http://dx.doi.org/10.1590/2317-1545v37n2148363

Seeds treatment times in the establishment and yield performance of soybean crops[1]

Cristian Rafael Brzezinski[2*], Ademir Assis Henning[3], Julia Abati[2], Fernando Augusto Henning[3], José de Barros França-Neto[3], Francisco Carlos Krzyzanowski[3], Claudemir Zucareli[2]

ABSTRACT – The objective was to assess the early treatment effect of soybean seeds and pre-sowing with different combinations of chemicals on the establishment of plants and crop yield performance. The design was in randomized blocks in a 2x7 factorial arrangement, with two times for seed treatment and seven treatments (six chemical treatments and an untreated control). The treatments were: 1) fipronil + pyraclostrobin + thiophanate methyl; 2) imidacloprid + thiodicarb + carbendazin + thiram; 3) abamectin + thiamethoxam + fludioxonil + mefenoxam + thiabendazole; 4) carbendazin + thiram; 5) fludioxonil + mefenoxam + thiabendazole; 6) carboxin + thiram; and 7) untreated control (water only). The assessments were: seedling emergence, final stand, plant height and insertion of first pod, number of pods per plant, seeds per pod and per plant, thousand-seed weight and grain yield. Early treatment of soybean seeds (240 days prior to sowing) hinders the establishment of the crop, the thousand-seed weight and grain yield in relation to the pre-sowing treatment. Chemical treatments tested containing fungicides and insecticides associated favor the establishment of the crop, but do not alter the soybean yield performance.

Index terms: *Glycine max* (L.) Merrill, fungicides, insecticides, seedling emergence, grain yield.

Épocas de tratamento de sementes no estabelecimento e desempenho produtivo da cultura da soja

RESUMO – O objetivo foi avaliar o efeito do tratamento de sementes de soja antecipado e em pré-semeadura com diferentes combinações de produtos químicos, sobre o estabelecimento de plantas e desempenho produtivo da cultura. O delineamento foi de blocos ao acaso, em esquema fatorial 2x7, sendo, duas épocas de tratamento de sementes e sete tratamentos (seis tratamentos químicos e uma testemunha sem tratamento). Os tratamentos foram: 1) fipronil + piraclostrobina + tiofanato metílico; 2) imidacloprido + tiodicarbe + carbendazin + thiram; 3) abamectina + tiametoxan + fludioxonil + mefenoxam + thiabendazole; 4) carbendazin + thiram; 5) fludioxonil + mefenoxam + thiabendazole; 6) carboxin + thiram; e 7) testemunha sem tratamento (somente água). As avaliações foram: emergência de plântulas, estande final, altura de plantas e inserção da primeira vagem, número de vagens por planta, sementes por vagens e por planta, massa de mil sementes e produtividade de grãos. O tratamento de sementes de soja antecipado (240 dias antes da semeadura) prejudica o estabelecimento da cultura, a massa de mil sementes e a produtividade de grãos, em relação ao tratamento em pré-semeadura. Os tratamentos químicos testados contendo fungicidas e inseticidas associados favorecem o estabelecimento da cultura, porém não alteram o desempenho produtivo da soja.

Termos para indexação: *Glycine max* (L.) Merrill, fungicidas, inseticidas, emergência de plântulas, produtividade de grãos.

Introduction

In the field, soybean plants are subject to biotic and abiotic stresses that can negatively affect their development and thus the grain yield. These production losses occur primarily through the occurrence of diseases, pests and nematodes (Bradley, 2008).

The most important diseases in soybean crops are caused by fungi, which can be transmitted by seeds or already be present in the soil at planting. These pathogens, associated or not to soil pests, harm germination and seedling establishment, thereby reducing the stand and crop yield (Lucca Filho, 2003; Mertz et al., 2009). Nematodes can also affect the soybean crop by infection of the roots, causing stand failure, lower

[1]Submitted on 04/09/2015. Accepted for publication on 06/01/2015.
[2]Departamento de Agronomia, UEL, Caixa Postal 6001, 86051-990 - Londrina, PR, Brasil.
[3] Embrapa Soja, Caixa Postal 231, 86001-970 – Londrina, PR, Brasil.
*Corresponding author <cristian_brzezinski@yahoo.com.br>

development and death of seedlings, affecting the final crop yield (Araujo et al., 2012; Dias et al., 2010).

