# TEMPERATURE, SEEDING DEPTH AND FERTILIZER EFFECTS ON GERMINATION AND EARLY SEEDLING GROWTH OF KIKUYU GRASS

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## ABSTRACT

*Controlled cabinet germination studies have shown that the optimum temperature for germination of kikuyu grass* (Pennisetum clandestinum) *seed was within the range 19-29°C. When germination rate was considered the optimum temperature was 29°C. The exposure of imbibing seeds to a temperature of 44°C for periods in excess of 12 hours resulted in a lower germination index but exposures of up to 48 hours had no significant effect on final germination.*

*Under non-limiting moisture and temperature conditions emergence from 3 cm was significantly lower than from 0 cm and 0.5 cm. Kikuyu seedlings showed a marked response to both nitrogen and phosphorus.*

*Under surface drying conditions surface sown seeds failed to germinate. There was no significant difference in emergence rates from depths ranging from 0.7 cm to 5.6 cm when seeds of the cultivar Whittet were used. The cultivar Breakwell differed in that emergence rates from depths of 2.8 cm and 5.6 cm were significantly lower than from depths less than 2.8 cm.*

## INTRODUCTION

Kikuyu grass (*Pennisetum clandestinum*) occurs naturally as a forest margin species in the highland plateaux of east and central Africa at elevations between 1,950 m and 2,700 m (Edwards 1935, Van Rensburg 1961, Barnard 1969, Morrison 1969). The soils where the grass is naturally distributed are often characterised by deep fertile lateritic red loams. In Australia kikuyu grass is often associated with *Paspalum dilatatum* and *Axonopus affinis*, kikuyu dominating in areas of high fertility (Mears 1970).

Considerable clonal variation exists in Australian accessions of kikuyu grass (Parker 1941, Wilson 1968). Two selections have recently been released as registered herbage plant cultivars. Whittet is a selection from introductions from Kenya made in 1960 and Breakwell is a selection from hermaphrodite material growing at Grafton (Barnard 1972).

To date there is no published literature on seed quality, germination conditions or seedling performance of kikuyu grass, but the availability of seed (Wilson 1970) has led to widespread interest in this highly productive grass.

This study was designed to collect basic information in the following areas—

(a) temperature effects on germination, including effects of high temperature on imbibed seed, and

(b) seedling performance from different sowing depths under varying conditions.

## MATERIALS AND METHODS

### *Experiment* 1

This experiment was concerned with the effect of constant temperatures on germination. Ten replicates, each of 100 seeds, of both Whittet and Breakwell were germinated in the dark at 9, 14, 19, 24, 29 and 34°C. Seeds were placed on

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germination pads in petri dishes and a seed was considered to have germinated when the length of the radicle exceeded the length of the seed. In addition to germination percentage, germination rate was measured and the two combined in a germination index (Maguire 1962) as follows—

$$\text{Index} = \frac{G1}{Y1} + \frac{G2}{Y2} \cdots\cdots\cdots + \frac{GN}{YN}$$

where G = number of seeds germinated on that day out of a total of 100 and Y = number of days from the start of the experiment.

Germination tests were terminated after 30 days or when there had been no germination for seven days.

*Experiment* 2

The effect of imbibition at high temperatures for varying periods of time was investigated using Whittet seed. Four replicates, each of 100 seeds, were allowed to imbibe at 44°C for 0, 6, 12, 18, 24, 48, 72 and 96 hours. The ninth treatment involved exposure to 44°C for 6 hours out of every 24 during the first four days (i.e. 0-6, 24-30, 48-54 and 72-78 hours).

After the high temperature imbibition periods the seeds were returned to a germination cabinet maintained at 24°C. Germination counts were made daily as for Experiment 1.

*Experiment* 3

Whittet was used in this experiment to study the effect of seeding depth and fertilizers on emergence and early seedling growth.

