

Potassium nitrate to overcome dormancy of *Urochloa humidicola* Comum seeds

Nitrato de potássio na superação da dormência de sementes de *Urochloa humidicola* Comum

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Highlights

Seeds of *Urochloa humidicola* exhibit a high percentage of dormancy.

Immersion of seeds in KNO₃ solution overcomes dormancy and promotes germination.

U. humidicola seeds must be immersed in 4% solution of KNO₃ for 24 h before sowing.

Abstract

The main difficulty with propagating *Urochloa humidicola* Comum is the high percentage of seed dormancy. Thus, the objective of this study was to develop a treatment to overcome seed dormancy and promote seed germination of this species that can be applied at a large scale. This study was conducted in two stages. First, the following treatments were evaluated using one seed lot: control (without treatment), immersion in H₂SO₄ (98%, 36N) for 10 min, moistening the germination substrate with KNO₃ (0.2%) and immersion in KNO₃ at concentrations of 0%, 2%, 4%, 6%, and 8% for periods of 12, 24, 36, and 48 h, followed by drying in the shade. In the second stage, three seed lots were evaluated in all of the aforementioned treatments, except for those of immersion in 0% KNO₃ and of all concentrations for 36 and 48 h. The seeds were evaluated for water content, germination, percentage of abnormal seedlings, dead and dormant seeds, first count, and average germination time. Immersion in the KNO₃ solution was efficient in overcoming dormancy and promoting germination. To be used by companies, the immersion of seeds in a 4% KNO₃ solution for 24 h was the most suitable treatment to overcome dormancy and promote the germination of *U. humidicola* Comum seeds.

Key words: *Urochloa humidicola*. Quicúio grass. Forage. Germination. KNO₃. Physiological potential.

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Resumo

A principal característica que dificulta a utilização das sementes de *Urochloa humidicola* cv. Comum é a alta porcentagem de dormência. Assim, o objetivo do trabalho foi obter um tratamento para a superação da dormência e promoção da germinação das sementes desta espécie passível de aplicação em grande escala. O trabalho foi conduzido em duas etapas. Na primeira, foram avaliados em um lote de sementes os seguintes tratamentos: testemunha (sem tratamento), imersão em H_2SO_4 (98%, 36N) por 10 minutos, umedecimento do substrato de germinação com KNO_3 (0,2%) e imersão em KNO_3 nas concentrações de 0, 2, 4, 6 e 8% por períodos de 12, 24, 36 e 48 horas, seguida por secagem à sombra. Na segunda etapa, foram avaliados em três lotes de sementes todos os tratamentos supracitados, exceto a imersão em KNO_3 0% e todas as concentrações nos períodos 36 e 48 horas. As sementes foram avaliadas quanto ao teor de água, germinação, porcentagem de plântulas anormais, sementes mortas e dormentes, primeira contagem e tempo médio de germinação. A imersão em solução de KNO_3 é eficiente para a superação da dormência e promoção da germinação. Visando a utilização pelas empresas, a solução de KNO_3 4% por 24 horas é o tratamento mais indicado.

Palavras-chave: *Urochloa humidicola*. Capim quicuiu. Forrageira. Germinação. KNO_3 . Potencial fisiológico.

Introduction

Urochloa humidicola (Rendle) Morrone & Zuloaga is an efficient forage which protects against soil against erosion by producing a large number of stolons (Alves et al., 2017). This species has greater tolerance than other *U.* species to acidic, low-fertility, and poorly drained soils, it shows resistance to intense grazing and has a greater capacity for establishment in new areas (Alves et al., 2017; Euclides et al., 2010).

For the formation of pastures, it is necessary to use seeds of high physical and physiological quality. However, the seeds of *U. humidicola* exhibit a high percentage of dormancy (above 40%), and this state persists for periods greater than 12 months (Costa, Araújo, & Villa Bôas, 2011; Libório et al., 2017). In the field, dormancy causes variation in the emergence of seedlings, impairing the establishment of pastures, and favoring the invasion of weeds (L. Martins & Silva, 2001).

