

Longevity of Buffel Grass Seed Sown in an Arid Australian Range¹

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Highlight

Three sets of buffel grass seed with germination percentages of 0.8, 35 and 94 were sown in a spinifex grassland near Alice Springs, N.T., at a depth of 2.5 cm. Replicated batches were recovered from each set at increasing intervals and their germinability compared to seed kept in laboratory storage. All seed lost dormancy progressively, more rapidly in soil than storage. In the soil natural death of non-dormant seeds was probably concurrent with loss of dormancy, the balance leading eventually to small germination percentages. Values of about 10% were obtained 2-4 years after sowing, the seed with highest germinability at sowing having the shortest span. In storage germination percentages remained above 60. Range seeding of adapted varieties of buffel grass in arid regions with infrequent establishment periods can be attempted with confidence in seed longevity.

In arid areas seedlings of perennial grasses mostly occur after "good rains" by which is implied relatively high precipitation over periods of several rainy days or in a favourable sequence. Establishment begins with the occurrence of conditions suitable for germination, especially the availability of soil water for periods sufficient to complete the

processes of germination (MacGinnies, 1959; Winkworth, 1963a). The presence of osmotic and physiological inhibitors in the dispersal organs of desert plants (Beadle, 1952; Koller, 1955a and 1957; Koller and Negbi, 1959; Koller et al., 1958) may impose particular rainfall requirements as suggested by Went (1949).

The infrequent occurrence of germination periods in arid regions means that seed of successful species remains alive for long periods after shedding or range seeding. In much of central Australia, for example, germination periods suitable for perennial grasses occur about once a year on the average. Seeding into wet soil is precluded by the briefness of the periods when moisture is available in the top soil. Hence seeding must be done into dry soil to await the onset of rain, even in water spreading systems.

The situation immediately poses the question of the longevity of seed in the sowing zone of the soil. The sparseness of plants and litter affords little cover to the seed and most of the potentially germinable seed will be buried under bare soil. In a previous experiment the percentage germination of batches of buffel grass (*Cenchrus ciliaris* L.) seed sown 2.5 cm deep among the tussocks of a spinifex grassland and recovered after various periods showed that the seed maintained original levels near 35% germination for 8 months, declined to 12% after one year and then remained near 10% for another two years (Winkworth, 1963b). Since it was thought that the proportions of dormant and non-dormant seed at the time of sowing affected the levels of germination maintained, the study was continued with two more sets of seed of the same origin with different proportions at sowing. As previously, the work was at

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a site (lat. 22°55'S, alt. 640 m) located 100 km northwest of Alice Springs, N.T., which has a long term average annual rainfall of 267 mm, 191 mm falling in summer (October to March inclusive). Average maxima and minima screen temperatures range from 35 C and 21 C respectively in the hottest month, January, to 19 C and 4 C in the coldest month, July. The soil was a red clayey sand typical of the central area of the extensive arid spinifex grasslands described by Winkworth (1967).

Literature Review

Characteristically the genus *Genchrus* has a spike-like inflorescence composed of fascicles which are clusters of a few spikelets surrounded by an involucre of bristles and which fall entire. The fertile dispersal unit, commonly called the seed, thus is made up of 1 or 2, rarely more, caryopses enclosed by paleas, lemmas and glumes all within the involucre. Lahiri and Kharabanda (1961) found in their material of *C. ciliaris* that caryopses were of two sizes, large ones being about 3 times heavier than small ones, and having higher germinability.

At the time of shedding, or more strictly at harvest time, buffel grass "seed" has small germination percentages which gradually increase during dry storage (see, for example, Winchester, 1954). Numerous scattered reports indicate a large variation in rates of dormancy loss and levels of germination reached but there are no critical data to relate this to varietal, developmental, environmental, or storage factors. Akamine (1944) showed that the complete removal of all floral parts from around the caryopses greatly enhanced the germination percentages which were further increased by cutting the coat of remaining seeds. Water extracts of any or all of the fascicle parts inhibited germination. He concluded that dormancy was caused by a combination of an inhibitor, which appeared to be absorbed to some extent by wet powdered charcoal and soil, and a block to gaseous exchange through the seed coat. The results obtained by Andersen (1953) were in keeping with this theory, as were those of Lahiri and Kharabanda (1963) who suggested that the inhibitor might be coumarin, though their data were insufficient for positive identification.

Various workers (see Andersen, 1953) showed that short exposures of buffel seed to sulphuric acid or low or high temperatures sometimes increased germination to levels equivalent to some months of dry storage at room temperatures; germination of both naked and enclosed seed was stimulated by 0.2% KNO₃ solution. The reasons for these treatment effects, common to many species, were not investigated. Isolation of the inhibitor and definition of the critical structures of the seed coat would enable a study of their reactions to treatments and changes during natural ageing.