A red podzolic soil known to be low in phosphorus and sulphur (Havilah pers. comm.) was collected from the Grafton area of New South Wales. Two replicates, each of 100 seeds, were planted in a 3 × 3 × 3 factorial experiment. Three sowing depths (0, 0.5 and 3 cm) × three nitrogen levels (0, 112 and 448 kg $ha^{-1}$) as ammonium nitrate × three phosphorus levels (0, 22, 88 kg $ha^{-1}$) as mono calcium phosphate were combined and plants were harvested at 2 and 4 weeks from sowing and tops and roots separated. The soil was watered initially to 90% of field capacity and the seed trays placed in a glasshouse on an automatic misting bench where a fine spray of water maintained the soil in a moist condition. A mean temperature of 21°C was maintained throughout the experiment. Surface sown seeds were considered germinated where the radicle length equalled the seed length.

*Experiment* 4

The same soil was used as in Experiment 3 in this investigation into the effects of seeding depth on both cultivars under surace drying conditions. Four replicates, each of 50 seeds, were sown at depths of 0, 0.7, 1.4, 2.8 and 5.6 cm. The boxes were placed in a growth cabinet maintained at 24°C day/19°C night temperature, and were watered to field capacity every second day. This allowed the surface to dry out to simulate field conditions. Emergence counts were taken daily for 12 days after which time no further seedlings emerged. Data presented are final emergence figures.

## RESULTS

*Experiment* 1

Temperature effects on both final germination % (Figure 1) and germination index (Figure 2) for both Whittet and Breakwell were marked. Optimum temperatures for both cultivars, under controlled conditions, lay in the range 19-29°C. Germination rate was fastest in the 29°C treatment. Temperatures outside this range caused a marked drop in both germination percentage and rate.

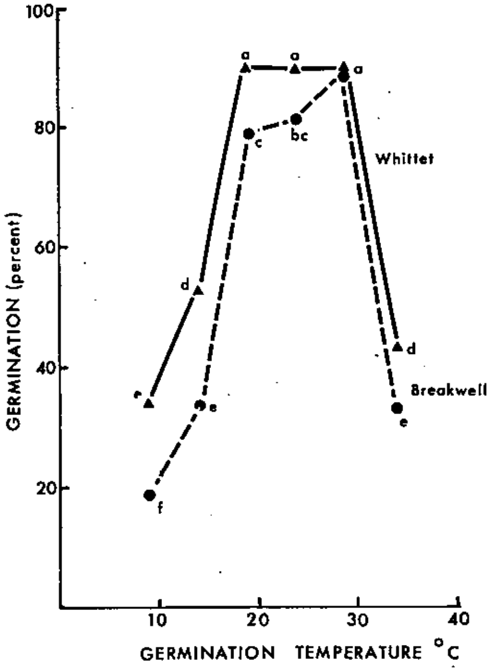


FIGURE 1
The influence of temperature on the final germination percentage of Whittet and Breakwell cultivars of kikuyu.

*Experiment* 2

Imbibition at high temperatures (44°C) for time periods of up to 48 hours had no significant affect on final germination (Table 1). Although periods in excess of 12 hours resulted in a decreased index figure, this appeared to be due more to a delay in the onset of germination rather than a lower rate *per se*. The multiple exposures resulted in a lower rate of germination although after termination of the treatment, the rate returned to normal.

TABLE 1

*The influence of time of imbibition at 44°C on the subsequent germination of kikuyu at 24°C*

| Imbibition time (Hrs) at 44°C | % Germination after return to 24°C 2 days | 30 days | Germination Index |
|---|---|---|---|
| 0 | 29 | 74 a | 34.9 n |
| 6 | 53 | 73 a | 36.8 m |
| 12 | 47 | 72 a | 34.5 n |
| 18 | 51 | 70 a | 32.0 o |
| 24 | 46 | 74 a | 30.7 o |
| 48 | 39 | 69 a | 25.7 p |
| 72 | 54 | 63 b | 22.8 q |
| 96 | 48 | 61 b | 20.1 r |
| 4 × 6 | 64 | 71 a | 25.6 p |

In all tables and figures treatment means identified by the same letter are not significantly different at the 5% level (Duncans Multiple Range Test).

