Time of contact of phosphate fertilizer with *Megathyrsus maximus* (cv. Massai) seeds in relation to germination and growth

Tiempo de contacto del fertilizante fosfatado con semillas de *Megathyrsus maximus* (cv. Massai) en relación con la germinación y el crecimiento

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ABSTRACT

The aim of this research was to evaluate the effect of the contact time of simple superphosphate fertilizer with Massai grass (*Megathyrsus maximus*) seeds on the physiological quality of the seeds. The experiment was conducted with seeds of Massai grass in two conditions: laboratory and field. The experiment was carried out in Teresina, Piauí, Brazil. The experimental design was completely randomized, with three replicates for both conditions. The treatments consisted of seven contact times: 0, 3, 6, 9, 24, 48, and 72 h. Germination (GP) and emergence (EP) percentages, seedling height (SH), root length (RL), and germination speed index (GSI) were evaluated. The contact time of the fertilizer with the seeds had a significant effect on all variables, except root length and emergence at 7 d. For GP in the second data collection and GSI, there were no differences up to 3 h of contact; however, for GP in the first collection, SH and GSI at 21 d, the contact of seeds with fertilizer for 3 h already had negative effects on these variables, reducing them by 23.33%, 12.13 cm and 14.28% respectively. The longer the contact time between single superphosphate with *M. maximus* (cv. Massai) seeds, the lower the germination and vigor values.

Key words: seedling emergence, physiological quality, forage, seed germination.

RESUMEN

El objetivo de esta investigación fue evaluar el efecto del tiempo de contacto del fertilizante superfosfato simple con semillas de pasto Massai (*Megathyrsus maximus*) sobre la calidad fisiológica de las semillas. El experimento se realizó con semillas de pasto Massai en dos condiciones: laboratorio y campo. El experimento se llevó a cabo en Teresina, Piauí, Brasil. El diseño experimental fue completamente al azar, con tres repeticiones para ambas condiciones. Los tratamientos consistieron en siete tiempos de contacto: 0, 3, 6, 9, 24, 48 y 72 h. Se evaluaron porcentajes de germinación (PG) y emergencia (PE), altura de plántula (AP), longitud de raíz (LR) e índice de velocidad de germinación (IVG). El tiempo de contacto del fertilizante con las semillas tuvo un efecto significativo en todas las variables, excepto en la longitud de las raíces y la emergencia a los 7 d. Para PG en la segunda toma de datos e IVG no hubo diferencias hasta las 3 h de contacto; sin embargo, para PG en la primera colecta, SH e IVG a los 21 d, el contacto de las semillas con el fertilizante durante 3 h tuvo efectos negativos sobre estas variables, reduciéndolas en 23.33%, 12.13 cm y 14.28% respectivamente. A mayor tiempo de contacto entre el superfosfato simple y las semillas de *M. maximus* (cv. Massai), menores valores de germinación y vigor.

Palabras clave: emergencia de plántulas, calidad fisiológica, forraje, germinación de semillas.

Introduction

The use of fertilizers when sowing forage seeds requires care, as the sowing time is very variable and interruption of sowing due to damage to agricultural implements, rain or other problems can increase the contact time of the seeds with the fertilizer (Almeida *et al*., 2017).

Sowing efficiency depends on the type of fertilizer and the contact time between the fertilizer and the seeds (Lima *et al.,* 2010). Sowing must consider that fertilizer can harm seed germination and seedling emergence, mainly due to saline effect of fertilizers (Pereira *et al.,* 2018).

Some production systems, such as integrated systems, suggest the use of forage together with annual crops, such as in maize-grass intercropping, where sowing of forage seeds is generally carried out together with fertilizers in the feed-box of a seed drill (Almeida *et al.,* 2017; Choudhary *et al*., 2018).

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The choice of forage species in the implementation of a pasture reform and adequate recommendation of mineral nutrients requires consideration by growers. In this sense, forage plants of the genus *Megathyrsus maximus* have drawn interest among researchers and growers of Brazil, due to their high productivity and wide adaptability to edaphic and climatic conditions of the country, akin to those of their center of origin (Pereira *et al.,* 2021).

Some practices employed in intensive production systems are the application of fertilizers at pre-sowing. In this context, mainly in the Northeastern Cerrado, where planting windows are short, there is a need to optimize planting because growers often apply only phosphorus fertilizer at sowing (Donagemma *et al.,* 2016).

Considering the requirements when mixing fertilizers and forage species in integrated systems and the growing use of species of the genus *Megathyrsus*, the aim of the present study was to evaluate the effect of the contact time of single superphosphate (SSP) fertilizer on the physiological quality of Massai grass seeds.