Andersen (1953) found that seed germinated over a temperature range of at least 10 C to 40 C with near optimal percentages obtained at 30 C constant or with alternations to 20 C at night. Light requirements have not been examined critically though the seeds are apparently insensitive. Optimum germination has been obtained in continuous dark, continuous light and light/dark alternations (Andersen, 1953; Al-Ani and Ouda, 1969).

Method and Materials

Galvanized iron rings, 17.8 cm in diameter and 5 cm in depth, were pushed into the soil until the upper rim was below the surface. Soil was excavated from within the rings to a depth of 2.5 cm. Batches of 200 or 400 fascicles were sprinkled into each hole after which the soil was replaced (see Fig. 1, Winkworth, 1963b).

At each sampling time ten batches of seed were excavated, all soil being removed to the bottom of the iron rings, the whole sample spread in trays, watered and incubated at 30 C. Each time five batches of stored seed were counted out, mixed with a similar volume of the same soil and incubated. Emergence of the coleoptiles above soil surface was counted for periods up to six weeks.

Three sets of seed with different initial germinability were obtained from one collection by natural ageing and production of progeny, compelling burial on different dates.

- (1) Set A, the original seed, was a commercial lot harvested from naturalized stands in arid areas of Western Australia. The seeds were received and 80 batches sown in September 1958, when 35% were germinable by incubation in soil at 30 C.
- (2) Set B was that portion of Set A which was kept in glass jars for 21 months when in June 1960, at near-peak germination of 94%, 80 batches were sown.
- (3) Set C was the seed harvested from a small irrigated plot sown with seed of Set A. Sufficient seed was obtained in a harvest to sow 120 batches in May 1962. At the time of sowing germination was 0.8%.

The eight sampling times for Set A are indicated by A1 to A8 in Table 1, which also shows the times B1 to B7 and C1 to C12 for Sets B and C.

Rainfall at the site was gauged by a 20.32 cm chart-recording pluviometer. Temperatures and relative humidities were recorded by a thermohygrograph in a standard meteorological screen.

Results and Discussion

The mean percentage germination of each sample of fascicles, of which a proportion contain more than one caryopsis, was plotted sequentially (Fig. 1). Analyses of variance on transformed data showed that effects of duration of burial or storage were significant ($P < 0.01$) in each set of seed. Individual comparisons (*t*) of successive mean germination percentages indicated significant differences between the samples joined by solid lines in Fig. 1.

Climate

Results for the three sets of seeds were plotted together on one time scale although buried during different calendar periods. A study of the site climatic records did not reveal any events such as excessively high or low temperatures distinctive to the different periods.

Rainfall was below average except in 1962 and 1966 and was less than half the Alice Springs average in 1959, 1961, 1963, 1964 and 1965 (Table 1). Soil moisture requirements for the germination of buffel grass seed known from other field experi-

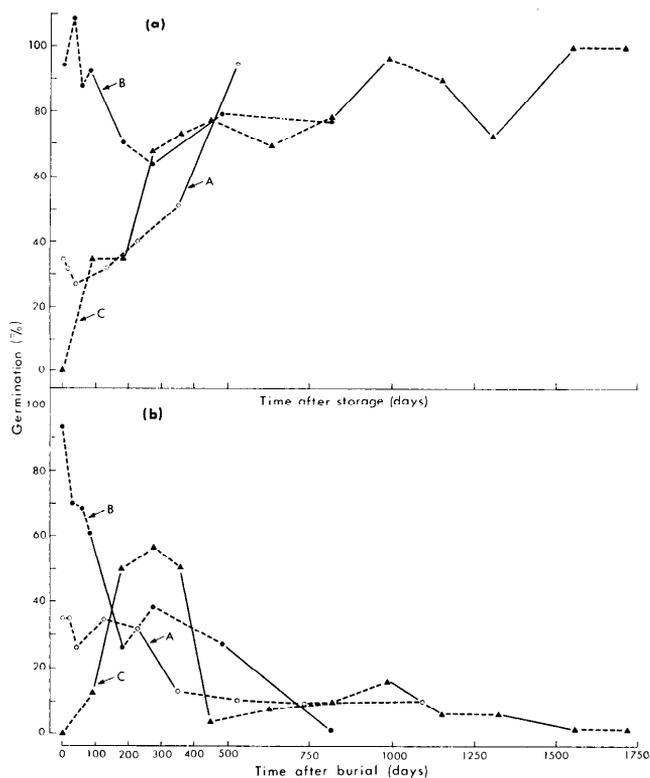


FIG. 1. Germination of 3 individual sets of buffel grass seed after (a) storage and (b) burial in the soil for different periods. Solid lines denote significant differences ($P < 0.01$).

ments at Alice Springs (Winkworth, unpublished) were satisfied possibly during 6 rainy periods, 2 occurring during the term of each set of seed, and at no other time. Emergence occurred in the field on 3 occasions, once from each seed set, amounting to < 0.1%, 1%, and 0.6% of the seed remaining in the soil at the particular times in A, B and C respectively.