Several tillage techniques are adopted so that these factors can cause the least possible damage to the soybean crop, and chemical seed treatment stands out. This process consists of applying compounds capable of protecting seeds against these deleterious effects, helping to control these diseases in the initial period of crop establishment, favoring the seedling emergence and development (Balardin et al., 2011).

The seeds chemical treatment was usually performed in pre-sowing, both in the farmer's property and in the resale itself. However, with the technological advancement of agriculture, seed companies are adopting techniques that can optimize logistics and maximize crop yield, such as the industrial seed treatment (IST). In this process, seeds are treated in the processing line itself and subsequently bagged and stored until the sowing time.

IST associates the use of innovative equipment and techniques such as the use of new formulations containing fungicides, insecticides and nematicides in the same treatment, as well as its carrier, which can maximize efficiency of the products, help protect operators and avoid environmental contamination.

Despite the benefits, industrial treatment may have some limiting factors, such as the possible effects that the active ingredients of the chemical products have on the seeds during storage, and later in the field. According to Munkvold et al. (2006) insecticides active ingredients may in some circumstances be harmful to seeds. Vanin et al. (2011) have found that treating sorghum seeds with the active ingredient acephate has caused reductions in germination percentage and seedling emergence due to phytotoxicity. Dan et al. (2013) have found reductions in the emergence of seedlings derived from soybean seeds treated with insecticide thiamethoxan during storage.

Given the above, and knowing that seed treatment has become a practice incorporated into agricultural production, particularly for soybean and maize, it is essential to study new formulations combinations that are being used in the IST. As well as the effect of storage of treated seed on the establishment of plantations and the development of soybean in the field.

The objective of this study was to assess the early treatment effect of soybean seeds and pre-sowing with different combinations of chemicals on the establishment of plants and crop yield performance.

Material and Methods

The experiments were conducted during the 2012/2013 harvest, in two locations with different soil and climatic characteristics. The first area was located in the Brazilian city of Faxinal, PR (location 1), which is at a latitude 23° 56' 38.26'' S; longitude 51° 14' 04.03'' W, with an altitude around 1056 m. The climate, according to Köppen climate classification, is Cfa, mesothermal humid subtropical with an average temperature in the coldest month below 15 °C and maximal annual average temperature at 23 °C. The second experimental area was in the Brazilian city of Boa Esperança, PR (location 2), with latitude 24° 17' 30.40'' S and longitude 52° 45' 43.33'' W, and altitude around 618 m. The climate, according to Köppen climate classification, is Cfa, with an average temperature in the coldest month below 15 to 18 °C and maximum annual average temperature from 27 to 29 °C (IAPAR, 2014).

The maximum and minimum daily temperature data and rainfall during the growing period for the two experimental areas are presented in Figure 1.