Materials and methods

The experiment was carried out at the State University of Piauí, located in Teresina, Piauí state, Brazil (5°04'34.4" S, 42°49'36.9" W) (Fig. 1), under both controlled laboratory conditions and in the field under full sun exposure.

The experimental design was completely randomized, with three replicates (20 g of seed in each). The treatments consisted of seven contact times between seeds and granulated phosphate fertilizer (single superphosphate, 18% P_2O_5): 0, 3, 6, 9, 24, 48, and 72 h. The design was the same for both trials (laboratory and full sun field exposure). The seeds of Massai grass (*M. maximus*) were in contact with SSP according to the mentioned periods, with a fertilizer rate equivalent to 20 kg ha^{-1} of P_2O_5 and a sowing rate of 5 kg ha^{-1}.

The mixture of fertilizer and seeds was kept in a closed plastic package of 0.5 dm^3, consisting of 20 g of forage seeds and 80 g of fertilizer. Homogenization (mixture of fertilizer with seeds) was performed according to each treatment; the control received no contact. The seeds had

FIGURE 1. Map of Brazil highlighting the state of Piauí and the town of Teresina.

a percentage Pure Life Seed (PLS) of 80% according to information contained on the label of the purchased batch.

After the pre-established contact times (3, 6, 9, 24, 48, or 72 h) of the Massai grass seeds with the phosphate fertilizer, tweezers were used to place 50 seeds on paper for seed germination (paper towel – “germitest”), in triplicate.

The seeds were initially moistened with 12 ml of distilled water, using 2.5 times the mass of the dry paper soaked in water, maintaining the necessary moisture throughout the trial. The papers were rolled and placed in a BOD (biochemical oxygen demand) incubator - Novatécnica: Equipamentos para laboratório®, Brazil - for 8 h at 35°**C** in light and for the remaining 16 h at 25°**C** in the dark, according to Santos *et al*. (2013).

Germination was assessed at 7 and 21 d and the seedlings considered normal were computed according to the criteria established in the Rules for Seed Analysis (MAPA, 2009). The length of normal seedlings from the germination test was measured using a millimeter ruler from the apex of the primary root to the apex of the aerial part (MAPA, 2009).

Furthermore, an analogous method was carried out in soil-filled pots by planting 50 seeds in triplicates of each treatment and leaving them in full sun conditions (November to December of 2016, without rain in the period, and average temperature in 28°C). Soil moisture was kept constant, and the duration of the test was the same as the laboratory test, evaluating the emergence at 7 and 21 d. The seeds were incorporated into the soil at a depth of 1 cm. The soil had the following chemical characteristics: pH (water), 7.7; P (Mehlich 1) 12 mg dm^{-3}; K, 0.51 $cmol_c\ dm^{-3}$; H+Al,1.5 ($cmol_c\ dm^{-3}$); OM, 1.1 (g dm^3), and sandy texture (9% clay).

In the full sun trial, the germination speed index (GSI) was also evaluated, using Equation 1 (Maguire, 1962):

$$GSI = \frac{G_1}{N_1} + \frac{G_2}{N_2} + \dots + \frac{G_n}{N_n} \quad (1)$$

where: G_1, G_2, G_n = number of seedlings germinated at the first, second, until the last count and N_1, N_2, N_n = number of days from the first, second, until the last count.

Assumptions of normality (Shapiro-Wilk test) and homogeneity of variances (Bartlett test) were tested to determine if the data were suitable for analysis of variance using the F test; when significant, the Scott-Knott mean test (5%) was applied and polynomial regression analysis was performed with the aid of the SISVAR software (Ferreira, 2011).

Results and discussion

Table 1 presents the average values of PG, growth, and seedling emergence of Massai grass as a function of contact times with SSP, which were significant for germination at the first and second counts (measurement days), shoot height of seedlings, emergence at 21 d, and GSI. For the second germination count (21 d) and GSI, no differences were found for up to 3 h of contact; however, for the first germination count (7 d), shoot height and emergence at 21 d, the contact of seeds with fertilizer for 3 h already promoted negative effects on these variables of 23.33, 12.13, and 14.28%, respectively.

TABLE 1. Average values of seed germination of Massai grass at 7 and 21 d, length of radicle and shoot, and seedling emergence percentage at 7 and 21 d as a function of the seed contact time with single superphosphate.

Times h	Germination		Radicle length	Shoot Height	Emergence		GSI
	7 d	21 d			7 d	21 d	
	%		cm		%		
0	30[a]	51[a]	2.71	1.73a	44	77[a]	49[a]
3	23[b]	51[a]	2.96	1.52[b]	37	71[b]	42[a]
6	20[c]	41[b]	2.95	1.36[c]	33	67[c]	37[b]
9	26[b]	40[b]	2.97	1.36[c]	37	64[c]	35[b]
24	23[b]	40[b]	3.23	1.34[c]	35	63[c]	35[b]
48	17[c]	37[b]	3.03	1.33[c]	21	63[c]	28[b]
72	15[c]	36[b]	3.02	1.15[d]	38	64[c]	34[b]
Test F	**	**	ns	**	ns	**	**
CV (%)	11.5	13.7	11.2	6.9	21.8	4.6	11.7

[ns], ** - Non significant and significant at 5% probability. [1]Means followed by the same letter in the column do not differ according to the Scott-Knott test (5%). GSI - germination speed index.