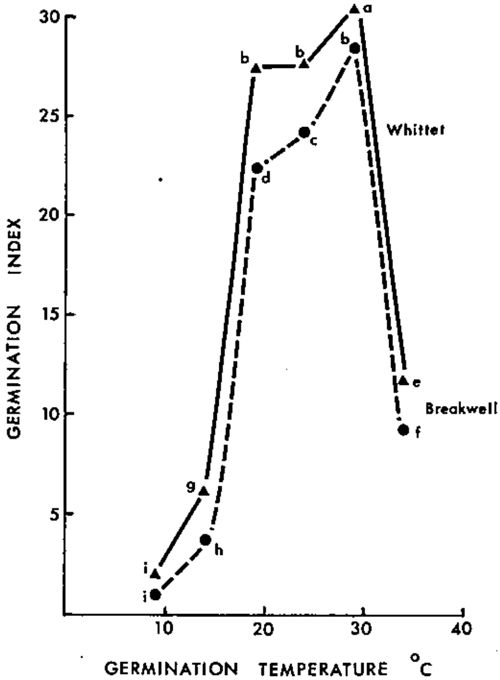


FIGURE 2
The influence of temperature on the germination index of Whittet and Breakwell cultivars of kikuyu.

### *Experiment* 3

Seeding depth had a significant effect on both the time to emergence and the final plant establishment (Figure 3). Surface sown seed, under these non-stress moisture conditions, were observed to swell and the seed coat to crack 40 hours after sowing. Emergence was delayed slightly from 3 cm (Figure 3). Final emergence from 3 cm (67%) was significantly lower ($P < 0.01$) than from 0 cm (74%) and 0.5 cm (75.2%). Fertilizer treatment had no significant effect on rate of mortality or final establishment.

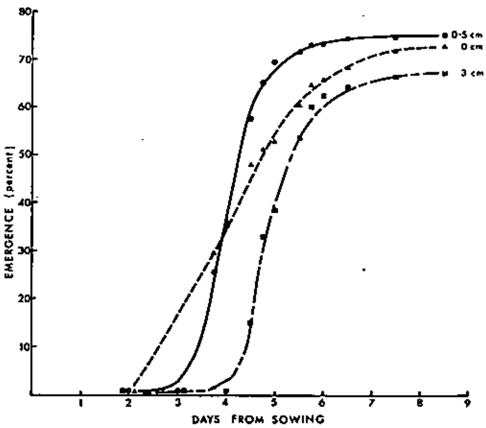


FIGURE 3
The effect of sowing depth on the emergence (%) of Whittet kikuyu.

No results of early growth for different seeding depths are presented as plant numbers were confounded with treatment yields. As root yields showed a similar pattern to shoot yields, data for the latter only are presented.

There was a significant response to both nitrogen and phosphorus (Table 2). Although 2 week-old plants were unable to utilize the heavier rates of nitrogen and phosphorus, the response to each and the interaction were significant 4 weeks after emergence.

TABLE 2

*The influence of nitrogen and phosphorus on the dry matter yield of 4 week old kikuyu seedlings*

| Phosphorus kg ha$^{-1}$ | Nitrogen (kg ha$^{-1}$) 0 | 112 | 448 |
|---|---|---|---|
| | | D.M. Yield (g box$^{-1}$) | |
| 0 | 0.14 a | 0.18 a | 0.19 a |
| 22 | 0.17 a | 2.27 b | 3.62 c |
| 88 | 0.22 a | 2.70 b | 4.48 d |

## *Experiment* 4

Neither Whittet nor Breakwell germinated from surface drying conditions in this experiment (Table 3). The emergence of Whittet was significantly greater than that of Breakwell from both the 2.8 and 5.6 cm depths.

