Available online at http://www.journalcra.com

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

International Journal of Current Research
Vol. 8, Issue, 09, pp.38456-38460, September, 2016

ISSN: 0975-833X

RESEARCH ARTICLE

PLANT PRE HARVEST DESICCATION AND PHYSIOLOGICAL PERFORMANCE OF WHEAT SEEDS BEFORE AND AFTER STORAGE

[1]Keli Kehl, [1]Kassiana Kehl, [2,]*Geison Rodrigo Aisenberg, [2]Felipe Koch, [2]Manoela Andrade Monteiro, [2]Vinícius Jardel Szareski, [2]Ivan Ricardo Carvalho, [2]Maicon Nardino, [4]Velci Queiróz de Souza, [2]Tiago Pedó, [3]Francisco Amaral Villela and [2]Tiago Zanatta Aumonde

[1]Pró-Sementes Foundation, CEP 99025-130, Passo Fundo, Rio Grande do Sul, Brasil
[2]Federal University of Pelotas, College of Agronomy "Eliseu Maciel", CEP 96050-500, Capão do Leão, Rio Grande do Sul, Brazil
[3]Federal University of Pelotas, CEP 96010-610, Pelotas, Rio Grande do Sul, Brazil
[4]University Federal of Pampa, CEP 96450-000, Dom Pedrito, Rio Grande do Sul, Brazil

ARTICLE INFO

Article History:
Received 15th June, 2016
Received in revised form
26th July, 2016
Accepted 24th August, 2016
Published online 30th September, 2016

Key words:

Triticum aestivum L.,
Herbicides, Germination,
Vigor of seeds.

ABSTRACT

The aim of this study was to evaluate the physiological performance of wheat seeds derived from plants subjected to desiccation with different herbicides and seed moistures, before and after storage. A randomized block experimental design was used in a 4 x 3 factorial, with three herbicides and application absence and three seed moisture contents at application. 1000-seed weight, germination and first count, germination speed index, emergence and emergence speed index, and accelerated aging and electrical conductivity were assessed. Seed vigor is reduced by herbicide action when applied in 40% moisture, what is related to the active principle. Germination and vigor of wheat seeds from plants subjected to herbicide application in different seed moistures have similarity when assessed before sowing and after storage.

Citation: Keli Kehl, Kassiana Kehl, Geison Rodrigo Aisenberg *et al.*, 2016. "Plant pre harvest desiccation and physiological performance of wheat seeds before and after storage", *International Journal of Current Research*, 8, (09), 38456-38460.

INTRODUCTION

Wheat has high importance in the world's grain production, and it is the third most planted crop, after rice and corn. Brazil's wheat production is not self-sufficient, importing more than 6.0 million tons of grains per year. Production of this species is concentrated in the Brazilian south region, where the three southernmost states were responsible for 93% of Brazilian wheat production in the 2014 season. In the same season, Brazilian mean wheat yield was 2.2 t ha^{-1}, and some states from the Brazilian Midwest region stood out. Appropriate farming practices, such as sowing in the recommended period (Meotti *et al*., 2012), weed management (Braz *et al*., 2010) and use of high quality seeds enable higher crop yields (Albrecht *et al*., 2009). High quality seeds enable uniform and rapid emergence (Lima *et al*., 2007), besides yielding plants that are capable to express their maximum genetic potential in the field (Toledo *et al*., 2014). Among main factors that affect seed physiological performance, the right time to harvest is highlighted (Guimarães *et al*., 2012). In seed production, it is recommended that harvest should be conducted as close to physiological maturity as possible (Bellé *et al*., 2014), as dry matter transferring from matrix to seeds is interrupted at this point (Terasawa *et al*., 2009). In addition, maximum dry matter accumulation, maximum germination and higher vigor are obtained at this point (Araujo *et al*., 2006). Premature harvesting results in malformed seeds with inadequate reserve levels (Peske *et al*., 2012), while delay causes vigor decrease (Sedyama, 2013). In many field situations, mechanical harvesting near physiological maturity point is not possible, as much of plant structural matter is still green due to plant development unevenness, causing improper harvester operation during plant material collection and seed damage during threshing (Terasawa *et al*., 2009). Thus, preharvest desiccation may be an alternative to standardize plants in relation to their green matter composition (Kappes *et al*., 2012). Herbicide use in plant desiccation during preharvest