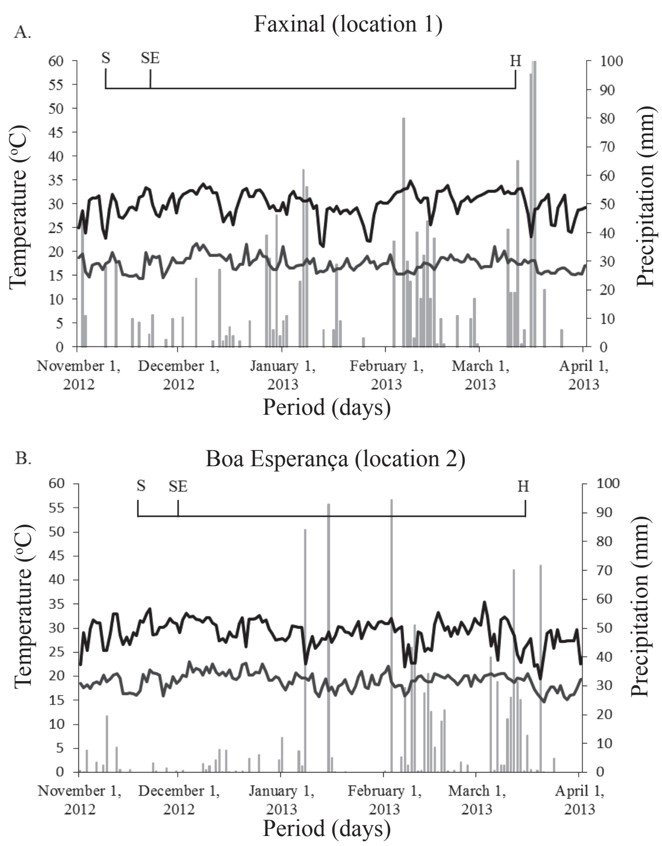

Figure 1. Maximum and minimum daily temperatures (°C) and rainfall (mm) in the Brazilian cities of Faxinal (location 1) (A) and Boa Esperança (location 2) (B) for the soybean crop development period. S: sowing; SE: seedling emergence; and H: harvest.

Soybean cultivars assessed were the BRS 360 RR, presenting early maturity of 105-120 days with relative maturity group 6.2, of indeterminate growth and edaphoclimatic region of adaptation 2. And cultivar BRS 284 of early cycle with relative maturity group 6.3, of indeterminate growth and regions of adaptation 1, 2 and 3 (Carneiro et al., 2013).

The seeds used in the experiment were subjected to two times of treatment with different products and formulations, and time 1: early seeds treatment (seeds treated and stored in a non-controlled temperature environment for 240 days in order to simulate the conditions and the maximum storage period used in the industrial processing of soybean seeds); time 2: treated seeds just before sowing (pre-sowing). The spray solution volume used was 600 mL.100 kg^{-1} of seeds, with the indicated dosage of the product and water (product + water). Seed treatment was made in polyethylene bags. The products were added to disposable syringes and the bags were vigorously shaken for homogeneous distribution of the spray solution over the seeds. The chemical treatments used are presented in Table 1.

Table 1. Active ingredients, commercial products, types and doses used for seed treatment of soybean cultivars BRS 360 RR and BRS 284.

Treatments	Active ingredient (a.i.)	Trade name	Type[1]	Commercial product dose[2]	Water dose[3]
1	fipronil + pyraclostrobin + thiophanate-methyl	Standak Top®	I + F + F	200	400
2	imidacloprid + thiodicarb + carbendazin + thiram	Cropstar® + Derosal Plus®	I + I + F + F	300+200	100
3	abamectin + thiamethoxam + fludioxonil + mefenoxam + thiabendazole	Avicta Completo (Avicta 500 FS® + Cruiser® 350 FS + Maxim Advanced®)	N + I + F + F + F	200+125+100	175
4	carbendazin + thiram	Derosal Plus®	F + F	200	400
5	fludioxonil + mefenoxam + thiabendazole	Maxim Advanced®	F + F + F	100	500
6	carboxin + thiram	Vitavax-Thiram 200 SC®	F + F	250	350
7	Control without treatment	-	-	-	600

[1]Type: I: insecticide; F: fungicide and N: nematicide
[2] Commercial product dose: mL.100 kg^{-1} of seeds
[3] Water dose: mL.100 kg^{-1} of seeds
Spray solution volume: 600 mL.100 kg^{-1} of seeds

The experimental design was randomized blocks in a 2x7 factorial arrangement, with four replications, being the factors: two treatment times (early treatment of seeds and in pre-sowing); and seven seed treatments (six chemical treatments and an untreated control – only with water).

The experimental plot consisted of four rows, six meters long, with row spacing of 0.5 m. The two central rows were considered as the plot floor area, leaving 0.5 m at the ends (borders). Sowing was performed mechanically with a density of 16 seeds per linear meter in the planting furrow. Fertilization and cultivation were the same as those used in the commercial fields where the experiments were conducted.

To determine the establishment of plants and yield performance of soybean cultivars, the following assessments were held:

Seedling emergence and plant final stand: the number of plants present in the four rows of each plot was recorded. For the variable seedling emergence, the assessment was conducted on the twelfth day after sowing, and for the final stand at harvest. The results were expressed as percentages.