The main strategy adopted by companies to overcome the dormancy of *U. humidicola* seeds in commercial production is storage for years; however, this procedure represents a higher production cost with storage and an obstacle to logistics (Costa et al., 2011). One of the possible causes of dormancy in species of the genus *Urochloa* is the restriction of gas exchange because of the presence of glume, palea, and lemma (Binotti, Sueda, Cardoso, Haga, & Nogueira, 2014). These structures can be removed by scarification with sulfuric acid (H_2SO_4) (Ministério da Agricultura, Pecuária e Abastecimento [MAPA], 2009). However, some authors have found that this treatment has a detrimental effect on seed viability, in addition to presenting risks to workers and the environment (Verzignassi et al., 2013; Moreira, 2014).

This dormancy can also be overcome by the application of substances that contain radicals, such as NO^{-3} (nitrate) or NO^{-2} (nitrite), because they have an oxidizing action and

act on physiological processes, causing the biosynthesis of new compounds and starting the germination process of seeds (Cardoso, Sá, Haga, Binotti, & Costa, 2015) by activating an anaerobic pathway, the pentose-phosphate pathway, which initiates metabolic reactions in the Krebs cycle. Consequently, this provides the energy supply for the germination process (N. M. Carvalho & Nakagawa, 2012). Sowing on a substrate moistened with a solution (0.2%) of potassium nitrate (KNO_3) is a method recognized for its efficiency in overcoming the dormancy of several species of forage grasses. However, its application is restricted to the installation of tests under laboratory conditions, because it is not feasible under field conditions (C. C. Martins & Silva, 1998; L. Martins & Silva, 2001; MAPA, 2009).

To determine the favorable effects of KNO_3 in overcoming dormancy and promoting germination, some researchers have immersed grass seeds in this solution, dried them, and sown them later, thereby obtaining promising results (Binotti et al., 2014; Libório et al., 2017; C. C. Martins, Velini, & Martins, 1997). However, there are still uncertainties regarding the best concentration of the KNO_3 solution and the immersion time for each species and cultivar. Thus, the objective of this study was to ascertain a treatment to overcome dormancy and promote germination of *U. humidicola* Comum that can be applied by companies.

Material and Methods

The research was conducted with three seed lots of *U. humidicola* Comum in the Seed Analysis Laboratory of the Department of Plant Production of the University of Agricultural and Veterinary Sciences of UNESP, Jaboticabal

Campus. Seeds were subjected to a pneumatic blower for cleaning and subsequently to manual picking to obtain a portion of pure seeds for the application of treatments from which to conduct the performance analysis.

The study was conducted in two stages. First, one of the lots was submitted to the following treatments: ST, absolute control wherein the seeds had no treatment; T KNO_3 sowing seeds in a substrate moistened with 0.2% KNO_3 solution; T H_2SO_4 , the immersion of seeds in H_2SO_4 (98%, 36N) for 10 min, followed by washing in running water for 3 min, removing surface moisture with absorbent paper, and drying in the shade on paper towels sheets at 25 °C for 24 h; immersion treatments in KNO_3 solution at concentrations 0% (distilled water), 2%, 4%, 6%, and 8% for periods of 12, 24, 36, and 48 h, followed by drying in the shade on paper towels at 25 °C for 24 h (L. Martins & Silva, 2001; Torres et al., 2016; Verzignassi et al., 2013). The immersion treatments that proved to be more efficient in overcoming dormancy and promoting seed germination were applied to three seed lots, together with the controls, in the second stage of the experiment.

For immersion in KNO_3 , 2 g of seeds were used in 40 mL of the solution inside a transparent 180 ml plastic cup, which was maintained at 25 °C for the pre-established periods. After the immersion period, seeds were removed from the solution and placed on paper towels to dry in the shade at 25 °C for 24 h. The seeds were evaluated using the following tests and analyses.