Corresponding author: Geison Rodrigo Aisenberg,
Federal University of Pelotas, College of Agronomy "Eliseu Maciel", CEP 96050-500, Capão do Leão, Rio Grande do Sul, Brazil.

has been a growing practice in seed production, and is aimed at anticipating plant removal from the field (Marcandalli *et al*., 2011). Chemical desiccation causes leaf tissue damage (Lacerda *et al*., 2001), which may adversely affect reserve formation, seed development and physiological potential if conducted precociously. Desiccation by chemicals promotes quick water content reduction in vegetables (Kappes *et al*., 2012), allowing for seed harvesting anticipation (Pereira *et al*., 2015). In chemical desiccation, paraquat, ammonium salt glufosinate (Pereira *et al*., 2015) and glyphosate (Bellé *et al*., 2014) herbicides are commonly used. Paraquat is a non-selective, post-emergent herbicide that has photosystem I inhibition as action mechanism (Vargas and Roman, 2006), besides being an electron acceptor (Martins, 2013). Plants submitted to paraquat application have CO_2 fixing inhibition, producing superoxides, which are molecules that promote cell membrane destruction (Martins, 2013). Ammonium salt glufosinate acts by inhibiting the glutamine synthetase enzyme (Rodrigues and Almeida, 2011), resulting in ammonium accumulation and plant death (Carneiro *et al*., 2006). On the other hand, glyphosate is a non-selective, systemic herbicide used in post-emergence (Toni *et al*., 2006), inhibiting the 5-enolpyruvylshikimate-3-phosphate synthase enzyme, which is responsible for phenylalanine, tyrosine and tryptophan aromatic amino acids synthesis, precursors of lignin, alkaloids, flavonoids and benzoic acids (Toni *et al*., 2006). In order to achieve success through preharvest desiccation, it is necessary to assess product effect at different seed development stages (Pereira *et al*., 2015). Moisture (or water content) can be related to wheat seeds development, which reach physiological maturity in 32-35% moisture (Peske *et al*., 2012). Therefore, preharvest paraquat application in beans may affect physiological quality, influencing on seedlings growth and biomatter accumulation (Kappes *et al*., 2012). In soybean, glyphosate use adversely affects physiological quality, while reducing soybean germination and seedling development (Toledo *et al*., 2014). Given the above, the application of desiccants can adversely affect the physiological quality of wheat seed, before and after storage, being that the humidity at the time of application also has an effect on this characteristic. Thus, the aim of this study was to evaluate the physiological performance of wheat seeds derived from plants subjected to desiccation with different herbicides and seed moistures, before and after storage.

MATERIALS AND METHODS

The experiment was conducted in an experimental area in Santo Augusto, Rio Grande do Sul state, 53°48'53" latitude, 27°54'52" longitude and elevation of 497 meters. Assessments regarding seed physiological performance were carried out in the Seed Analysis Didactic Laboratory from the Phytotechnology Department. The experimental area soil is classified as dystrophic purple Latosol, with the following characteristics in the 0-20 cm deep layer: clay = 51.3%; pH = 5.4; O.M = 3.5%; Al = 0.6 $cmol_c\ dm^{-3}$; Ca = 4.0 $cmol_c\ dm^{-3}$; Mg = 2.1 $cmol_c\ dm^{-3}$; P = 36.4 mg dm^{-3}; K = 392 mg dm^{-3}. Fertility and soil acidity correction was done by previous analysis, as recommended by the fertilization and liming manual for the states of Rio Grande do Sul and Santa Catarina. Seeds were sown with a plot sower through direct sowing at a depth of 2.5 cm and adopting 20 cm spacing between rows, with a density of 300 seeds per square meter. TBIO Sinuelo cultivar was used. A randomized block experimental design was used in a 4 x 3 factorial, with three herbicides + no application (control) and three seed moistures at application, which were, as follows: 15%; 30% and 40%, with four repetitions. Herbicides used in the treatments with their respective characteristics and applied doses are shown in Table 1. Applications were conducted with a CO_2-pressurized backpack sprayer, using a spray volume of 200 L ha^{-1}. Plots were harvested mechanically with a plot harvester, and seeds had 16% moisture at harvest. Afterwards, seeds were placed separately in cotton bags and stored in cold and dry chamber, as recommended, until the tests were conducted (Peske *et al*., 2012). In order to determine seed physical and physiological performance, 1000-seed weight was assessed from eight repetitions, through manual counting of a hundred seeds in eight subsamples per repetition (Brasil, 2009). Germination was assessed immediately after harvest and also after storage, before the next sowing window, through four repetitions with four subsamples of 50 seeds each per treatment. In order to do so, seeds were placed to germinate between three germination sheets soaked in a ratio of 2.5 times the dry paper mass. Rolls were transferred to a BOD incubator at 20 °C with a 12-hour photoperiod. Assessments were conducted eight days after sowing and results were expressed in percentage of normal plants (Brasil, 2009).