Plants heights: assessed in ten plants randomly measured from the floor area of each plot, in full maturity stage (95% of pods with ripe coloring – R8) from the soil surface to the apical end of the main stem. The results were expressed in centimeters.

First pod insertion height: determined by assessing ten plants randomly collected in the floor area of each experimental plot, measuring the distance from the plant neck to the insertion of the first pod. The results were expressed in centimeters.

Number of pods per plant: obtained by the ratio between the number of pods and the total number of sample plants, in this case, ten plants per plot.

Number of seeds per pod: determined by the ratio between the total number of seeds and the total number of pods of ten plants randomly taken from the floor area of the plot.

Number of seeds per plant: determined by the ratio between the total number of seeds and the total number of plants, in this case, ten plants randomly taken from the floor area of the plot.

Thousand-seed weight: obtained by means of eight subsamples of 100 seeds per replication. Based on the weight of the subsamples, determined by an analytical balance, the mean, variance, standard deviation and coefficient of variation were calculated for subsequently obtaining the thousand-seed weight (Brasil, 2009). The result was expressed in grams.

Grain yield: obtained by weighing the seeds harvested in the floor area of each experimental plot, with humidity corrected to 13.0% (wet basis) and transformed into $kg.ha^{-1}$.

The data were submitted to normality tests (Shapiro-Wilk) and homoscedasticity (Hartley) and by means of these ones it was verified that there was no need for transformation. Analysis of variance was carried out and means were compared by Tukey test at 5% probability, separately for each cultivar and location. Analyses were performed using the computer program Sistema para Análise de Variância – SISVAR (System for Analysis of Variance) (Ferreira, 2011).

Results and Discussion

By means of the data obtained, it was found that there was no interaction between the factors studied. Thus, only the significant single effects were presented for treatment times and seeds chemical treatment.

Early treatment of seeds (time 1) for both cultivars and crop locations has damaged seedling emergence compared to treatment in pre-sowing (time 2) (Table 2). This result may be associated with reduced seed physiological quality (germination and vigor) during the storage period, marked by a possible phytotoxic effect of the active ingredients of the chemicals used in the treatments. Similar results were found by Krohn and Malavasi (2004) and Pereira et al. (2011), upon noticing that soybean seeds treated with fungicides and stored for longer than four months and six months, respectively, had lower emergence compared to the other treatment times.

Table 2. Yield performance of two soybean cultivars (BRS 360 RR and BRS 284) yield in the Brazilian cities of Faxinal (location 1) and Boa Esperança (location 2), according to two seed treatment times: treated and stored seeds (time 1) and seeds treated in pre-sowing (time 2).

Faxinal (location 1)		
--------------- BRS 360 RR ---------------		
Times	SE (%)	M1000 (g)
1	92 b	170.9 b
2	96 a	250.9 a
CV (%)	1.64	4.37

---------------- BRS 284 ---------------					
Times	SE (%)	FS (%)	NPP	NSP	M1000 (g)
1	57 b	53 b	68.2 a	149.4 a	162.4 b
2	80 a	73 a	61.1 b	132.0 b	174.6 a
CV (%)	7.36	7.23	14.32	15.80	4.46

Boa Esperança (location 2)						
---------------- BRS 360 RR ----------------						
Times	SE (%)	FS (%)	PIH (cm)	NSPo	NSP	PRO ($kg.ha^{-1}$)
1	57 b	56 b	9.87 a	1.83 a	122.96 a	2505.5 b
2	65 a	62 a	8.33 b	1.41 b	95.62 b	2684.7 a
CV (%)	11.13	9.21	30.40	19.26	20.39	13.99
---------------- BRS 284 ----------------						
Times	SE (%)	FS (%)	PIH (cm)	NPP	NSPo	NSP
1	41 b	37 b	8.14 a	104.49 a	1.70 a	176.4 a
2	55 a	46 a	7.30 b	89.58 b	1.47 b	131.6 b
CV (%)	12.81	13.58	20.93	19.11	17.39	22.79

Means within each column followed by the same letter do not differ by Tukey test ($p \leq 0.05$).
SE: seedling emergence; FS: plants final stand; PIH: insertion height of the first pod; NPP: number of pods per plant; NSPo: number of seeds per pod; NSP: number of seeds per plant; M1000: thousand-seed weight and PRO: grain yield.