Germination rates at 7 d (Fig. 2) fitted best to a decreasing linear model ($P<0.05$). However, for germination at 21 d (Fig. 3), shoot height (Fig. 4), seedling emergence at 21 d (Fig. 5) and GSI (Fig. 6), they were fitted to a decreasing exponential model, with stabilization of the reduction of these variables after 24 h of contact of seeds with the phosphate fertilizer. A similar result has already been verified in other studies evaluating contact times between fertilizers and forage seeds (Maciel *et al.,* 2019; Ferreira *et al.,* 2020).

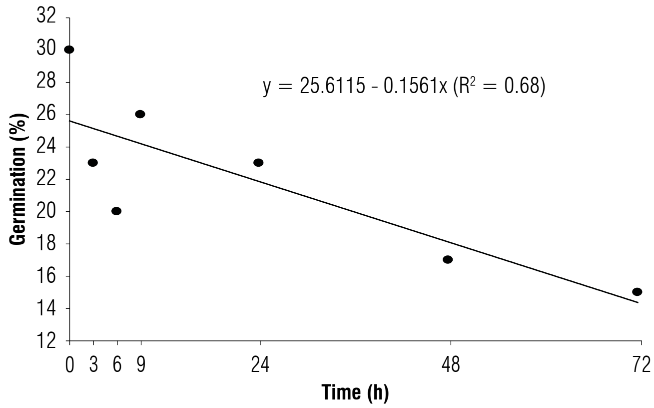

FIGURE 2. *Megathyrsus maximus* Masai grass seed germination at 7 d as a function of contact times with single superphosphate.

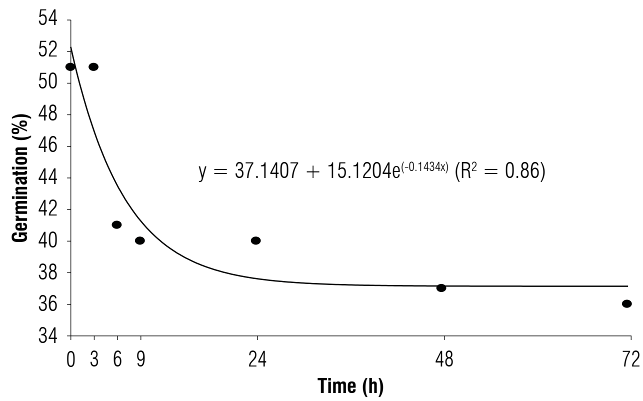

FIGURE 3. *Megathyrsus maximus* Masai grass seed germination at 21 d as a function of contact times with single superphosphate.

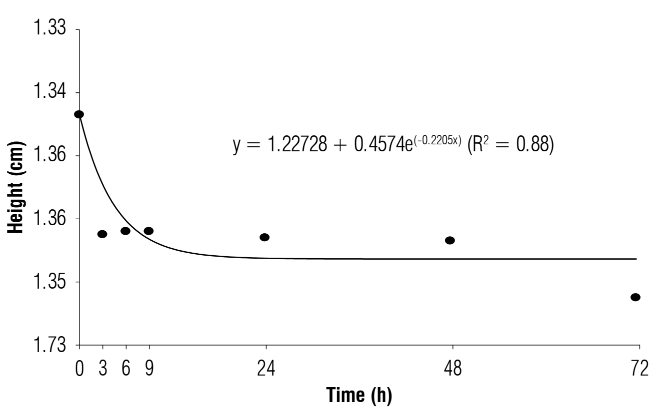

FIGURE 4. Shoot height of *Megathyrsus maximus* 'Massai' grass seedlings as a function of contact times with single superphosphate.

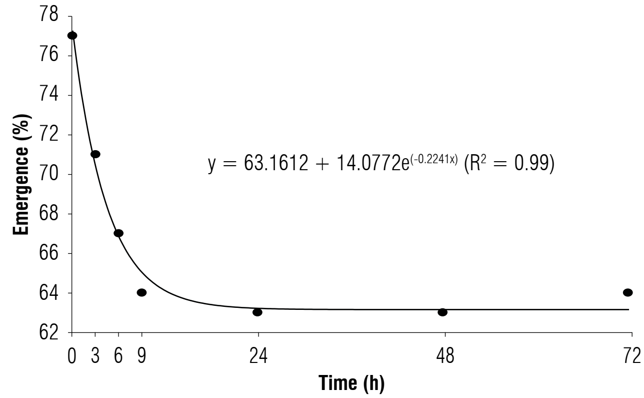

FIGURE 5. Seedling emergence at 21 d of *Megathyrsus maximus* 'Massai' grass as a function of contact times of seeds with single superphosphate.