Table 1. Commercial name, concentration, active ingredient and dose of each herbicide used in wheat plants preharvest desiccation

Commercial name	Concentration	Active ingredient	Dose used[1]
Controle	-	-	-
Glizmax®	648 g L^{-1}	Glyphosate	1296 g
Finale®	200 g L^{-1}	Ammonium salt glufosinate	400 g
Helmoxone®	276 g L^{-1}	Paraquat	552 g

[1]Active ingredient per hectare

Seedling emergence in greenhouse was conducted in four repetitions with four subsamples of 50 seeds per treatment. Sowing was conducted in a solodic Haplic Eutrophic Planosol soil belonging to the Pelotas mapping unit. Assessment was conducted 21 days after sowing, and results were expressed in percentage (Nakagawa, 1994). For the accelerated aging test, seeds were distributed on a metal screen fixed inside plastic boxes ("gerbox") containing 40 mL of saturated saline solution. Saturated saline solution was composed of 11 grams of NaCl per each 100 mL of water, and plastic boxes containing the seeds were kept in a BOD incubator at 43 °C for a period of 48h. Subsequently, seeds were placed to germinate under the same conditions of the germination test, and the assessment was conducted four days after sowing (Brasil, 2009). Electrical conductivity test was conducted in four repetitions with four subsamples of 25 seeds. Seeds had their mass determined beforehand. Afterwards, seeds were placed in polyethylene beakers containing 80 mL of deionized water and were kept in a BOD incubator at 20 °C with a 12-hour photoperiod. Electrical conductivity readings were made after 3; 6 and 24 hours of imbibition, using a digital conductivity meter. Results were expressed in $\mu S\ cm^{-1}\ g^{-1}$ of seeds. After collection, data related to physiological performance of wheat seeds subjected to preharvest desiccation in different moistures were subjected to analysis of variance, and means were compared by Tukey test at 5% probability.

RESULTS AND DISCUSSION

Wheat preharvest desiccation, adopted in seeds with different moisture degrees, resulted in a different response for each variable. There was interaction between herbicides and desiccation moistures for all variables, except for the first germination count when measured before storage (immediately after harvest). 1000-seed weight was significantly affected by herbicides and seed moistures at application (Table 2). Herbicide application when seeds had 40% moisture caused the highest 1000-seed weight reduction for the three products, compared to application in lower moistures. According to Guimarães *et al.* (2012), time or moisture of seeds in which desiccants were applied did not affect seed yield.

Table 2. Germination (G), accelerated aging (AE), field emergence (E) and 1000-seed weight (M_{1000}) obtained from wheat seeds derived from plants subjected to preharvest desiccation with different herbicides and seed moistures (U_{MA})

Herbicide	U_{MA} (%)	G (%)	AE (%)	E (%)	M_{1000} (g)
Control	-	95 a[1]	81 ab	81 a	34.13 b
Glyphosate	40	24 e	21 e	21 d	31.68 d
Glyphosate	30	84 ab	76 b	80 a	33.55 bc
Glyphosate	15	80 b	87 a	81 a	33.77 bc
Paraquat	40	15 e	4 f	9 e	30.12 e
Paraquat	30	63 c	58 c	63 bc	33.67 bc
Paraquat	15	83 b	77 b	68 b	34.08 b
A. glufosinate	40	41 d	37 d	55 c	33.70 bc
A. glufosinate	30	88 ab	77 b	80 a	35.02 a
A. glufosinate	15	81 b	83 ab	81 a	33.29 c
CV (%)		7.58	6.45	7.46	1.24

[1]Means with the same letter in columns do not differ significantly by Tukey test (p<0.05).

