GERMINATION REQUIREMENTS AND DORMANCY EFFECTS IN SEED OF *UROCHLOA MOSAMBICENSIS*

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ABSTRACT

A condition of apparent physiological dormancy in seed of Urochloa mosambicensis *with a post harvest age of nine months was partly overcome by use of alternating temperatures (10-30°C) during the germination period, and by treatment of the seed with potassium nitrate (0.2%) and gibberellic acid (100 μg/ml). With some older seed of the species germination delay was attributed to physical constriction of the embryo by the enclosing lemma and palea and not to impermeability of, or presence of chemical inhibitors in these structures.*

INTRODUCTION

Urochloa mosambicensis, a sub-tropical grass species introduced into Australia in recent years, is regarded as having considerable potential as a pasture grass in the lower rainfall areas of the northern part of the continent. Most commonly grown are the introductions Q2447, from Greytown, Natal, and C.P.I. 6559, from Salisbury, Rhodesia. The species is an aposporous apomict (Pritchard 1970).

Commercial seed production of *U. mosambicensis* has been undertaken in north Queensland over the last few years but from the outset, it has been noted that the germinability of harvested seed is frequently very low. In many instances it is difficult to induce the seed to germinate at all, particularly when tests are carried out within 12 months from the time of harvest .

Germination may be inhibited in seeds for a number of reasons: (1) rudimentary embryos, (2) physiologically inactive embryos (inactive enzyme systems), (3) mechanically resistant seed coats, (4) impermeable seed coats, and (5) presence of chemical inhibitors (Amen 1968). Any of these factors with the exception of (1) could be a cause of germination delay in *U. mosambicensis*. Akamine (1944) attributed germination delay in the species *U. pullulans* to two factors: embryo dormancy, and physical constriction of the embryo by the lemma and palea. Dormancy in *U. pullulans* was overcome by after-ripening dry seed at warm temperatures (34.5 to 44.9°C) for approximately 13 weeks: such treatment may induce physical changes in seed coats or it may have physiological effects such as increasing water absorbing potential of the embryo by favouring conversion of starch to sugar (Koller et al. 1962).

The de-awned fertile floret of *U. mosambicensis* consists of a lemma and palea closely enclosing the caryopsis (Fig. 1). At the lower end of the lemma there is a raised semi-elliptical flap, which at germination is broken open by coleorrhizal hairs which grow out in a clump, followed by the radicle. As with the seed of most other angiosperms, radicle emergence precedes that of the shoot, and in *U. mosambicensis* the shoot elongates rapidly and usually emerges at an angle to the longitudinal axis of the seed, forcing the palea and lemma apart at the same time. Opening of the lemma and palea appears to be impeded by a resin-like deposit overlying the palea on its upper edge, at the base of the awn (Fig. 1).

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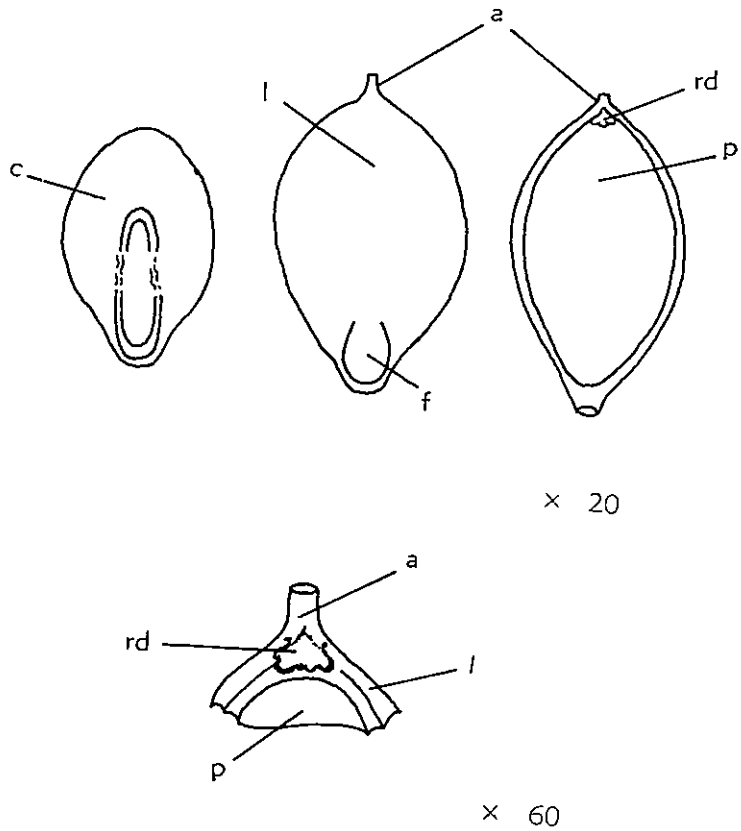