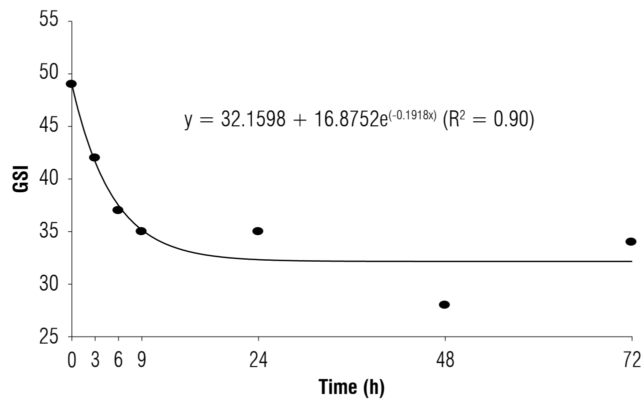

FIGURE 6. Germination speed index (GSI) of *Megathyrsus maximus* 'Massai' grass as a function of contact times of seeds with single superphosphate.

The stabilization could be due to the saline effect of the fertilizer. From 0 to 9 h of ion-seed contact, seeds had not yet reached their maximum osmotic potential (Ψs), which only occurs within 24 to 72 h, possibly allowing the fertilizer to break the cell cytoplasmatic membrane, consequently reducing seed germination and seedling development.

However, other studies mention that phosphate fertilizers are obtained by processing the phosphate rock using sulfuric and phosphoric acids (Cheremisina *et al*., 2019; Sari *et al*., 2020; Samrane & Bouhaouss, 2022). Therefore, some processing residues could negatively affect the germination and vigor of the seeds, and such negative effect can be accentuated with the contact time with fertilizer (Soratto *et al.,* 2003).

When evaluating the development of the plant, a small growth in height of the seedlings was observed when they remained in contact with the fertilizer for a longer period; thus, possible deleterious effects could be linked not only to seed germination and vigor. The decrease in values obtained in the SH variable is due to the loss of water and nutrients present in the seed in mixture of fertilizer, probably due to its salinity. With little water inside the cells, cell turgidity does not occur, which together with calcium, phosphorus and nitrogen, is responsible for cell division and consequently the increase in SH. This result has also been observed for another source of phosphorus (triple superphosphate) mixed with seeds (Lima *et al*., 2009).

Another point to be highlighted in the present work is that both trials, full sun field exposure and laboratory, yielded results with the same trend, with a decrease in germination and emergence as the contact times increased.

Studies on the effects of contact time between fertilizers and seeds evaluated millet (Soratto *et al.,* 2003), *Brachiaria brizantha* (Lima *et al.,* 2009; Lima *et al.,* 2010), and *Brachiaria ruziziensis* (Dan *et al.,* 2011). All studies reported trends close to those of the present study. Therefore, regardless of the species, contact between fertilizers and forage seeds is deleterious if it remains for long periods.

Single superphosphate (SSP) and monoammonium phosphate (MAP), another source of phosphorus, were kept in contact of with seeds of *Brachiaria brizantha* cv. Marandu. Considering an acceptable germination rate of 60%, the seeds can be kept in contact with SS and MAP at a rate of 80 kg P_2O_5 ha^{-1} for 71.2 and 16.2 h, respectively (Peres *et al.,* 2012).

The loss of physiological quality of *M. maximus* cv. Massai seeds was, probably, due to the imbalance in osmotic potential of the seeds, which may be due to the cationic characteristic of the phosphate fertilizer, which prevented water uptake by the seeds (Chien *et al.,* 2011). Due to the ionic strength of several salts, the fertilizer can be in contact with the developing plant tissues, potentially causing phytotoxicity (Pereira *et al.,* 2012).

Conclusion

The longer the contact time between single superphosphate with *M. maximus* seeds (cv. Massai), the lower the germination and vigor values.

The mixture of seeds with single superphosphate for the renewal or planting of pastures can be recommended as long as the seed sowing is immediate.

Conflict of interest statement

The authors declare that there is no conflict of interests regarding the publication of this article.

Author's contributions

HCAR formulated the overarching research goals and aims. RRM carried out activities to annotate scrub data and maintain research data for initial use and later re-use. RCTB applied statistical, mathematical, computational. EDON and HAS carried out the critical review. All authors reviewed the final version of the manuscript.

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