According to Martins *et al.* (2006), test weight and 1000-seed weight are also not affected by herbicide use in preharvest. The response regarding herbicide application may be related to harvest period and environmental conditions during seed storage in the field (Terasawa *et al.*, 2009). In addition, it may also be related to the fact that some herbicides do not affect seed filling and do not hinder reserve accumulation. Wheat seeds produced under the influence of plant desiccation in 40% moisture showed germination, germination after accelerated aging and seedling emergence decrease compared to seeds of the control treatment (no herbicide application) (Table 2). However, when herbicide application occurred in 15% seed moisture, germination maintenance was above the required for commerce. There was similarity between germination values for seeds subjected to herbicide effect in 15 and 30% moisture, as well as for plants not subjected to the effect of these molecules.

Herbicides used during seed filling caused seed vigor reduction in higher moistures (Table 2). However, herbicide use influence, which is aimed at precocious harvesting, depends on seed development stage. Contact desiccant use does not affect seed physiological quality, which is not observed for systemic herbicides (Daltro *et al.*, 2010). However, response to the herbicide may be related to application at different physiological maturation stages, which may affect crop yields due to reduction or stoppage of assimilate translocation and allocation to the seeds (Pelúzio *et al.*, 2008). Wheat seeds germination prior to storage reached higher values for all herbicides when they were applied in 15% moisture, compared to 40% moisture (Table 3). By analyzing seed germination in each moisture, this variable reduced when paraquat was applied in 40% moisture. However, no difference was observed between products when wheat plants were subjected to preharvest desiccation and had seeds with 15% moisture. On the other hand, seed germination before sowing showed similarity with germination before storage. Desiccation with all herbicides in the highest seed moisture resulted in germination reduction compared to desiccation with 15% moisture. Seed lower germination or harmful effects when plants are subjected to preharvest desiccation and seeds have higher moistures can be attributed to herbicide effect, either by systemic translocation to the seeds or by the contact action contact on the mother plant leaf area. These effects may directly affect the seed, resulting in low seedling performance. In addition, these effects may indirectly affect seeds by acting in the mother plant, resulting in inappropriate reserve deposition and cell membrane formation.

Table 3. Germination of wheat seeds derived from plants subjected to preharvest desiccation with different herbicides and seed moistures

Herbicide	Germination before storage (%)					
	Seed moisture (%)					
	15		30		40	
A. glufosinate	81	aA[1]	88	aA	41	aB
Glyphosate	80	aA	84	aA	24	bB
Paraquat	83	aA	63	bB	15	bC
CV (%)			8.05			
	Germination after storage					
A. glufosinate	84	aA	85	aA	45	aB
Glyphosate	89	aA	88	aA	29	bB
Paraquat	86	aA	73	bB	9	cC
CV (%)			6.11			

[1]Means followed by the same lowercase letter in the column and capital in the line do not differ statistically by Tukey test (p<0.05).

Seen in these terms, according to Lamego *et al.* (2013), harvest conducted at the right time favors seed germination and vigor. Campos *et al.* (2012), reports that harvest can be anticipated with preharvest desiccation. It is known that seed germination may be influenced by herbicide and moisture at desiccation (Pelúzio *et al.*, 2008; Toledo *et al.*, 2014). The three herbicides applied during preharvest reduced seed vigor when applied in 40% moisture, with the highest effect observed for paraquat. Plant desiccation through herbicide use may reduce seed vigor, as noted by the first germination count (Campos *et al.*, 2012). However, its use for harvest anticipation after physiological maturity reduces deterioration risks in the field, allowing for harvest, when seeds have high vigor (Terasawa *et al.*, 2009). In the accelerated aging test, assessed before seed storage, the number of normal wheat seedlings produced and obtained from seeds originating from plants under desiccation decreased with moisture increase for the three herbicides (Table 4). There was no difference between herbicides in 15% moisture, when seeds were assessed before sowing. However, for glyphosate and paraquat herbicides in 30 and 40% moisture, lower germination values occurred after accelerated aging compared to those observed for ammonium salt glufosinate in the same moisture contents.