Figure 1. Florets and Caryopsis of *U. mosambicensis.*

MATERIALS AND METHODS

Three seed lots were selected for examination (Table 1).

TABLE 1

Details of seed used in the investigations

Sample	Introduction	Where Grown	Year of Harvest
1	C.P.I. 6559	Unknown*	Unknown
2	Q2447	Mareeba**	1969
3	Q2447	Mareeba**	1970

*Seed obtained from Pastoral Research Laboratory, C.S.I.R.O., Townsville.

**Successive yearly harvests of seed from an area on the property of Mr. C. P. Vicary, Mareeba.

The C.P.I. 6559 seed was of unknown age, but showed no sign of dormancy either in the rate or in the extent of germination. It was thought to have been harvested in 1968 or 1969. The Q2447 (1969 seed) also showed no sign of dormancy but the Q2447 (1970 seed) was quite dormant.

In preliminary experiments with the C.P.I. 6559 seed the effect of a standard drying procedure, 12 days at 40°C, used in seed testing (Prodonoff 1970) was examined and the effect of light on germination at alternating temperatures of 20-30°C was also examined. White fluorescent light of intensity 2000-3000 lux was supplied for 8 hr each 24 hr during the high temperature phase. Germination of separated caryopses was measured in water and potassium nitrate (0.2%) and the effect of cutting through the seed coats was also measured. Cutting involved removal of about one quarter of the lemma and palea (together with a small portion of the caryopsis) by means of a transverse cut across the upper end of the floret.

Experiments to investigate permeability of the lemma and palea to water and oxygen were carried out on the C.P.I. 6559 seed.

Oxygen uptake of cut and uncut florets during the first 26 hr of imbition was measured using Warburg manometers. Seed was stored for 48 hr in a desiccator above 80% potassium hydroxide to remove pre-formed carbon dioxide before being put into the apparatus for measurement of oxygen uptake. Batches of 25 and 50 seeds were used either cut as described previously or whole. The centre well of the flasks contained 0.5 ml of 20% potassium hydroxide, and 0.6 ml distilled water was added to the seed. The shaking rate was 104 oscillations per minute, and the bath was set at 20°C.

Oxygen uptake of cut and uncut florets during the first 26 hr of imbibition Uptake by caryopses removed from the florets before and after imbibition for the various times was compared with that of the full florets. Six lots of ten florets and caryopses were weighed at intervals and water uptake was recorded as weight increase.

The response of dormant and non-dormant Q2447 seed to temperature was investigated. Alternating temperatures 10-25, 10-30, 10-35, 15-25, 15-30, 15-35, 20-25, 20-30, 20-35°C were on a 16/8 hr cycle with the shorter high temperature phase accompanied by white light from a fluorescent source of intensity 2000-3000 lux. Constant temperature treatments 25, 30 and 35°C received similar light for equivalent periods. The response of the Q2447 seed to potassium nitrate (0.2%) and gibberellic acid (100 μg/ml) was compared at temperatures of 30, 10-30 and 20-30°C.

Except where otherwise stated, germination tests were carried out on 3 x 100 replicates in 8 in. x 10 in. trays lined with paper (Green's LR52), moistened initially with 90 ml solution. Counts were made at the end of 21 days.