Water content was determined using the oven drying method at 105 °C immediately after the application of the treatments and before the germination test with two subsamples of 0.5 g of seeds at 105 ± 3 °C for

24 h (MAPA, 2009). Germination was conducted using four subsamples of 50 seeds sown on two sheets of germination test paper moistened with 2.5 times the weight of the paper placed in transparent plastic boxes with a lid (11.0 × 11.0 × 3.5 cm) and maintained under an alternating temperature of 20-35 °C and photoperiod of 8 h (MAPA, 2009). Seedlings were counted daily after the beginning of germination until the 21st day after sowing. The percentage of normal and abnormal seedlings were calculated.

Tetrazolium was used for the identification and counting of dormant and dead seeds. The remaining seeds in the germination test were cut in half in the longitudinal direction, and one of the halves was immersed in a solution of 0.1% 2,3,5 triphenyl tetrazolium chloride at 37 °C for 3 h. After this period, the embryos were evaluated using a magnifier (10× magnification) with LED lighting, and the results were expressed as a percentage (MAPA, 2009).

The first germination count was conducted together with the germination test by counting the normal seedlings present on the fifth day after sowing, and the results were presented as a percentage (Silva, Martins, Cruz, Jeromini, & Bruno, 2017). Average germination time (AGT) was performed with the germination test and was conducted by applying a previously described method (D. B. Carvalho & Carvalho, 2009).

The data obtained were analyzed using a completely randomized experimental design (CRD) in a 5 × 4 + 3 factorial scheme (concentrations of KNO₃ × periods + controls) with four replications in the first stage of the research, and 11 × 3 (treatments × lots) with four repetitions in the second stage. For the factors germination, abnormal seedlings, dead

and dormant seeds, and the first germination count, data were transformed using arcsine $(x/100)^{1/2}$ to meet the assumptions of the tests of normality and homogeneity of variance using the Shapiro-Wilk test. The treatment means were subjected to an analysis of variance using the F test and compared by the Tukey test at 5% probability using Agroestat software (Barbosa & Maldonado, 2015). The averages presented in the tables are the percentages of the original data. Data regarding the water content of the seeds were not evaluated statistically.

Results and Discussion

First stage of the research

The water content of the seeds obtained immediately after the application of the treatments ranged from 13.2% (control) to 54.4%. In immersion treatments, the lower the concentration of the solution, the greater the hydration of the seeds. For concentrations of 0%, 2%, 4%, 6%, and 8% KNO₃, the average values of water content were 50.8%, 47.0%, 46.0%, 45.3%, and 40.9%, respectively. Scarification in sulfuric acid resulted in a water content of 24.9% in the seeds.

The presence of salts reduced the water potential of the solution by restricting water uptake by the seed (Lopes & Macedo, 2008). Thus, with the increase in the concentration of KNO₃ in the solution, there was an increase in osmotic pressure and less water absorption by the seeds (Dias et al., 2016). The increase in hydration observed in H₂SO₄ scarified seeds occurred because of the rupture of the physical barrier caused by acid on the seed lining structures, favoring the absorption of water after rinsing (Tomaz, Martins, Silva, &

Vieira, 2016). Although there was substantial variation in the water content of the seeds immediately after the treatments, drying for 24 h before the installation of the quality tests allowed for uniformity of the values, which were between 7.5% and 8.9%. Thus, the evaluations could be conducted without interference from the hydration levels of the seeds (MAPA, 2009; Melo, Martins, Silva, Boneti, & Vieira, 2016; Steiner, Oliveira, Martins, & Cruz, 2011).

The analysis of variance showed significant effect of both the concentration and the period of immersion in the solution for dormant seeds (Table 1). For germination, dead seeds and AGT the interaction between concentration and immersion period was statistically significant (Table 2), and for abnormal seedlings and the first count test (Table 3), only the isolated effect of the concentration of the KNO_3 solution was significant. The high coefficient of variation could be explained by the variability of the treatments tested and the differences in the quality of the lots.

