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Desiccants application season in pre-emergence in conventional soybeans[1]

Época de aplicação de dessecantes em pré-emergência na soja convencional

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Abstract - The weed management in soybean cultures stands out as an important tool to ensure its high yield potential. The direct tillage advent increased the importance of management performed in the soybean off season and pre-seeding, in order to avoid the weeds interference in the initial cultivation period. The survey was conducted in order to evaluate the weeds control and the agronomic performance of conventional soybean, using different desiccant herbicides. The experiment was conducted in randomized blocks design with four replications. Treatments were arranged in factorial 4x3, the first factor being the glyphosate herbicides application - diisopropylamine salt; glyphosate - potassium salt, glyphosate isopropylamine- salt + 2,4-D; and paraquat + diuron, the second factor the application time periods (13 and 7 days before seeding - DBS; and 1 day after seeding - DAS). The percentage of weed control, booth, seedling emergence, plants height, number of pods, mass of hundred seeds and productivity were evaluated. Only the management desiccation with glyphosate near the seeding time showed a decrease in the weeds control percentage, the glyphosate + 2,4-D use led to a decrease in the early crop growth, due to seeding proximity, the paraquat + diuron application near the seeding season caused a lower insertion of the first pod in the culture. There were no significant differences between treatments for soybean production components under these experimental conditions.
Keywords: burndown; phytotoxicity of herbicides; weeds

Resumo - O manejo de plantas daninhas na cultura da soja destaca-se como importante ferramenta para assegurar seu alto potencial produtivo. O advento do plantio direto aumentou a importância do manejo realizado na entressafra e pré-semeadura da soja visando evitar a interferência das plantas daninhas no período inicial do cultivo. A pesquisa foi realizada com o

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objetivo de avaliar o controle de plantas daninhas e o desempenho agronômico da soja convencional com o uso de diferentes herbicidas dessecantes. O experimento foi realizado no delineamento de blocos casualizados, com quatro repetições. Os tratamentos foram arranjados no esquema fatorial 4x3, sendo o primeiro fator constituído dos herbicidas aplicados glyphosate - sal isopropilamida; glyphosate – sal de potássio; glyphosate – sal isopropilamida + 2,4-D; e paraquat + diuron e o segundo fator das épocas de aplicação (13 e 7 dias antes da semeadura - DAS; e 1 dia depois da semeadura - DDS). Avaliou-se o porcentual de controle de plantas daninhas, estande, emergência de plântulas, altura de plantas, número de vagens, massa de cem sementes e produtividade. A dessecação de manejo somente com glyphosate próximo a semeadura ocasionou decréscimo no percentual de controle de plantas daninhas, já uso de glyphosate + 2,4-D ocasionaram diminuição no crescimento inicial do cultivo devido à proximidade com a semeadura, aplicação de paraquat+diuron próximo a época se semeadura causou menor inserção de primeira vagem na cultura. Não houve diferenças significativas entre os tratamentos para componentes de produção da soja, nestas condições experimentais.
Palavras-chaves: dessecação de manejo; fitotoxicidade de herbicidas; plantas daninhas

Introduction

Soybean (*Glycine max* (L.) Merrill) is a crop with high representation in the national production, its production complex corresponding to 12.8% only of exports from Brazil (CONAB, 2014). This commodity obtained a production increase of 7.4%, with 87.6 million tones production in 2013/14 crop (FAESPSENAR, 2014), the state of Paraná being the second largest producer (CONAB, 2014).

To ensure high yields, the weed control is of great importance in agriculture, as it represents 20 to 30% of the production cost of large cultures (Smith, 2010). The soybean crop due to horseweed interference (*Coniza* spp.) has in its yield losses from 20 to 70%, according to this weed infestation level (Gazziero et al., 2010). Besides, the soybean cohabitation with sourgrass (*Digitaria insularis*) causes yield losses from 23 to 44% with populations of 1-8 plants per m^{-2} (Gazziero et al., 2012).