Regarding the effect of chemical treatments on seedling emergence, it was observed that treatments 1 (fipronil + pyraclostrobin + thiophanate-methyl) and 3 (abamectin + thiamethoxam + fludioxonil + mefenoxam + thiabendazole) propitiated highest percentages of emergence for both cultivars sowed at location 2 (Table 3). This result demonstrates the importance of using the new combinations (insecticide + fungicide or insecticide + fungicide + nematicide) in seed treatment. Mainly due to the beneficial effect promoted when controlling pathogens and insect pests, especially when sowing coincides with adverse conditions of temperature and rainfall distribution, as happened at location 2 (Figure 1B).

Table 3. Seedling emergence (SE), final plant stand (FS) and thousand-seed weight (M1000) for two soybean cultivars (BRS 360 RR and BRS 284) grown in the Brazilian city of Boa Esperança (location 2), with different chemical treatments.

--------------- BRS 360 RR ---------------			
Treatments[1]	SE (%)	FS (%)	M1000 (g)
1	70 a	68 a	124.7 ab
2	63 ab	63 ab	125.1 ab
3	71 a	68 a	112.1 b
4	59 b	57 bc	114.6 ab
5	54 b	50 c	125.6 a
6	57 b	50 c	124.8 ab
7 (control)	53 b	50 c	126.3 a
CV (%)	11.13	9.21	8.07
--------------- BRS 284 ---------------			
Treatments	SE (%)	FS (%)	
1	57 a	50 a	
2	51 ab	47 ab	
3	58 a	54 a	
4	49 ab	41 bc	
5	45 b	39 bc	
6	46 b	38 c	
7 (control)	32 c	26 d	
CV (%)	12.81	13.58	

Means within each column followed by the same letter do not differ by Tukey test ($p \leq 0.05$).

[1]Treatments: 1: fipronil + pyraclostrobin + thiophanate-methyl; 2: imidacloprid + thiodicarb + carbendazin + thiram; 3: abamectin + thiamethoxam + fludioxonil + mefenoxam + thiabendazole; 4: carbendazin + thiram; 5: fludioxonil + mefenoxam + thiabendazole; 6: carboxin + thiram; 7: control (no treatment).

From the results, it was also possible to see that, for the experiment conducted in location 1, the lack of a significant effect of chemical treatment for the variable seedling emergence was probably due to the favorable conditions of humidity and temperature during the crop establishment (Figure 1A). According to Goulart (2005), the effect of the treatment becomes somewhat evident when soybeans are planted in ideal conditions of temperature and soil moisture due to the rapid germination and seedling emergence providing an escape in relation to the attack of soil fungi. However, when seeding is performed in water deficit conditions, as in the second location, the protective effect of treatment of soybean seeds becomes more evident. Balardin et al. (2011) and Conceição et al. (2014) working with soybeans, and Abati et al. (2014) with wheat, have achieved a similar result, when observing that treating seeds with fungicides, insecticides and polymers alone or combined have resulted in higher emergence values in the field. According to Pereira et al. (1993), the treatment protective effect on the seeds can last for a period of four to 12 days; however, this effect depends on a combination of several factors such as the product formula and mode of action, the treatment quality and the seeds physical and physiological quality.

The results found on the assessment of the plants final stand corroborate those obtained in seedling emergence (Tables 2 and 3), both for seed treatment times and for the chemical treatments. Thus it demonstrates that there was no significant reduction in stand along the development of the crop in terms of environment biotic and abiotic factors.

For the variable insertion height of the first pod, there was an effect of seed treatment times only for the experiment conducted in location 2 (Table 2). From the averages presented, higher insertion height of the first pod for the plants grown from seeds submitted to the early treatment (time 1) was seen in both cultivars. However, despite this significant difference, there was no need to change the height of the harvester cutting boom because these were 9.87 and 8.33 cm for cultivar BRS 360 RR and 8.14 and 7.30 cm for cultivar BRS 284, for seeds treated and stored and treated in pre-sowing, respectively.