The effect of seed immersion treatments in KNO_3 solution on dormancy is presented in Table 1. It was observed that,

when compared to water immersion (KNO_3 0%), KNO_3 solutions at all concentrations reduced dormancy between 92% and 96% (38.4% and 40.2%, respectively), and immersion for periods greater than 24 hours gave the best results to overcome dormancy with an average percentage of 9.2%.

For germination, seed immersion in KNO_3 for 12, 24, and 36 h was the most favorable for all concentrations equal to or greater than 2% (Table 2), with values between 59% and 72%. In contrast, in a previous study (Libório et al., 2017) seed immersion treatment of *U. humidicola* BRS Tupi in KNO_3 solution at concentrations below 1% did not yield promising results.

The positive results of treatments with KNO_3 suggest that a possible cause of the dormancy in this species is the restriction of gas exchange. After being absorbed, nitrate acts in the formation of NADP^+ , stimulating respiration through the pentose-phosphate pathway, which does not require oxygen; thus, dormancy is overcome by energy production to begin the germination process (Marcos, 2015).

Table 1
Dormant seeds (D) of *Urochloa humidicola* Comum as a function of KNO₃ solution immersion treatments applied in the first stage of the research.

Concentration KNO ₃	D (%)
0%	41,8 b
2%	3,4 a
4%	2,9 a
6%	1,6 a
8%	1,8 a
MS	3665,20**
CV (%)	39,05
Period	D (%)
12h	13,7 b
24h	9,2 a
36h	8,9 a
48h	9,5 a
MS	221,37**
CV (%)	39,05

Means followed by the same lowercase letter in a column for each parameter do not differ statistically by the Tukey test ($P > 0.05$). Data were transformed by arcsine $(x/100)^{1/2}$ and original means are presented.

MS: Mean square; CV: Coefficient of variation; *, **: indicate significant difference by the F test ($P \leq 0.05$ and $P \leq 0.01$, respectively).

Table 2

Germination (G), dead seeds (M), and average germination time (AGT) of seeds of *Urochloa humidicola* Comum as a function of KNO₃ solution immersion treatments applied in the first stage of the research

	KNO ₃ Concentration	Period			
		12h	24h	36h	48h
G ¹ (%)	0%	23,5 bAB	14,3 bB	34,8 bA	24,0 cAB
	2%	63,3 aA	66,0 aA	69,8 aA	61,0 aA
	4%	72,0 aA	66,0 aAB	65,3 aAB	49,8 abB
	6%	70,8 aA	69,3 aA	58,3 aA	40,5 bB
	8%	68,8 aA	66,3 aAB	59,3 aAB	51,5 abB
MS		84,24**			
CV (%)		11,48			
M ¹ (%)	0%	27,3 aAB	36,8 aB	20,0 aA	30,5 aAB
	2%	23,5 aA	27,5 aA	28,3 abA	34,0 aA
	4%	20,0 aA	32,0 aAB	33,3 abB	45,3 abB
	6%	18,3 aA	29,8 aAB	39,5 bB	57,0 bC
	8%	27,8 aA	28,8 aA	34,5 bAB	45,0 abB
MS		76,69**			
CV (%)		14,27			
AGT (days)	0%	10 bAB	11 bB	9 aA	10 bAB
	2%	8 aA	7 aA	7 aA	8 aA
	4%	7 aA	8 aAB	8 aAB	9 abB
	6%	9 abAB	8 aA	8 aA	10 bB
	8%	8 aA	8 aA	9 aAB	11 bB
MS		3,33**			
CV (%)		11,88			

Means followed by the same lowercase letter in a column and uppercase in each row for each parameter do not differ statistically from each other by the Tukey test ($P > 0.05$).

¹: Data transformed into the arcsine of the square root of $x/100$ and original means are presented.

MS: Mean square; CV: Coefficient of variation; *, **: indicate significant difference by the F test ($P \leq 0.05$ and $P \leq 0.01$, respectively).

