	1	0	1	0	0	0	7	5
	10.0–1.25	1	1	0	0	0	0	6	4
	12.5–15.0	1	1	0	0	0	0	2	2
		8 e	7 x	5 f	3 y	0 g	0 z	26 c	20 v

[1]Means followed by the same letter (a through f for apparent and 5 through z for actual) are not significantly differnt at the 0.01 level of probability as determined by Duncan's multiple range test. All sum compared by treatment, totals compared horizontally.

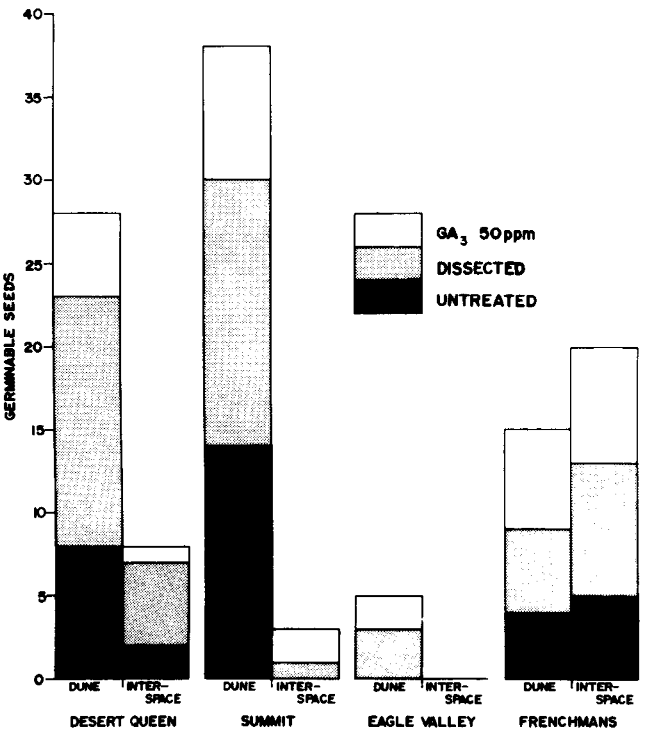

Fig. 1. *Number of germinable* Oryzopsis hymenoides *seeds without wear marks per 15,000 cm³ of Lahontan sand (0.1 m² surface by 15 cm deep) at 4 locations. Germination treatments are additive; first control incubation, followed by dissection, and then the addition of 50 ppm gibberellin.*

embryo was dissected from the lemma and palea varied from 33% for the dune sands at Frenchman's to 62% for the interspace sands at Desert Queen.

The seeds that failed to germinate after the lemma and palea were removed, but did germinate with the addition of gibberellin to the substrate, provided an estimated percentage of the seed population in the soil with embryo dormancy. Indirectly, this provides a partial estimate of the age of the seeds in the soil because the embryo dormancy that is overcome by gibberellin enrichment also responds to cool-moist stratification (Clark and Bass 1970).

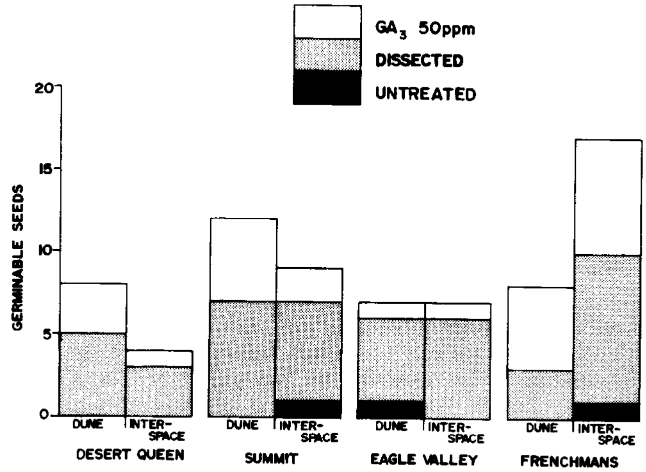

Fig. 2. *Number of germinable* Oryzopsis hymeoides *seeds with wear marks per 15,000 cm³ of Lahontan sand (0.1 m² surface by 15 cm deep) at 4 locations. Germination treatments are additive; first control incubation, followed by dissection, and then the addition of gibberellin.*

Oryzopsis hymenoides seeds that lay in the soil for one or more winters should have their stratification requirements satisfied unless the seedbed was dry for the entire winter. The percentage of seeds that required gibberellin enrichment for germination was highest for Summit interspace samples (66%) and lowest for Desert Queen interspace samples (13%).

Seeds with Apparent Wear Marks

For most locations and microtopographies, the number of seeds of *Oryzopsis hymenoides* with wear marks on lemma and palea markedly exceeded the number without (Table 3). In comparison to seeds without wear marks, worn seeds were especially numerous in Eagle Valley.