Table 4. Germination after accelerated aging (AE) and seedling emergence in field (E) of seeds originated from plants subjected to preharvest desiccation with different herbicides and seed moistures

Herbicide	AE (%)						E (%)					
	Before storage											
	15		30		40		15		30		40	
A. glufosinate	83	abA[1]	77	AA	37	aB	81	aA	80	aA	55	aB
Glyphosate	87	aA	76	aB	21	bC	81	aA	80	aA	21	bB
Paraquat	77	bA	58	BB	4	cC	68	bA	63	bA	9	cB
CV (%)	6.93						7.83					
	After storage											
A. glufosinate	76	aA	76	AA	40	aB	83	aA	85	aA	54	aB
Glyphosate	82	aA	63	BB	19	bC	86	aA	82	aA	22	bB
Paraquat	82	aA	62	BB	3	cC	85	aA	80	aA	9	cB
CV (%)	8.08						7.34					

[1]Means followed by the same lowercase letter in the column and capital letter in the line do not differ statistically by Tukey test ($p<0.05$).

Seed vigor, assessed by accelerated aging test, is reduced by herbicide application, according to Toledo *et al.* (2014). Thus, results obtained in the three desiccation moistures, when seeds were assessed before storage, demonstrate herbicide adverse effect (Table 4). Higher paraquat effect in the highest seed moisture is due to the fact that this is a contact product. In addition, it is also due to moisture non-uniformity between seeds, as some had higher or lower humidity than 40%, that is, there were immature seeds. Ammonium salt glufosinate and glyphosate application resulted in the highest seedling emergence values compared to paraquat application in 15 and 30% moisture. Before sowing, no differences were observed between herbicides in 15 and 30% moisture when seedling emergence was taken into account (Table 4). Exception was observed for desiccation in 40% moisture, both before and after storage, and seedling emergence was higher when ammonium salt glufosinate, glyphosate and paraquat were applied. At physiological maturity, maximum seed quality is obtained, which depends on species, cultivar and the environment to where seeds are exposed in the field (Marcandalli *et al*., 2011). Seedling emergence uniformity is important to determine the initial plant population, which is related to crop yield (Marcos Filho *et al*., 2009). However, seedling emergence uniformity is influenced by seed vigor, which is related to seed development in field (Peske *et al*., 2012). Electrical conductivity, regardless of herbicide and imbibition time, was higher in seeds from plants that were subjected to desiccation in 40% moisture (Table 5).

Table 5. Electrical conductivity of wheat seeds originated from plants subjected to preharvest desiccation with different herbicides and seed moistures (U_{MA}) after 3, 6 and 24 hours (h) of imbibition

Herbicide	U_{MA} (%)	3 h	6 h	24 h
Control	-	5.00 c[1]	7.59 c	17.90 c
Glyphosate	40	22.80 a	29.90 a	59.10 a
Glyphosate	30	4.55 c	7.05 c	15.60 c
Glyphosate	15	4.83 c	7.36 c	16.50 c
Paraquat	40	22.90 a	30.50 a	57.40 a
Paraquat	30	4.49 c	6.62 c	16.20 c
Paraquat	15	4.49 c	7.21 c	18.30 c
A. glufosinate	40	13.10 b	18.70 b	36.80 b
A. glufosinate	30	4.22 c	6.78 c	15.80 c
A. glufosinate	15	4.62 c	7.22 c	16.40 c
CV (%)		7.58	10.21	6.45

[1]Values with the same letter in columns do not differ significantly by Tukey test ($p<0.05$).

The conductivity test indicates that higher electrolyte leakage is a result of lower cell membrane selectivity, which had lower reorganization level. Thus, according to Toledo et al. (2014), seed electrical conductivity varies according to moisture content at desiccation.