Table 3
Abnormal seedlings (A) and first count of germination (FC) of seeds of *Urochloa humidicola* Comum as a function of KNO₃ solution immersion treatments applied in the first stage of the research.

Concentration KNO ₃	A	FC -----%-----
0%	5,4 b	1,3 b
2%	3,3 ab	12,0 a
4%	1,3 a	9,1 ab
6%	2,5 ab	5,0 ab
8%	2,8 ab	2,8 b
MS	100,63*	492,69**
CV (%)	62,44	110,78

Means followed by the same lowercase letter in a column do not differ statistically from each other by the Tukey test ($P > 0.05$). Data transformed by arcsine $(x/100)^{1/2}$ and the original means are presented.

MS: Mean square; CV: Coefficient of variation; *, **: indicate significant difference by the F test ($P \leq 0.05$ and $P \leq 0.01$, respectively).

The percentage of germinated and dead seeds after water immersion (KNO₃ 0%) for the different periods showed fluctuations in the values. Because the seeds of this species are not restricted from water absorption (Libório, Verzignassi, Fernandes, & Lima, 2018), more physiological studies are necessary to better explain the oscillation of the effect of the periods of immersion at this concentration. This effect was also observed in the AGT. For the KNO₃ solutions, at all concentrations, the seed immersion periods 12 and 24 h were least harmful. Higher seed mortality was observed with immersion times longer than 36 h and at concentrations above 4% (Table 2).

The immersion of the seeds in KNO₃ solution at concentrations higher than 2% between 12 and 36 h reduced the AGT. After these treatments, the seeds took 7 and 9 days to germinate, whereas seeds immersed for 48 h required up to 11 days to germinate.

Based on data from dead seeds and AGT, there was a deleterious effect on seed quality, the higher the concentration and the longer the period of immersion in the KNO₃ solution. This fact can be attributed to the phytotoxic effect that salts can have on seeds (Schossler, Machado, Zuffo, Andrade, & Piauilino, 2012). In addition to influencing water absorption by seeds, ions can be assimilated and accumulated in the protoplasm of cells, causing the destruction of enzymes and membranes, which can damage the embryos (Betoni, Scalón, & Mussury, 2011; Oliveira, Matias, Silva, Ribeiro, & Dantas, 2014). Additionally, seed treatments conducted for shorter periods have positive economic implications for producing companies, because they allow a reduction in the time needed for treatment, increasing the yield of the production system and improving the processing, commercialization, and distribution of the seeds (Tomaz et al., 2016).

The immersion of *U. humidicola* seeds in water (KNO₃ 0%) resulted in a higher rate of abnormal seedlings and lower germination speed in the first count test (Table 3). However, for both tests, the treatments that exceeded immersion in water were only KNO₃ at 4% and 2%. The deleterious effect of immersion in water on these variables may have been caused by hypoxia, which compromises cell metabolism and results in loss of the physiological potential and viability of the seeds (Gazola, Zucareli, & Camargo, 2014).

The seeds without treatment had the highest percentage of dormancy (Table 4). Sowing in a substrate moistened with KNO₃ and the scarification of the seeds with H₂SO₄ were equally efficient in overcoming dormancy. However, scarification with H₂SO₄ caused the death of the seeds, and the breakage of dormancy was not reversed with an increase in the production of normal seedlings. Therefore, seeds placed in substrate moistened with KNO₃ to germinate exhibited the highest germination percentages.

Table 4

Dormant seeds (D), dead seeds (M), germination (G), abnormal seedlings (A), first count (FC), and average germination time (AGT) of seeds of *Urochloa humidicola* Comum of controls without treatments (ST), substrate moistened with 0.2% KNO₃ (T KNO₃) and scarification of the seeds with H₂SO₄ (T H₂SO₄).