In comparison to the 80% germination for seeds recovered without wear marks, only 6% of worn seeds germinated (Fig. 2). When the germinable worn seed recovery rates were converted to a per unit area basis and adjusted for the variable amounts of dunes and interspace among sites, Desert Queen produced 0.6×10^6, Summit 1.1×10^6, Eagle Valley 0.7×10^6 and Frenchman 0.9×10^6 seeds per hectare. Except at Eagle Valley, all yields were considerably lower than yields for unworn seeds.

Table 3. Number of apparently germinable and actually germinable seeds of *Oryzopsis hymenoids* with wear marks on the lemma and palea per 2,560 cm³ of Lahontan Sand by 2.5-cm increments in the soil at 4 locations.[1]

		No. of Seeds							
		Desert Queen		Summit		Eagle Valley		Frenchman	
Microtopography	Depth (cm)	Apparent	Actual	Apparent	Actual	Apparent	Actual	Apparent	Actual
Dune	0–2.5	7	1	23	2	21	1	34	33
	2.5–5.0	7	1	20	2	12	1	7	1
	5.0–7.5	3	0	68	1	3	0	4	0
	7.5–10.0	7	2	38	2	13	1	7	2
	10.0–12.5	5	1	24	3	6	1	6	1
	12.5–15.0	9	3	26	2	56	3	3	1
		38 e	8 yz	199 a	12 xy	111 c	7 yz	61 d	8 yz
Interspace	0–2.5	13	1	9	2	9	4	32	6
	2.5–5.0	5	1	10	3	2	0	6	1
	5.0–7.5	5	1	3	1	3	1	38	3
	7.5–10.0	2	0	6	1	3	1	34	2
	10.0–12.5	4	1	3	1	2	0	30	3
	12.5–15.0	2	0	3	1	3	1	15	2
		31 e	4 z	34 e	9 yz	22 f	7 yz	155 b	17 x

[1]Means followed by the same letter (a through f for apparent and x through z for acutal) are not significantly different at the 0.01 level of probability as determined by Duncan's multiple range test. All sum compared by treatment, totals compared horizontally.

Table 4. Numbers of emtpy lemmas and paleas of *Oryzopsis hymenoides* per 2,560 cm³ of Lahontan Sand by 2.5-cm increments in the soil at 4 locations.[1]

Microtopography	Depth (cm)	No. of lemmas and paleas			
		Desert Queen	Summit	Eagle Valley	Frenchman
Dune	0–2.5	35	77	32	83
	2.5–5.0	33	72	27	36
	5.0–7.5	52	111	52	9
	7.5–10.0	53	74	19	18
	10.0–12.5	22	97	30	14
	12.5–15.0	36	162	13	15
		231 d	593 a	173 e	175 e
Interspace	0–2.5	23	30	15	84
	2.5–5.0	23	27	5	18
	5.0–7.5	58	10	3	93
	7.5–10.0	64	8	2	131
	10.0–12.5	79	3	6	133
	12.5–15.0	16	3	5	26
		263 c	81 f	36 g	485 b

[1]Means followed by the same letter are not significantly different at the 0.01 level of probability as determined by Duncan's multiple range test. The sums are compared together and the totals horizontally.

Germination Characteristics—Seeds with Wear Marks

Among all locations and microtopographies, only 4% of the germinable seeds recovered with wear marks germinated with no pretreatment. This compares to 28% for seeds without wear marks. Germination was enhanced 61% by dissection of the lemma and palea and an additional 35% by the addition of gibberellin. The enhancement of worn seed germination by dissection or addition of gibberellin was relatively constant among locations and microtopographies in comparison to that observed for seeds without wear marks (Fig. 2).

Number of Empty Lemmas and Paleas Recovered

Recoveries were much greater of disjointed or spread lemmas and paleas than of apparently germinable seeds of *Oryzopsis hymenoides* (Table 4). When the microtopographies were combined on a proportionate basis, lemmas and paleas (one of each per seed) were recovered at the rates of 12.4 × 10⁶ at Desert Queen, 19.4 × 10⁶ at Summit, 5.3 × 10⁶ at Eagle Valley, and 10.4 × 10⁶ at Frenchman.