On several occasions during the burial period of each seed set rainy periods wet the soil briefly. Germination without emergence was considered unlikely on most of these occasions. Alternate wetting and drying of seed was detrimental to subsequent levels of germination in some species observed by Griswold (1936) but stimulation has been reported in many others, sometimes being possibly related to the leaching of inhibitors. In this study samples were not taken especially before and after rainy periods. An examination of the occurrences of effective rain in relation to the observed changes in germinability was inconclusive about the effect of wetting and drying on ungerminated buffel seed other than that stimulation did not occur.

Declines in germination percentages of buried seed took place during periods when rain was insufficient to wet the seed, amounting to 78% of the total decline in Set A, 35% in Set B, and 27% in Set C, suggesting that natural death of embryos in dry soil was an important cause of loss.

Initial Germinability

Seeds that were non-dormant at the time of sowing rapidly died in the soil as seen in Set B which had 94% of the sample germinable at commencement. Initial mortality rates were nearly 1% per day for a month, then became less, germination falling to 26% after 26 weeks. In the other two sets of seed it seems possible that death of nondormant seed would be concurrent with a progressive loss of dormancy and that the observed levels of germination represent a balance between the prevailing rates of the two processes. For example in Set C, which had less than 1% germinable seed at sowing, loss of dormancy proceeded at a rapid rate for at least the first nine months in the soil after which mortality rate was the greater. In Set A it is likely

Table 1. Rainfall (mm) and sampling months (A1–A8, B1–B7, C1–C12) at the experimental site, 1958 to 1967.

	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
January		0	58	20	91	26	27	0	85 ^{C10}	14
February		17 ^{A3}	19	3	13	1 ^{C3}	0 ^{C6}	0 ^{C8}	1	13 ^{C12}
March		15	0 ^{A6}	0 ^{B5}	159	19	0	0	2	
April		0	0	15	0	0	3	0	10	
May		54 ^{A4}	59	0	17	48 ^{C4}	17	0	0	
June		0	4	0	54	4	13	16	46	
July		3	0 ^{B1}	0	26	0	0	0	0	
August		0	0 ^{B2}	0	18 ^{C1}	0 ^{C5}	0 ^{C7}	4 ^{C9}	68	
September	0	0 ^{A5}	0 ^{B3}	0	0 ^{B7}	0	11	0	0 ^{C11}	
October	28 ^{A1}	10	25 ^{A7}	2 ^{A8} 2 ^{B6}	33	7	13	19	30	
November	62 ^{A2}	8	2	10	29 ^{C2}	3	5	16	12	
December	4	13	23 ^{B4}	1	6	10	18	42	13	
Year	—	120	190	51	446	118	107	97	267	—

that the balance resulted in the observed insignificant changes in germination percentages for the first eight months after which there was the major decline in dry soil.

Stored seed behaved similarly from both 35% and 0.8% initial germination. Note that Set B is the continuation of Set A from the 94% level.

Longevity

A small proportion of seed remained viable for 3, 2 and 4 years in the soil in A, B and C respectively, showing an approximate relationship to initial germinability. The behaviour of Sets B and C suggest that the early and relatively large changes in germinability were distinct from the later survival period, where a rise and fall in germination percentage occurred in buried seed after the major declines. Seed in dry storage showed an apparent "secondary dormancy" when germination percentages fell and rose again after reaching peak values. It seems likely that dormancy was lost more rapidly in soil than in storage and appreciable increases in germination percentages of stored seed occurred later than the major declines shown by buried seed. It is difficult to assess whether the long term survival in soil was due to a fraction of seed with a different dormancy condition rather than to resistant non-dormant seed. The natural death of seed in the soil contrasted sharply with the high germination percentages maintained in storage and emphasize the need to examine the germination behaviour of seed surviving under natural conditions.

It has been assumed here with buffel grass that all germinable seed responded when incubated at 30 C with adequate moisture for several weeks. In other species cases are known when the conditions required for successful germination distinctly changed with time in storage or in response to external stimuli (see, for example, Mayer and Poljakoff-Mayber, 1963; Koller, 1955b) and this possibility cannot be ruled out for buffel grass.

Conclusions

The survival of 10% of seed for 2 years should ensure a reasonable amount of germinable seed sown into dry soil and range seeding with buffel grass can be attempted in arid regions with infrequent and unpredictable establishment periods. The changes in germination percentages according to the proportions of dormant and non-dormant seed at sowing time will determine the desirable condition of seed lots for seeding only in those areas in which rainfall is predictable in the short term of one year or less. Both conclusions are based on the survival spans of the single collection of seed and their progeny used here. The survival of many naturalized stands of several varieties in

arid Australia for more than 50 years and many indigenous varieties in arid India and Africa suggests that seed longevity is common in the species. The rate of changes which might occur in other climatic areas and soils, and with other varieties or collections of a single variety cannot be predicted from this single exploratory study; prediction may come from the elucidation of the ageing processes in the embryo, seed coat and enveloping floral organs whilst in the soil and the effects of the micro-environment on the rates of change.

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