As for the yield components, there was an isolated effect of seed treatment times for the number of pods per plant, of seeds per pod and seeds per plant of cultivar BRS 284, produced in both crop locations, and for the number of seeds per pod and seeds per plant of cultivar BRS 360 RR produced in location 2 (Table 2). It was observed that the early treatment of seeds (time 1) led to the development of plants with a larger number of pods, seeds per pod and seeds per plant, compared to the treatment performed in pre-sowing (time 2). These differences were found due to the reduced plant population observed in the assessment of seedling emergence. This result is closely related to the balance between the production of flowers per plant and the ratio of these who develop until the pod, since the number of flowers per plant is determined by the number of flowers per node and the number of nodes per plant. At higher densities, there is greater competition for light and reduced availability of photoassimilates, causing the plant to decrease the number of branches and produce a smaller number of nodes. In these nodes, the reproductive buds develop. Thus, decreasing the number of branches reduces the number of potential nodes, and consequently, the number of pods and their components (Bord and Settimi, 1986; Jiang and Egli, 1993; Mauad et al., 2010).

For the thousand-seed weight of cultivar BRS 284 assessed in the experiment conducted in location 1, the treatment in pre-sowing (time 2) had yielded increased thousand-seed weight produced in relation to the early treatment (time 1) (Table 2). This difference may be due to reduced seed quality during storage, more sharply for chemically treated seeds. Consequently, the crop establishment was damaged, and thus, under smaller populations, soybean plants tend to adapt to these conditions by means of changes in plant morphology and yield components, producing a higher number of pods per plant and a higher number of seeds per pod. As for populations that are appropriate to plants, they distribute better their photoassimilates for grain filling, favoring the increase of their average mass. Similar results were obtained by Mauad et al. (2010), in work performed in order to assess the effect of sowing density in the soybean yield components.

When comparing the chemical treatments, it was observed for location 1 that the plants in treatment 3 (abamectin + thiamethoxam + fludioxonil + mefenoxam + thiabendazole) produced seeds with lower mass compared to control for cultivar BRS 360 RR (Table 3). However, this difference probably did not occur due to the active ingredients of the products used in the treatment, but by the reduction of the establishment of plants associated with soybeans recovery plasticity, observed from the seedling emergence, as shown above.

For grain yield, there was a single effect of seed treatment times only for cultivar BRS 360 RR produced in location 2 (Table 2). It was observed that the treatment in pre-sowing (time 2) provided greater grain yield compared to the early treatment (time 1), with an average yield of 2684 and 2505 $kg.ha^{-1}$, respectively. However, these values were found below the national average obtained for the same harvest, which was 2854 $kg.ha^{-1}$ (CONAB, 2014). This was due to the water restriction period observed in the experimental site during the crop establishment (Figure 1B), which hindered the plants development and, consequently, the yield components (number of seeds per pod and number of seeds per plant).

Based on the results obtained, it is possible to see the importance of an appropriate choice of treatment time and seed chemical treatments compared to the establishment of plants in the field, especially under adverse conditions of temperature and humidity, as a precursor for obtaining high yields of grains. Thus, for the tested treatment times, treatment in pre-sowing favored the establishment of plants in the field and grain yield in relation to early treatment (240 days). However, the importance of new studies testing more treatment times should be emphasized, mainly related to reduced storage time of treated seeds in order to avoid possible phytotoxic effects of the products active ingredients on the seeds that later harm the establishment and development of plants in the field.

Conclusions

Early treatment of soybean seeds (240 days prior to sowing) hinders the establishment of the crop, the thousand-seed weight and grain yield in relation to the pre-sowing treatment.

Chemical treatments tested containing fungicides and insecticides associated favor the establishment of the crop, but do not alter the soybean yield performance.

Acknowledgments

To CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior; Brazilian Coordination of Improvement of Higher Education), for granting the scholarship to the first author. To Universidade Estadual de Londrina and the company Empresa Brasileira de Pesquisa Agropecuária, Centro Nacional de Pesquisa de Soja (Embrapa Soja) for the structure and financial support for the development of the work.