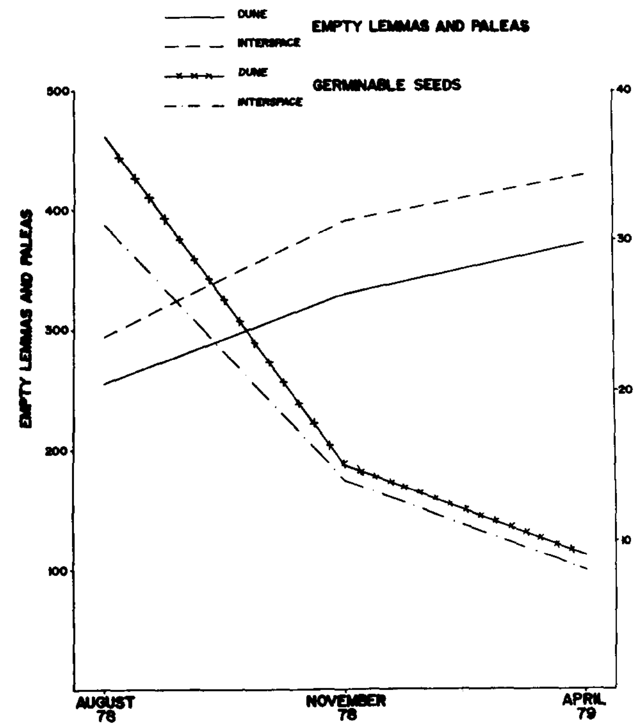

Fig. 3. *Average number of empty lemmas and paleas and germinable seeds of* Oryzopsis hymenoides *recovered per 15,000 cm³ of Lahontan sand at the Desert Queen site in August and November 1978 and April 1979.*

The recovered lemmas and paleas ranged from shiny, indurate specimens that looked fresh to dull ones that could be crushed between the thumb and forefinger. The lemma and palea are not easily removed from the seeds. Dissection is difficult unless the seeds are soaked, and even then, considerable skill and force are necessary to part the lemma and palea. Many of the lemmas and paleas recovered from the soil were still attached at the callus base, but were spread open with the embryo and endosperm missing.

Seed Production

Total *Oryzopsis hymenoides* seed production at Desert Queen in 1978 was estimated at 40.9 × 10⁶ seeds per hectare (Table 5). Long-term observation has shown that specific *Oryzopsis hymenoides* stands in the Carson Desert may not produce seed in dry years. During seasons such as 1978, however, seed production far exceeds the total germinable reserves in the soil.

Fate of *Oryzopsis hymenoides* Seeds Produced in 1978 at Desert Queen

As we followed *Oryzopsis hymenoides* seed reserves in the soil after the excellent seed production of 1978 a trend became apparent for empty lemmas and paleas to increase and germinable seeds to decrease (Fig. 3).

We made careful observations during the winter and spring 1979 to detect *Oryzopsis hymenoides* seedling establishment. Very few seedlings were found, except those growing from obvious rodent caches. We detected 0.5 rodent caches per m² with at least 1 *Oryzopsis hymenoides* seedling emerging.

Discussion

The distribution of *Oryzopsis hymenoides* seeds in the surface 15 cm of the soil is in sharp contrast to results for other grass species in nonaeolian soils in the same general environment (Young and Evans 1975). In *Artemisia* / bunchgrass communities, the reserve of germinable seeds is located immediately above and below the soil

Table 5. *Oryzopsis hymenoides* seed production at the Desert Queen site. 1978.

Seed type	Production per hectare	
	Number × 10⁶	Weight kg
Brown	26.6	22.7
Black	14.3	41.1
Total	40.9	63.8

surface. Possibly the constant movement of the Lahontan sands influenced distribution of *Oryzopsis hymenoides* seeds. Rodent burial may also be a major factor in dispersal. There are numerous references to the diversity of seed-consuming rodents in sandy desert areas (Reynolds 1950, 1958; Brown 1973) and to their seed-caching activities (Shaw 1934, Beatley 1969, LaTourette et al. 1979, Lockard and Lockard 1971).

The abundance of germinable seeds in the sands was markedly depressed on sites that had been severely overgrazed by domestic livestock but not on sites that had been only moderately grazed. On the overgrazed site, the high number of seeds with wear marks might be attributed to accelerated wind erosion associated with poor vegetation. Even on the severely grazed site, however, a reserve of germinable *Oryzopsis hymenoides* existed in the soil. In similarly degraded *Artemisia*/ bunchgrass communities the reserve of germinable perennial grass seeds may be nondetectable (Young and Evans 1975).

We saw no evidence of the microbial breakdown of the indurate lemma and palea covering of germinable seeds recovered from the soil. We saw considerable evidence of mechanical abrasion of this covering, apparently from saltation. However, this wear appeared more closely associated with loss of viability than enhancement of germination. Embryo dormancy apparently is a factor in the germinability of *Oryzopsis hymenoides* seed reserves in the soil, but not to the extent of the dormancy caused by indurate lemma and palea.

The numerous opened lemmas and paleas found in the sands and the abundant rodent caches with germinated *Oryzopsis hymenoides* seedlings attested to the role of rodents in enhancing the germination of dormant seeds of this species as indicated by McAdoo et al. (1983).

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