Controls	D ¹	M ¹	G ¹	A ¹	FC ¹	AGT (days)
	-----%-----					
ST	51,8 b	19,3 a	26,0 c	3,0 a	0,0 a	11,0 b
T KNO ₃	6,0 a	14,0 a	75,0 a	4,5 a	4,5 a	10,0 ab
T H ₂ SO ₄	3,0 a	36,0 b	54,0 b	7,0 a	1,5 a	8,5 a
MS	1576,15**	270,31**	889,02**	28,66 ^{NS}	43,61 ^{NS}	6,33**
CV (%)	39,05	14,27	11,48	62,44	110,78	11,88

Means followed by the same lowercase letter in a column do not differ statistically from each other by the Tukey test ($P > 0.05$). ¹: Data are transformed by arcsine $(x/100)^{1/2}$ and original means are presented.

MS: Mean square; CV: Coefficient of variation; *, **: indicate significant difference by the F test ($P \leq 0.05$ and $P \leq 0.01$, respectively); ^{NS}: indicates that there was no significant difference by the F test ($P \leq 0.05$).

Regarding the germination speed, the seeds without treatment showed the highest AGT, with a higher value than those scarified with H₂SO₄. However, the average times of these treatments did not differ from that obtained for seeds germinated in substrate moistened with KNO₃ (0.2%).

Second stage of the research

Based on the results of the first stage, treatments with concentrations between 2% and 8% and immersion periods of 12 and 24 h were those with the highest germination and the lowest percentage of dead and dormant seeds. Therefore, these were selected for replication in the three seed lots of *U. humidicola* along with the three control treatments.

Similar to that observed in the first stage, the water content of the seeds immediately after chemical scarification and immersion in KNO_3 solution was higher. This occurred independently of the lot, the concentration of KNO_3 , and the time of immersion in the solution because of the contact of the seeds with the water during these procedures. However, after the drying period, seeds showed water contents between 7.1% and 9.0%. Thus, the results of physiological seed evaluations were free from interference caused by differences in

water content (Araújo, Zonta, Araújo, Herbele, & Zonta, 2011).

The percentage of abnormal seedlings showed a significant effect only by treatments, and germination and AGT showed significant differences for the isolated effect of both treatments and lot (Table 5). The lots used in this study showed different germination and vigor values. Based on the results of germination and AGT, lots 1 and 3 responded better than did lot 2.

Table 6
First count of germination (FC) of *Urochloa humidicola* Comum as a function of the lots and treatments applied in the second stage of the research

		G ¹	A ¹	AGT (days)
		-----%-----		
Lots	Lot 1	61,6 a	8,95 a	7,4 a
	Lot 2	50,7 b	11,27 a	10,0 c
	Lot 3	63,4 a	9,43 a	8,5 b
MS		754,16**	66,19NS	70,69**
CV (%)		9,10	47,92	13,29
Treatments	ST	23,8 d	4,7 abc	11 c
	T KNO_3	69,8 a	4,2 abc	10 bc
	T H_2SO_4	50,2 c	6,0 bc	9 ab
	KNO_3 2%12h	59,6 bc	6,8 c	8 a
	KNO_3 2%24h	62,3 ab	2,8 ab	7 a
	KNO_3 4%12h	66,0 ab	2,5 a	8 a
	KNO_3 4%24h	64,9 ab	2,3 a	8 a
	KNO_3 6%12h	64,9 ab	3,2 abc	9 ab
	KNO_3 6%24h	61,3 ab	3,0 abc	8 a
	KNO_3 8%12h	65,2 ab	2,3 a	9 ab
	KNO_3 8%24h	56,3 bc	3,7 abc	8 a
MS		709,80**	83,29**	12,27**
CV (%)		9,10	47,92	13,29

ST: control without treatment; T KNO_3 : control of moistening of the substrate with KNO_3 (0.2%); T H_2SO_4 : control with scarification by H_2SO_4 .

Means followed by the same lowercase letter in a column for each parameter do not differ statistically from each other by the Tukey test ($P > 0.05$).

¹: Data transformed by arcsine $(x/100)^{1/2}$ and the original means are presented.