With the direct planting advent, the weeds control in the off-season and pre-seeding period has become the most widely used method in order to eliminate or reduce weeds presence in the initial development of soybean cultivation in Brazil. Initial high weed infestation can cause damage to the soybean crop by shorting the period prior interference (PAI), therefore the producer will have to handle these plants earlier with higher expenses and higher failure possibilities in control and re-growth (Pitelli, 1985; Silva et al., 2009).

The most widespread technique for this purpose is the application of non-selective desiccant herbicides, also known as management desiccation, specifically the use of molecules as glyphosate, 2,4-D and paraquat + diuron trade mixture (Procópio et al., 2006; Constantin e Oliveira Jr., 2005a). However, the desiccation management season has been one of the problems of these herbicides use, because when applied very close to the seeding season, it can exert negative influence on the culture development, if applied much earlier before seeding, it might fail in the plants weeds management, being subject to a new seeds flow, emerging during the critical period of the cultivation interference (PCPI) (Constantin and Oliveira Jr., 2005b; Pitelli, 1985).

The application time period of pre-emergent herbicides is also very influenced by the region soil and climatic characteristics, where the control effectiveness and the degradation of herbicides are directly linked to this factor (Procópio et al., 2006). Another factor that greatly influences in determining the application timing is the type and amount of vegetation cover (Procópio et al., 2006).

Therefore, in order to be more accurate, studies should be done in more regional character.

This study aimed to evaluate the weed control in pre-emergence of soybean crop and its agronomic performance, with herbicides use at different application period times.

Material and Methods

The experiment was conducted in the agricultural year of 2011/2012 in the experimental region in Palotina municipality, at a 320 m altitude. The soil was classified as eutrophic Red Latosol, with a clayey texture (EMBRAPA, 2006). The region has a subtropical climate (CFA), according to Köppen classification, with no defined dry season (Köppen and Geiger, 1928). The rainfall and maximum/minimum temperatures in 2011/12 crop, with the crop in the field, are represented in the Figure 1.

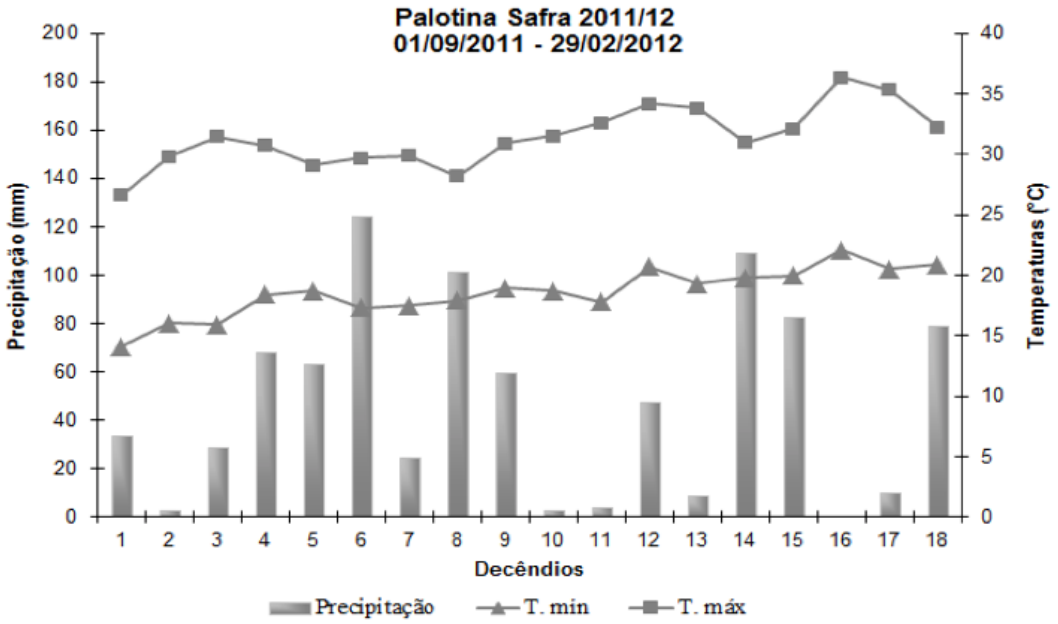

Figure 1. Harvest 2011/12, Rainfall (mm), Temperatures (C), Ten days period, Precipitation, Minimum temperature - Maximum temperature. Palotina, PR – 2011/2012.