Conclusions

Germination and vigor of wheat seeds from plants subjected to herbicide application in different seed moistures were similar when assessed before sowing and after storage. Seed vigor is reduced by herbicide action when applied in 40% moisture. The effect is related to the active principle used in desiccation. Herbicide use for wheat preharvest desiccation in seeds with more than 30% moisture reduces 1000-seed weight.

REFERENCES

Albrecht, L. P., Braccini, A. de L., Ávila, M. R., Scapim, C. L., Barbosa, M. C., Stulp, M. 2009. Sementes de soja produzidas em épocas de safrinha na região oeste do Estado do Paraná. *Acta Scientiarum Agronomy***,** 31, 121-127. DOI: 10.4025/actasciagron.v31i1.6638.

Araujo, E. F., Araujo, R. F., Sofiatti, V., Silva, R. F. da. 2006. Qualidade fisiológica de sementes de milho-doce colhidas em diferentes épocas. *Bragantia*, 65, 687-692. DOI: 10.1590/S0006-87052006000400020.

Bellé, C., Kulczynski, S. M., Basso, C. J., Kaspary, T. E., Lamego, F. P., Pinto, M. A. B. 2014. Yield and quality of wheat seeds as a function of desiccation stages and herbicides. *Journal of Seed Science,* 36, 63-70. DOI: 10.1590/S2317-15372014000100008.

Brasil. 2009. Ministério da Agricultura, Pecuária e Abastecimento. *Regra para análises de sementes*. Brasília: Mapa/ACS, 399 p.

Braz, G. B. P., Cassol, G. M., Ordoñez, G. A. P., Simon, G. A., Procópio, S. de O., Oliveira Neto, A. M. de, Ferreira Filho, W. C., Dan, H. de A. 2010. Componentes de produção e rendimento de soja em função da época de dessecação e do manejo em pós-emergência. *Revista Brasileira de Herbicidas*, 9, 63-72. DOI: 10.7824/rbh.v9i2.83.

Campos, C. F., Martins, D., Costa, A. C. P. R., Pereira, M. R. R., Cardoso, L. A., Martins, C. C. 2012. Efeito de herbicidas na dessecação e germinação de sementes remanescentes de *Lolium multiflorum* L. *Semina: Ciências Agrárias*, 33, 2067-2074. DOI: 10.5433/1679-0359.2012v33n6p2067.

Carneiro, C. E. A., Molinari, H. B. C., Andrade, G. A., Pereira, L. F. P., Vieira, L. G. E. 2006. Produção de prolina e susceptibilidade ao glufosinato de amônio em plantas transgênicas de citrumelo Swingle. *Pesquisa Agropecuária Brasileira*, 41, 747-753.

Daltro, E. M. F., Albuquerque, M. C. de F., França Neto, J. de B., Guimarães, S. C., Gazziero, D. L. P., Henning, A. A. 2010. Aplicação de dessecantes em pré-colheita: efeito na qualidade fisiológica de sementes de soja. *Revista Brasileira de Sementes*, 32, 111-122. DOI: 10.1590/S0101-31222010000100013.

Guimarães, V. F., Hollmann, M. J., Fioreze, S. L., Echer, M. M., Rodrigues-Costa, A. C. P., Andreotti, M. 2012. Produtividade e qualidade de sementes de soja em função de estádios de dessecação e herbicidas. *Planta Daninha*, 30, 567-573. DOI: 10.1590/S0100-83582012000300012.

Kappes, C., Arf, O., Ferreira, J. P., Portugal, J. R., Alcalde, A. M., Arf, M. V., Vilela, R. G. 2012. Qualidade fisiológica de sementes e crescimento de plântulas de feijoeiro, em função de aplicações de paraquat em pré-colheita. *Pesquisa Agropecuária Tropical*, 42, 9-18. DOI: 10.1590/S1983-40632012000100002.

Lacerda, A. L. S., Lazarini, E., Sá, M. E., Walter Filho, V. V. 2001. Aplicação de dessecantes na cultura de soja: Antecipação da colheita e produção de sementes. *Planta daninha*, 19, 381-390. DOI: 10.1590/S0100-83582001000300011.