TABLE 3

*The influence of sowing depth on the emergence of kikuyu under surface drying conditions*

| Sowing depth (cm) | Emergence at 12 days (%) Whittet | Breakwell |
|---|---|---|
| Surface | 0 a | 0 a |
| 0.7 | 82 d | 80 d |
| 1.4 | 86 d | 78 d |
| 2.8 | 81 d | 62 c |
| 5.6 | 80 d | 41 b |

## DISCUSSION

There are few reports in the literature of studies on the effects of temperature upon germination of tropical grasses. McWilliam, Shanker and Knox (1970) reported that *Hyparrhenia hirta*, a species of Mediterranean adaption but with temperature response curves more characteristic of tropical species, germinated well over a temperature range of 10–40°C. However, rates were low at temperatures below 25°C. Other reports state optimum temperatures (Table 4) rather than indicating responses to different temperatures. Some tropical species appear to germinate better when subjected to alternating rather than constant temperatures (Prodanoff 1967), although the range covered is similar to the optimum for kikuyu.

Soil temperatures as high as 45°C have been reported for red loam soils in northern New South Wales and in Queensland (Crofts 1957; Bowen and Kennedy 1959). Kikuyu seed was relatively insensitive to similar temperatures during imbibition and during other germination stages (Hughes 1970). The tropical legume

TABLE 4

*Optimum temperatures for germination of some tropical species*

| Species | Optimum temperature | Author |
|---|---|---|
| *Panicum coloratum*<br>*Panicum maximum*<br>*Paspalum dilatatum*<br>*Cenchrus ciliaris*<br>*Chloris gayana*<br>*Setaria sphacelata* | 20-30°C A* | Prodanoff (1967) |
| *Cynodon dactylon* | 15-38°C A | Moringa (1926) |

*A = alternating temperatures (i.e. night/day)

glycine (*Glycine wightii*) has been shown to be much more sensitive to these temperatures during germination (Murtagh 1970). Hence, providing soil moisture is adequate, kikuyu can be sown during periods when soil temperatures are in excess of 20°C.

The germination percentages in the experiments were much higher than those commonly experienced with many tropical species (Anon 1970). The rates of germination were surprisingly high in view of reports of hard seededness (Younger 1961). However, the harvesting procedure used may have had a scarifying effect on the seed (Wilson 1970). A similar scarification process is believed to take place when kikuyu seed passes the bovine alimentary tract (Mears 1970).

The optimum sowing depth for any species appears to depend on both soil type, particularly structure, and soil moisture regimes (Bogdan 1964). Variations in soil moisture can influence the composition of the soil gaseous phase which, in turn, influences germination (Mayer and Poljakoff–Mayber 1963). These soil moisture effects are the most probable causes of the discrepancies in emergence rates between Experiments 3 and 4.

If seed placed on the soil surface is to germinate, water gain must exceed water loss. To do this, the seed must make good contact with available water, the soil moisture tension must be low or the rate of water loss from the seed to the atmosphere must be lowered by increased humidity (Harper and Benton 1966). In their study, Harper and Benton found that seeds with smooth testas, a small area of contact, and producing no mucilage (i.e. Kikuyu type seeds) did not germinate when placed on sintered glass plates at water tensions of 50 cm or greater. Surface sowing of kikuyu is therefore unlikely to succeed.

Nutrient reserves in the germinating seedling are depleted within about a week and, for the plant to survive, nutrients must then be available in the soil solution (Anslow 1962; McWilliam, Clements and Dowling 1970). Nutrient levels in the soil solution will depend upon both the soil type and the fertilizer added. The actual levels required will depend upon the species. These experiments have shown that kikuyu seedlings are strongly responsive to high levels of nitrogen and phosphorus. Mears (1970), in his review, documented the response of kikuyu pasture to nitrogen and phosphorus. There appears to be considerable variation in nutrient requirements for seedlings of various tropical grasses. Buffel grass (*Cenchrus ciliaris*) and Birdwood grass (*Cenchus setigerus*) have shown large responses to phosphorus, and to nitrogen in the presence of phosphorus (Humphreys 1959). *Setaria sphacelata* (cv. Kazungula) has been found to be very competitive for phosphorus, nitrogen and potassium and can establish on soils where deficiencies have been shown using other species (Mears 1968; Blunt and Humphreys 1970).

The differences between Whittet and Breakwell in these experiments were small and may have been due as much to environmental and management influences acting on the parent plants as to any inherent varietal differences.

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