RESULTS AND DISCUSSION

Seed coat effects in non-dormant C.P.I. 6559 seed

In the preliminary experiments with this seed, the standard drying procedure improved germination in light with both water and potassium nitrate. Germination was significantly improved by potassium nitrate but the effect of nitrate was greatly diminished in the dark (Table 2).

TABLE 2
*The effect of light on the germination of dried and undried C.P.I. 6559 florets at 20-30°C. Germination per cent after 21 days.**

Medium	Light		Dark
	Dried	Undried	Undried
Water	22	6	5
KNO_3	54	47	12
L.S.D. ($P < .01$)	3		

*6 replicates of 25 caryopses

Caryopses separated by hand from the lemmae and paleae (palems) germinated up to 69%. Nitrate depressed the germination of caryopses, but significantly promoted the growth of those caryopses which did germinate (Table 3).

TABLE 3
Germination in light at 20-30°C, of C.P.I. 6559 caryopses

Medium	Germination per cent after 6 days*	Mean shoot length per germinated caryopsis (mm)
Water	69	16.5
KNO_3	63	23.5
L.S.D. ($P < .05$)	11.4	4.3

*6 replicates of 25 caryopses

Cutting the floret transversely about one quarter of the distance back from the end distal to the embryo resulted in rapid germination. After 65 hr 47% of the cut florets had germinated but only 7% of the uncut florets.

Gas exchange measurements disclosed that the rapid germination associated with cutting florets was not associated with increased uptake of oxygen (Table 4).

Although there did appear to be a delay in the uptake of water by enclosed caryopses, both these and isolated caryopses absorbed similar amounts of water after 9 hr of imbibition (Fig. 2). After approximately 50 hr of imbibition, caryopses had commenced germinating, and this was associated with a large increase in fresh weight. Owing to the small quantities of material involved it was not possible to measure this increase in terms of dry weight, but it is likely that much of the increase in weight at this stage would have been associated with further uptake of water, associated with vacuolation and expansion of the cells of the embryo.

TABLE 4
Respiration of whole and cut C.P.I. 6559 florets

	μ.l. O_2 per seed per hour			
	3-4 hours	4-5 hours	5-6 hours	25-26 hours
Uncut seed	.268	.644	1.716	.696
	.392	.560	.922	.782
	.608	.332	1.436	.552
	.570	.870	2.502	1.060
Means	.459	.601	1.644	.773
Cut seed	.272	0	.916	.484
	.540	.248	2.056	.880
	.418	.366	1.334	1.986
	.414	.494	1.622	.962
Means	.411	.277	1.482	1.078
L.S.D. ($P < .05$)	.236	.374	.998	.826