References

ABATI, J.; ZUCARELI, C.; FOLONI, J.S.S; HENNING, F.A.; BRZEZINSKI, C.R.; HENNING, A.A. Treatment with fungicides and insecticides on the physiological quality and health oh wheat seeds. *Journal of Seed Science*, v.36, n.4, p.392-398, 2014. http://www.scielo.br/pdf/jss/v36n4/a02v36n4.pdf

ARAUJO, F.F.; BRAGANTE, R.J.; BRAGANTE, C.E. Controle genético, químico e biológico de meloidoginose na cultura da soja. *Pesquisa Agropecuária Tropical*, v.42, n.2, p.220-224, 2012. http://www.scielo.br/pdf/pat/v42n2/13.pdf

BALARDIN, R.S.; SILVA, F.D.L.; DEBONA, D.; CORTE, G.D.; FAVERA, D.D.; TORMEN, N.R. Tratamento de sementes com fungicidas e inseticidas como redutores dos efeitos do estresse hídrico em plantas de soja. *Ciência Rural*, v.41, n.7, p.1120-1126, 2011. http://www.scielo.br/pdf/cr/v41n7/a5711cr4207.pdf

BORD, J.E.; SETTIMI, J.R. Photoperiod effect before and after flowering on branch development in determinate soybean. *Agronomy Journal*, v.78, n.6, p.995-1002, 1986. http://www.researchgate.net/publication/250102478_Photoperiod_Effect_Before_and_After_Flowering_on_Branch_Development_in_Determinate_soybean

BRADLEY, C.A. Effect of fungicide seed treatments on stand establishment, seedling disease, and yield of soybean in North Dakota. *Plant Disease*, v.92, n.1, p.120-125, 2008. http://apsjournals.apsnet.org/doi/pdf/10.1094/PDIS-92-1-0120

BRASIL. Ministério da Agricultura, Pecuária e Abastecimento. *Regras para análise de sementes*. Ministério da Agricultura, Pecuária e Abastecimento. Secretaria de Defesa Agropecuária. Brasília: MAPA/ACS, 2009. 395p. http://www.agricultura.gov.br/arq_editor/file/2946_regras_analise__sementes.pdf

CARNEIRO, G.E.S.; PÍPOLO, A.E.; MELO, C.L.P.; LIMA, D.; MIRANDA, L.C.; PETEK, M.R.; BORGES, R.S.; GOMIDE, F.B.; DALBOSCO, M.; DENGLER, R.U. *Cultivares de soja – Macrorregiões 1, 2, 3*. Centro-sul do Brasil. Embrapa Soja, Londrina, PR, 2013. 56p.

CONAB. Companhia Nacional de Abastecimento. *Acompanhamento da safra brasileira – Grãos*. Disponível em: http://www.conab.gov.br/OlalaCMS/uploads/arquivos/14_06_10_12_12_37_boletim_graos_junho_2014.pdf Accessed on: July 12th, 2014.

CONCEIÇÃO, G.M.; BARBIERI, A.P.P.; LÚCIO, A.D.; MARTIN, T.N.; MERTZ, L.M.; MATTIONI, N.M.; LORENTZ, L.H. Desempenho de plântulas e produtividade de soja submetida a diferentes tratamentos químicos nas sementes. *Bioscience Journal*, v.30, n.6, p.1711-1720, 2014. http://ainfo.cnptia.embrapa.br/digital/bitstream/item/113098/1/Desempenho-de-plantulas-e-produtividade-de-soja-submetida-a-diferentes-tratamentos-quimicos-nas-sementes.pdf

DAN, L.G.M.; BRACCINI, A.L.; BARROSO, A.L.L.; DAN, H.A.; PICCININ, G.G.; VORONIAK, J.M. Physiological potential of soybean seeds treated with thiamethoxam and submitted to storage. *Agricultural Sciences*, v.4, n.11, p.19-25, 2013. http://www.scirp.org/journal/PaperInformation.aspx?PaperID=40173

