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Germination characteristics of the grass weed *Digitaria nuda* (Schumach.)

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ABSTRACT

The effect of various pre-treatments and their interaction with temperature on cumulative percentage and the rate of germination were evaluated for *Digitaria nuda*. Stored and fresh seeds were pre-treated with either 0.02 M KNO_3, soaked in water for 24 h (priming), sterilized with 0.5% NaOCl or heat treated at 60 °C. Seeds were germinated at constant temperatures of 25 and 30 °C and fluctuating temperature regimes of 25/10 and 30/15 °C. The effect of pre-chilling on germination of stored and fresh seed was evaluated at 30/15 °C, and seed emergence in two soil types at different burial depths (0, 0.5, 1, 2, 3, 4, 5 and 6 cm) was also determined. The pre-treatment of stored seed with KNO_3 resulted in the highest germination percentage (100%), whereas the pre-treatment of fresh seed with water for 24 h gave the best germination (99%), at constant temperatures of 25 and 30 °C. Pre-chilling of seed increased germination by more than 30%. Emergence from clay loam soil was greater compared with the emergence from sandy loam soil. Total seedling emergence decreased exponentially with increasing burial depths with only 5% of seed germinating from a burial depth of 6 cm. Results from this study showed that germination requirements are species specific and knowledge of factors influencing germination and emergence of grass weed seed can assist in predicting flushes in emergence allowing producers to implement control practices more effectively.

1. Introduction

Digitaria nuda (Schumach.), commonly known as naked crabgrass, is a relatively unknown *Digitaria* grass species in South African cropping systems. It has recently been positively identified in maize fields in the Free State and North-West Provinces of South Africa. Although *D. nuda* is listed as a weed occurring in crop fields in South Africa, and other countries to the north in Africa, very little information about the ecology and biology of this *Digitaria* grass species is available to establish its weed status and impact on crops (Botha, 2010; Bromilow, 2010; Gerbrandt, 1985).

Various taxonomic identification keys (Barkworth et al., 2003; Launert and Pope, 1989; Webster, 1983) have demonstrated the morphological similarities between *D. nuda* and the more common *Digitaria sanguinalis* (L) Scop. (large crabgrass) and *Digitaria ciliaris* (Retz.) Koeler (southern crabgrass). The most distinguishable characteristic with which to identify these *Digitaria* spp. correctly can, however, only be seen on the seed when grasses are physiologically mature, making it extremely difficult to distinguish at the seedling stage. *D. sanguinalis* has a very distinct lower glume on the lower lemma and also has some spicules on the lateral veins of the lower lemma. *Digitaria nuda* has no lower glume on the lower lemma in most cases, and if visible, it is only a slight shrivel of a glume. The lower lemma is also very smooth with no spicules on the lateral veins, hence the common name "naked crabgrass". *D. ciliaris* also has an inferior lower glume on the lower lemma, but the lower lemma is smooth like that of *D. nuda* and the upper lemma is longer. Kok (1984) and Kok et al. (1989) made a systematic description of the *Digitaria* section in southern Africa and presented five species; including *D. acuminatissima* (Stapf) and *D. nuda* that were not previously recorded. They found that *D. nuda* only occurred in the north-eastern regions of KwaZulu-Natal and Mpumalanga since it prefers more tropical environments, but it was suggested that this species could be more wide-spread due to incorrect identification.

Research on the weed status of *Digitaria* spp. was mostly done on large crabgrass in South Africa (Wells et al., 1980). In field germination studies *D. sanguinalis* is one of few weeds that can germinate throughout the summer growing season with a germination peak two weeks later than most of the common weeds found in maize fields (Du Toit and Le Court De Billot, 1991). Competition of grass infestations, which were dominated by large crabgrass and African goosegrass (*Eleusine coracana* subsp. Africana (K.-O'Byrne) Hilu & De Wet), reduced maize yield up to 70%, and was more severe than *Cyperus esculentus* (L.) (yellow nutsedge) infestations (Jooste and Van Biljon, 1980). *D. sanguinalis* is, however, known to develop high infestations and cause severe competition problems in various crops world-wide (Aguyo and Masiunas, 2003; Forcella et al., 1992; Fu and Ashley, 2006; Kim et al., 2002; King and Oliver, 1994; Monks and Schultheis, 1998). *D. nuda* has been identified as a troublesome weed in West African

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countries and Brazil, especially in sugarcane production (Chikoye et al., 2000; Dias et al., 2005). Prior research on *D. nuda* is limited to its taxonomy while its biology and germination ecology are unknown and cannot be inferred from research on other *Digitaria* spp.

Specific requirements for effective germination often differ amongst related weed species and a slight variation in environmental conditions can increase or decrease the rate of their emergence (Hartzler et al., 1999). Knowledge on the biology and germination characteristics of weeds can be an important tool when implementing integrated weed control strategies, and can be used to prevent significant numbers of new weed seeds being added to the soil seed bank (Chauhan and Johnson, 2009; Hartzler et al., 1999). Initial germination and the consistency of emergence of a species can support the decision making process for producers for optimal timing of tillage and herbicide applications. Temperature and soil water content are two of the most important factors influencing germination and emergence of weed species (Chauhan et al., 2006; Ghorbani et al., 1999). The germination characteristics of *D. sanguinalis* and *D. ciliaris* have been extensively studied (Chauhan and Johnson, 2008a, 2008b; Gardner, 1996; Halvorson and Guertin, 2003), but no such studies exist for *D. nuda*.