MS: Mean square; CV: Coefficient of variation; *, **: indicate significant difference by the F test ($P \leq 0.05$ and $P \leq 0.01$, respectively); NS: indicates that there was no significant difference by the F test ($P \leq 0.05$).

All methods of overcoming dormancy were superior to the control without treatment for germination. However, when comparing with the control treatment, the moistening of the substrate with KNO_3 was superior to scarification with H_2SO_4 . Although H_2SO_4 scarification was efficient in overcoming seed dormancy, it did not increase the production of normal seedlings (Table 5). These results were similar to those observed in a previous study with the same species (Torres et al., 2016) and to those obtained in the first stage of the research (Table 2).

The treatments that provided greater germination were those wherein seeds were sown in a substrate moistened with KNO_3 (0.2%) and immersed in KNO_3 at 4%, 6%, and 8% for 12 h and 2%, 4%, and 6% for 24 h (Table 5). Seed scarification with H_2SO_4 and sowing on a substrate moistened with KNO_3 solution (0.2%) are methods recognized for their efficiency in overcoming the dormancy of several species, including forage grasses

(MAPA, 2009; Mendonça, Martins, Martins, & Lopes, 2015).

The treatment that caused the largest formation of abnormal seedlings was the immersion of the seeds in a 2% KNO_3 solution for 12 h. However, this result did not differ from those obtained in other treatments, such as the three controls and the immersion of the seeds in 4%, 6%, and 8% KNO_3 for 24 h and 6% for 12 h.

The effects of lots and treatments on the first count of germination are presented in Table 6. Similar to the first stage of research, the variability in the treatments tested and the difference in the quality of lots caused a high coefficient of variation. For lot 1, a greater result was obtained with the scarification of seeds with H_2SO_4 , and for lot 2, there was no difference between the treatments. In lot 3, the immersion of seeds in 2% and 4% KNO_3 for 12 h provided superior results compared to that of the control without treatment.

Table 6
First count of germination (FC) of *Urochloa humidicola* Comum as a function of the lots and treatments applied in the second stage of the research.

Treatments	FC (%)		
	Lot 1	Lot 2	Lot 3
ST	3,5 bA	0,0 aA	0,0 bA
T KNO ₃	3,5 bA	0,0 aA	4,5 abA
T H ₂ SO ₄	48,0 aA	0,0 aB	1,5 abB
KNO ₃ 2%12h	7,0 bA	7,0 aA	15,3 aA
KNO ₃ 2%24h	13,0 bA	12,0 aA	11,0 abA
KNO ₃ 4%12h	13,8 bA	3,0 aA	16,5 aA
KNO ₃ 4%24h	7,0 bA	1,0 aA	9,3 abA
KNO ₃ 6%12h	5,5 bA	5,0 aA	5,5 abA
KNO ₃ 6%24h	13,8 bA	1,0 aB	7,5 abAB
KNO ₃ 8%12h	7,0 bA	2,5 aA	1,0 abA
KNO ₃ 8%24h	7,0 bA	1,5 aA	7,0 abA
MS		211,64**	
CV (%)		73,28	

ST: control without treatment; T KNO₃: control of moistening of the substrate with KNO₃ (0.2%); T H₂SO₄: control with scarification by H₂SO₄.

Means followed by the same lowercase letter in a column and uppercase in a row for each parameter do not differ statistically from each other by the Tukey test ($P > 0.05$).

Data transformed by arcsine $(x/100)^{1/2}$ and the original means are presented.

MS: Mean square; CV: Coefficient of variation; *, **: indicate significant difference by the F test ($P \leq 0.05$ and $P \leq 0.01$, respectively).

A significant interaction of the lot with the treatments was observed for dead and dormant seeds (Table 7). Overcoming dormancy by the three lots in all treatments was superior to that of the control without treatment. The high percentage of dormant seeds from the untreated controls has been recurrent in several *U. humidicola* studies (Costa et al., 2011; Libório et al., 2017, 2018). KNO₃ immersion treatments were efficient for all lots regardless of the dormancy rate.