DIAS, W.P.; GARCIA, A.; SILVA, J.F.V.; CARNEIRO, G.E.S.N. *Nematoides em Soja*: Identificação e controle. Londrina-PR: Embrapa Soja, 2010. 8p. (Circular Técnica, 76). http://www.cnpso.embrapa.br/download/CT76_eletronica.pdf

FERREIRA, D.F. Sisvar: A computer statistical analysis system. *Ciência e Agrotecnologia*, v.35, n.6, p.1039-1042, 2011. http:/www.scielo.br/pdf/cagro/v35n6/a01v35n6.pdf

GOULART, A.C.P. *Importância do tratamento de sementes de soja com fungicidas em condições de déficit hídrico do solo*. Embrapa Agropecuária Oeste. 2005. 6p (Comunicado Técnico, 106). http://ainfo.cnptia.embrapa.br/digital/bitstream/item/24686/1/COT2005106.pdf

IAPAR. Instituto Agronômico do Paraná. *Cartas climáticas do Estado do Paraná*. http://200.201.27.14/Sma/Cartas_Climaticas/Classificacao_Climatica.htm. Accessed on: May 21th, 2014.

JIANG, H.; EGLI, D.B. Shade induced change in flower and pod number and flower and fruit abscission in soybean. *Agronomy Journal*, v.85, n.2, p.221-225, 1993. https://www.agronomy.org/publications/aj/abstracts/85/2/AJ0850020221?access=0&view=pdf

KROHN, G.N.; MALAVASI, M.M. Qualidade fisiológica de sementes de soja tratadas com fungicidas durante e após o armazenamento. *Revista Brasileira de Sementes*, v.26, n.2, p.91-97, 2004. http://www.scielo.br/pdf/rbs/v26n2/24494.pdf

LUCCA FILHO, O.A. *Patologia de Sementes*. In: PESKE, S.T., TOSENTHAL, M.D., ROTA, G.R. (Eds.) Sementes: Fundamentos Científicos e Tecnológicos. Ed. Universitária. 2003. p.225-282.

MAUAD, M.; SILVA, T.L.B.; ALMEIDA NETO, A.I.; ABREU, V.G. Influência da densidade de semeadura sobre características agronômicas na cultura da soja. *Revista Agrarian*, v.3, n.9, p. 175-181, 2010. http://www.periodicos.ufgd.edu.br/index.php/agrarian/article/view/75/649

MERTZ, L.M.; HENNING, F.A.; ZIMMER, P.D. Bioprotetores e fungicidas químicos no tratamento de sementes de soja. *Revista Ciência Rural*, v.39, n.1, p.13-18, 2009. http://www.scielo.br/pdf/cr/v39n1/a03v39n1.pdf

MUNKVOLD, G.; SWEETS, L.; WINTERSTEEN, W. *Iowa commercial pesticide applicator manual* – Category 4. Ames: Iowa State University, 2006. 39p.

PEREIRA, L.A.G.; COSTA, N.P.; ALMEIDA, M.R.; FRANÇA-NETO, J.B.; GIGLIOLI, J.L.; HENNING, A.A. Tratamento de sementes de soja com fungicida e/ ou antibiótico, sob condição de semeadura em solo com baixa disponibilidade hídrica. *Revista Brasileira de Sementes*, v.15, n.2, p.241-246, 1993. http://www.abrates.org.br/revista/artigos/1993/v15n2/artigo17.pdf

PEREIRA, C.E.; OLIVEIRA, J.A.; GUIMARÃES, R.M.; VIEIRA, A.R.; EVANGELISTA, J.R.E.; OLIVEIRA, G.E. Tratamento fungicida e peliculização de sementes de soja submetidas ao armazenamento. *Ciência e Agrotecnologia*, v.35, n.1, p.158-164, 2011. http://www.scielo.br/pdf/cagro/v35n1/a20v35n1.pdf

VANIN, A.; SILVA, A.G.; FERNANDES, C.P.C.; FERREIRA, W.S.; RATTES, J.F. Tratamento de sementes de sorgo com inseticidas. *Revista Brasileira de Sementes*, v.33, n. 2, p. 299-309, 2011. http://www.scielo.br/pdf/rbs/v33n2/12.pdf