Preliminary germination tests on *D. nuda* showed very poor germination (<20%) and seed dormancy is expected to be the main reason. Most grass species exhibit some form of dormancy where low germination percentages are experienced despite prevailing favorable conditions. Several treatments that promote or enhance germination can be used to break physiological dormancy and have been used to do so in *D. sanguinalis* and *D. ciliaris* (Chauhan and Johnson, 2008a, 2008b; Gallart et al., 2008; Moreno and McCarty, 1994).

The objectives of this study were to determine germination characteristics of *D. nuda* utilizing various pre-treatments aimed at breaking dormancy and increasing seed germination using constant and fluctuating temperature regimes in order to identify optimal germination conditions for each of the pre-treatments. Knowing the optimum temperature range in which a specific weed species germinates could shed light on the biology of such a species and can be useful in predicting significant flushes of emergence, leading to more pro-active and practicable control measures. Furthermore, the influence of soil type and seed depth below the soil surface was also investigated to determine the effects on seedling emergence.

2. Materials and methods

2.1. Seed collection

D. nuda seed was collected annually from physiologically mature plants during March and April from 2007 to 2011 at the research station of the ARC-Grain Crops Institute, Potchefstroom (North-West Province, 26°43′41.9″ S, 27°04′47.8″ E). Since *D. nuda* is a relatively unknown grass species in South Africa, at least with regard to its distribution, racemes sampled in each year were sent to the National Herbarium of the South African National Biodiversity Institute to be positively identified. After collection, seed was left to dry in a glasshouse at 30/15 °C (day/night) temperature range for two weeks. Seed was removed from racemes by hand and cleaned from inert material to obtain experimental samples. Samples of each year were kept separate and stored in air-tight plastic containers at 15 °C. Seed properties are summarized in Table 1.

Table 1
Seed properties of *D. nuda* collected in Potchefstroom from 2007 to 2011.

Seed year collected	Seed mass ($g \cdot 100^{-1}$)	Pure seeds[a]	Caryopsis present[b]	Viable seed[c]
		%		
2007	0.189	94	43	28
2008	0.199	98	59	50
2009	0.188	91	31	14
2010	0.248	96	57	58
2011	0.292	94	78	49

[a] Seeds of *D. nuda* per sample.
[b] Intact, germinable seeds.
[c] Viable seeds determined with tetrazolium tests.

2.2. Germination tests

Germination tests were done using both 1-year old seed (harvested in 2010) and fresh seed (harvested in 2011) of *D. nuda* to compare germination. Seed harvested during 2010 was stored in air-tight plastic containers at 15 °C following drying until commencement of germination tests in 2011. Five different seed pre-treatments to enhance germination of *D. nuda* were applied to both stored (1-yr old) and fresh seed: 1) KNO_3 applied at 0.02 M in place of distilled water, 2) immersing (priming) seed for 24 h in distilled water (water 24 h), 3) sterilization in 0.5% NaOCl solution for 10 min followed by rinsing with distilled water, 4) heat treatment of seed in brown paper bags at 60 °C for 24 h (heat treatment), and 5) control treatment where seed was not pre-treated.

One hundred seeds of *D. nuda* were placed separately in polyethylene containers (22 × 15 × 5.5 cm) on brown Anchor germination paper (once folded) for each treatment, which was replicated four times (total of 400 seeds per treatment). Distilled water (13 ml) was added to the germination paper to provide moisture, except where KNO_3 was used. Since temperature can play a major role in the germination of grass seed, all germination treatments were repeated at constant temperatures of 25 and 30 °C, and fluctuating temperature regimes of 25/10 and 30/15 °C using growth chambers with day/night (14 h light/10 h dark) conditions. These temperatures and day/night light regimens were chosen to reflect temperature and diurnal variation in maize-producing areas in South Africa where *D. nuda* and *D. sanguinalis* commonly occur as troublesome weeds in maize fields (Table 2). Germinated seeds were counted and removed when a white protrusion of the radicle was observed. The duration of each trial was 30 days.

2.3. Effect of pre-chilling

Minimum temperatures during winter months in areas where *D. nuda* occur fluctuate between 0 and 10 °C, with frost occurring regularly. *D. nuda* seed from stored (1-yr old) and fresh samples was pre-chilled for three months at 4 °C after which germination tests were carried out as described above. Germination tests were, however, only done at the fluctuating temperature regime of 30/15 °C (14 h light/10 h dark) in a growth chamber, thus simulating seasonal temperature fluctuations.

2.4. Data analysis of germination trials

A split–plot factorial analysis was done on data with temperatures (4 factors) as whole plots, and treatments and seed age (5 × 2 factors) as sub-plots. The means of significant interaction effects were compared

Table 2
Average 10-year maximum and minimum temperatures for four South African localities where severe *D. nuda* infestations had been reported.

Locality	Potchefstroom		Viljoenskroon		Bothaville		Wesselsbron	
GPS co-ordinates	27°04′31.91″ S 26°43′50.18″ E		26°54′32.29″ S 27°10′45.05″ E		26°40′55.88″ S 27°18′12.31″ E		26°26′30.69″ S 27°41′27.85″ E	
	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin
	°C							
Early[a]	28.80	13.46	29.86	11.56	30.28	9.62	29.79	11.92
Mid	29.05	16.51	30.72	15.6	30.15	15.2	31.03	15.76
Late	29.08	15.02	29.01	13.86	28.29	13.8	28.94	14.19

[a] Crop growth season was divided into early season (Oct to Nov), mid-season (Dec to Jan) and late season (Feb to March).