Lamego, F. P., Gallon, M., Basso, C. J., Kulczynski, S. M., Ruchel, Q., Kaspary, T. E. Santi, A. L. 2013. Dessecação pré-colheita e efeitos sobre a produtividade e qualidade fisiológica de sementes de soja. *Planta Daninha*, 31, 929-938. DOI: 10.1590/S0100-83582013000400019.

Lima, W. A. A., Borém, A., Dias, D. C. F. S., Moreira, M. A., Dias, L. A. S., Piovesan, N. D. 2007. Retardamento de colheita como método de diferenciação de genótipos de soja para qualidade de sementes. *Revista Brasileira de Sementes*, 29, 186-192. DOI: 10.1590/S0101-31222007000100026.

Marcandalli, L. H., Lazarini, E., Malaspina, I. G. 2011. Épocas de aplicação de dessecantes na cultura da soja: Qualidade fisiológica de sementes. *Revista Brasileira de Sementes*, 33, 241-250. DOI: 10.1590/S0101-31222011000200006.

Marcos Filho, J., Kikuti, A. L. P., Lima, L. B. 2009. Métodos para avaliação do vigor de sementes de soja, incluindo a análise computadorizada de imagens. *Revista Brasileira de Sementes*, 31, 102-112. DOI: 10.1590/S0101-31222009000100012.

Martins, C. C., Nakagawa, J., Martins, D. 2006. Seletividade de herbicidas sobre a produtividade e a qualidade de sementes de sorgo granífero. *Agropecuária Técnica*, 27, 37-42.

Martins, T. 2013. Herbicida Paraquat: conceitos, modo de ação e doenças relacionadas. *Semina: Ciências Biológicas e da Saúde*, 34, 175-186. DOI: 10.5433/1679-0367.2013v34n2p175.

Meotti, G. V., Benin, G., Silva, R. R., Beche, E., Munaro, L. B. 2012. Épocas de semeadura e desempenho agronômico de cultivares de soja. *Pesquisa Agropecuária Brasileira*, 47, 14-21.

Nakagawa, J. 1994. *Teste de vigor baseado no crescimento de plântulas*. In: Vieira, R. D., Carvalho, N. M. de. *Teste de Vigor de Sementes*. Jaboticabal: FUNEP, 164 p.

Pelúzio, J. M., Ramo, L. N., Fidelis, R. R., Afférri, F. S., Castro Neto, M. D., Correia, M. A. R. 2008. Influência da dessecação química e retardamento de colheita na qualidade fisiológica de sementes de soja no sul do Estado do Tocantins. *Bioscience Journal*, 24, 77-82.

Pereira, T., Coelho, C. M. M., Souza, C. A., Mantovani, A., Mathias, V. 2015. Dessecação química para antecipação de colheita em cultivares de soja. *Semina: Ciências Agrárias*, 36, 2383-2394. DOI: 10.5433/1679-0359.2015v36n4p2383.

Peske, S. T., Villela, F. A., Meneghello, G. E. 2012. *Fundamentos Científicos e Tecnológicos.* 3 Ed., p. 372-421.

Rodrigues, B. N., Almeida, F. S. 2011. *Guia de herbicidas*. 6ª Ed., Londrina, 697 p.

Sedyama, T. 2013. *Tecnologia e produção de sementes de soja*. Londrina: Mecenas, 352 p.

Terasawa, J. M., Panobianco, M., Possamai, E., Koehler, H. S. 2009. Antecipação da colheita na qualidade fisiológica de sementes de soja. *Bragantia*, 68, 765-773. DOI: 10.5433/1679-0359.2015v36n4p2383.

Toledo, M. Z., Ishizuka, M. S., Cavariani, C., França-Neto, J. B., Picoli, L. B. 2014. Pre-harvest desiccation with glyphosate and quality of stored soybean seeds. *Semina: Ciências Agrárias,* 35, 765-774. DOI: 10.5433/1679-0359.2014v35n2p765.

Toni, L. R. M., Santana, H., Zaia, D. A. M. 2006. Adsorção de glifosato sobre solos e minerais. *Química Nova*, 29, 829-833.

Vargas, L., Roman, E. S. 2006. *Resistência de plantas daninhas a herbicidas: conceitos, origem e evolução.* Passo Fundo: Embrapa Trigo, 22 p.