Variation was observed for the dead seeds between the most efficient treatments for each lot. However, the least harmful

treatments for all lots were the control with moistening the substrate with KNO₃ and the treatments with 12 h of immersion of the seeds in KNO₃ at 2%, 4%, and 6%. The ideal immersion period of the seeds in KNO₃ limits the entry of ions into cells, preventing phytotoxicity (Bonome, Guimarães, Oliveira, Andrade, & Cabral, 2006).

In lots 2 and 3, the control with H₂SO₄ caused the highest seed mortality, with an increase of 43% and 86%, respectively, compared to the control without treatment. These data corroborated those obtained in the first stage of this research (Table 4), and that

of other studies that pointed out that the use of H_2SO_4 could be harmful to the physiological

quality of the seeds (Macedo, Groth, & Lago, 1994; C. C. Martins & Silva, 1998; Moreira, 2014).

Table 7

Dormant seeds (D) and dead seeds (M) of *Urochloa humidicola* Comum as a function of the lots and treatments applied in the second stage of the research

Treatments	Dormancy (%)			Deads (%)		
	Lot 1	Lot 2	Lot 3	Lot 1	Lot 2	Lot 3
ST	30,3 bA	38,0 bAB	51,8 cB	37,8 abB	37,5 abcB	19,3 abA
T KNO_3	1,0 aA	6,0 aB	6,0 bB	24,8 abB	26,0 aB	14,0 aA
T H_2SO_4	3,5 aA	4,0 aA	3,0 abA	31,5 abA	53,5 cB	36,0 cA
KNO_3 2%12h	3,0 aA	7,5 aA	9,5 bA	27,0 abA	29,8 abA	23,5 abcA
KNO_3 2%24h	3,0 aA	12,0 aB	2,0 abA	25,5 abA	34,0 abA	27,5 bcA
KNO_3 4%12h	4,0 aA	5,0 aA	5,5 bA	24,3 abAB	35,5 abB	20,0 abA
KNO_3 4%24h	1,0 aA	7,0 aB	1,5 abAB	24,0 aA	32,0 abA	32,0 bcA
KNO_3 6%12h	4,0 aA	3,5 aA	5,5 bA	31,0 abB	32,3 abB	18,3 abA
KNO_3 6%24h	1,0 aA	2,0 aA	0,0 aA	32,0 abAB	42,8 bcB	29,8 bcA
KNO_3 8%12h	2,5 aA	3,5 aA	1,5 abA	29,5 abA	32,5 abA	27,8 bcA
KNO_3 8%24h	3,0 aA	2,5 aA	1,0 abA	40,3 bB	44,8 bcB	28,8 bcA
MS		58,17**			39,34*	
CV (%)		43,90			12,79	

ST: control without treatment; T KNO_3 : control of moistening of the substrate with KNO_3 (0.2%); T H_2SO_4 : control with scarification by H_2SO_4 .

Means followed by the same lowercase letter in a column and uppercase in a row for each parameter do not differ statistically from each other by the Tukey test ($P > 0.05$).

Data transformed by arcsine $(x/100)^{1/2}$ and the original means are presented.

MS: Mean square; CV: Coefficient of variation; *, **: indicate significant difference by the F test ($P \leq 0.05$ and $P \leq 0.01$, respectively).

In the comparison of treatments, it was found that the immersion of the seeds in KNO_3 solution at all concentrations and periods tested was efficient. However, only at concentrations of 4%, 6%, and 8% for 12 h and 2%, 4%, and 6% for 24 h did the overcoming of dormancy result in a significant increase in germination. All of these treatments were subjected to the application by companies. However, to adjust the work routine and reduce costs, the recommended treatment is 4% for 24 h.

Conclusion

The immersion in the KNO_3 solution was efficient to overcome dormancy and promote germination. To be used by forage producers, the immersion of seeds in KNO_3 2 and 4% solution for 24 h are the most suitable treatments to overcome dormancy and promote the germination of *U. humidicola* Comum seeds.

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