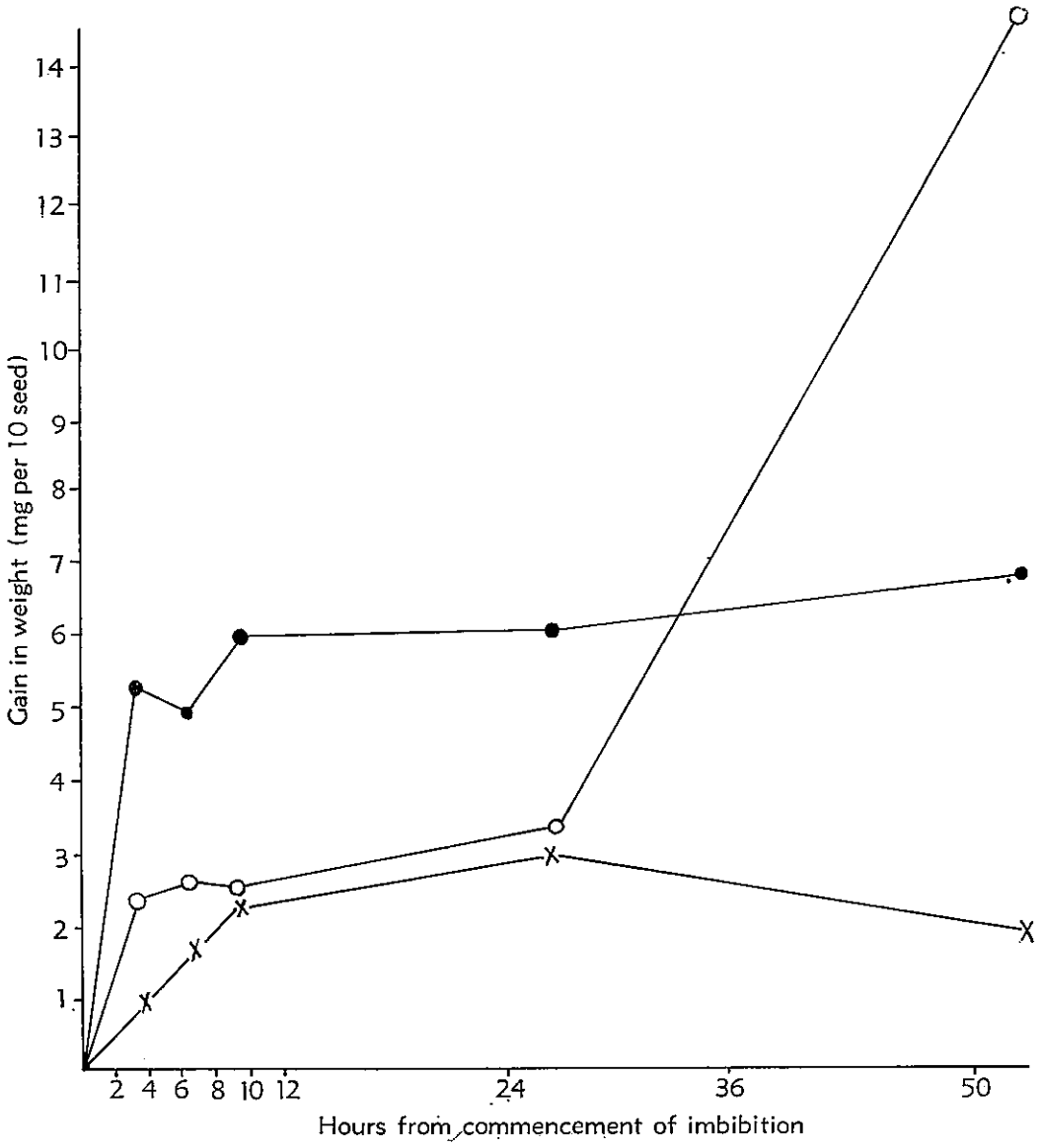

Figure 2. Weight gain of seed during 50 hours of imbibition.

Effects of temperature and chemicals on the germination of dormant and non-dormant Q2447 seed

The germination of Q2447 seed harvested in 1969 and 1970 is shown in Table 5 in response to constant temperature, and in Table 6 in response to alternating temperature.

TABLE 5
The effect of constant temperatures on the germination of Q2447 seed

°C	Germination per cent							
	1969 Seed			Mean	1970 Seed			Mean
25	22	20	22	21	0	2	0	1
30	20	18	23	20	12	5	5	7
35	25	22	18	22	6	3	5	5

Temperature effects N.S.

TABLE 6
The effect of alternating temperature within a 24 hour cycle on the germination of Q2447 seed

	Germination Per Cent							
	1969 Seed °C				1970 Seed °C			
°C	10	15	20	Mean	10	15	20	Mean
25	11	17	16	15	4	3	1	3
30	20	23	20	21	12	8	2	7
35	22	22	16	20	10	4	1	5
Mean	18	21	17		8	5	1	

L.S.D. ($P < .01$) for temperature differences = 4.7

The two lots of seed differed significantly in germination, that of the older seed being higher. When germinated under constant temperature conditions, neither seed lot responded significantly to temperature (Table 5). With alternating temperatures, on the other hand, both seed lots germinated better at the higher maximum temperatures, 30° and 35°C, compared with the lowest maximum temperature, 25°C. The older seed harvested in 1969 was unresponsive to the minimum temperatures used but the dormant 1970 seed germinated significantly better at 10°C than at 20°C minimum temperature.

The 1969 seed was unaffected by potassium nitrate or gibberellic acid. Potassium nitrate significantly improved germination of the 1970 seed at 30° and at 20-30°C but had no effects at 10-30°C. The 1970 seed reacted more significantly still to gibberellic acid in a response which was not influenced by temperature (Table 7).

TABLE 7
The effect of potassium nitrate and gibberellic acid on the germination of Q2447 seed harvested in 1969 and 1970

Temperature °C	Medium	Germination Per Cent	
		1969	1970
30	H_2O	19	5
30	KNO_3	17	14
30	GA	20	25
10–30	H_2O	8	10
10–30	KNO_3	14	8
10–30	GA	14	24
20–30	H_2O	19	2
20–30	KNO_3	15	14
20–30	GA	17	23

L.S.D. ($P < .05$) = 5.0

The germination responses measured with gibberellic acid suggest that a form of physiological dormancy may exist in the embryo of *U. mosambicensis* for a period after harvest of at least nine months (the post harvest age of the 1970 Q2447 seed). On the other hand, seed which was apparently not dormant was delayed in germination by the presence of the lemma and palea.

The presence of the lemma and palea was instrumental in causing delayed germination of the C.P.I. 6559 seed. There could be three likely explanations for this according to the previously quoted criteria of Amen (1968). The lemma and palea could be mechanically constrictive, impermeable or chemically inhibitory.

That the lemma and palea do not chemically inhibit germination is indicated by the rapid germination of florets in which only a small portion of the covering structures was removed by cutting. The caryopses were still largely in contact with the lemma and palea and potentially susceptible to the action of any chemical inhibitors located in these structures.

The fact that potassium nitrate induced germination in the light to a much greater extent than in the dark would tend to eliminate gas exchange effects (Table 2), and the actual gas exchange measurements (Table 4) did not disclose any difference due to cutting, thus confirming that low rates of gas exchange were not responsible for the retardation of germination. It must be concluded that the lemma and palea probably exerted a physical restraining force on the embryo of this seed, delaying emergence of the radicle and limiting the extension of the embryonic axis which would otherwise occur upon imbibition. This would agree with the situation found to occur in the species *U. pullulans* by Akamine (1944).

Physiological dormancy and physical constriction of the embryo of *U. mosambicensis,* moreover, may be interdependent, at least to some extent. One of the effects of endogenous and exogenous gibberellic acid in the germination process of cereal seed is to mediate in the release of endosperm food reserves (Paleg 1965). In a study of wheat germination by Wellington and Durham (1961) it was found that where seed coats were constrictive, germination was delayed until nutrients became available from the endosperm. The availability of such reserves from the endosperm would increase the water holding capacity of the embryo and in the case of *U. mosambicensis* may be essential for the expansion of the embryonic growth axis in the early stages of germination with consequent rupture of the germination flap by the coleorrhiza.

Germination delay in grass seed is often attributed to impermeable seed coats and both acid and mechanical scarification treatments have been recommended to overcome this condition (Burton 1939; Hodgson 1949; McLean and Grof 1968). As there is no impedance at least initially to the entry of water in the case of *U. mosambicensis* florets (Fig. 2), it is likely embryo damage would result if acid treatment were used on seed of this species. Mechanical scarification would probably not be effective either, unless it were able to promote separation of the lemma and palea by weakening or dislodging the point of overlap below the awn (Fig. 1): percussion treatment may be more suitable in this regard than abrasion of the palem.

Improvement of germination in *U. mosambicensis* with age probably comes about through modification of the physiological factors causing embryo dormancy, but deterioration of the primary and secondary structures uniting the lemma and palea may also be involved. It should be stressed that dormancy effects reported here relate to seed of a post harvest age of at least nine months and may be different from dormancy effects in freshly harvested seed.

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