The conventional soybean cultivar seeding VMax®, of indeterminate growth habit, was held on September 27, 2011, with direct tillage system respecting its agricultural zoning and regional recommendations, with a NPK fertilizer at 250 kg ha^{-1} basis of 2-20-20 formulation. This cultivation had as previous crop corn culture, planted in the second crop.

The experimental design was a randomized block with four replications. Treatments were arranged in factorial 4x3, the first factor consisting of the following herbicides application: (1440 g ha^{-1} glyphosate-diisopropylamine salt e.g. - Roundup Original, 360 L^{-1}g e.g., CS, MONSANTO); (1440 g ha^{-1} glyphosate–potassium salt e.g. – Roundup Transorb R, 480 L^{-1} g e.g., SL, MONSANTO); (1440 g ha^{-1} - Roundup Original + 2,4-D 1340 g ha^{-1} e.g. - 2,4-D NORTOX, 670 L^{-1} g e.g., SL, NORTOX); and paraquat + diuron, 500 + 250 g ha^{-1} e.g. - Gramocil, paraquat 200 L^{-1} g i.g. + diuron 100 L^{-1} g i.g., SC, SYNGENTA. The second factor being the application time periods (13 and 7 days before seeding - DBS; and 1 day after seeding - DAS).

Herbicides were applied using a O_2 pressurized knapsack sprayer, with six points fan type bar, 110.02 series, to which a 2 kgf- cm^{-2} pressure with spray volume of 200 L ha^{-1} was applied.

The three application time periods were held in ideal windy, temperature and relative humidity conditions. In addition to these treatments, a post-emergence weed control with Cobra® herbicide (lactofen) in the experimental plots was carried out, at 180 g ha^{-1}i.g. dosage, which is widely used in the region, between v3 and v4 vegetative stages, obtaining an effective control.

Given that, the area had a weed uniform distribution and phytosociology pattern, treatments were compared by assessing the weed control percentage 14 days after the last desiccants application. Through a SBCPD methodology adaptation (1995), where a percentage scale from 0 to 100 is established, where 0 represents no weed control, showing no symptoms of injury by the herbicide and 100 means a complete weed control.

In the soybean culture the booth (seven days after seeding), the plant height (at 15, 25 and 130 days after emergency-DAE), number of pods and the first pod insertion (R8.2 vegetative stage) were evaluated (Ritchie, 1982; Albrecht, 2014).

The soybean plots harvest was performed manually during the R8 vegetative stage, where over 95% of the plants showed optimal maturation (Fehr et al., 1971), and then using an experimental threshing, all plants of the experimental units were shelled with their grains separated from impurities and placed in Kraft paper bags for further assessment. The mass of one hundred seeds and productivity have also been estimated (corrected at 13% moisture and data transformed in $Kgha^{-1}$) (Albrecht, 2011).

Data were submitted to the variance analysis, carrying out all necessary contributions and when significant, the Tukey test average ($p \leq 0.05$) was performed, with the help of Sisvar® program (Ferreira, 1999).

Results and Discussion

As stated previously (Figure 1) the experiment suffered interference of meteorological factors, due to the occurrence of drought at the culture development critical periods in the region, reducing the development and production of evaluated soybeans. The environmental stress caused by meteorological parameters, as it will be seen, was a determining factor in the variables results, specifically those relevant to the culture productive performance.

Comparing treatments within the application time periods, there was no difference between weeds percentage control. As for the application periods within treatments, the first period (13 DBS) had better weed control than the last one (1 DAS) for glyphosate- diisopropylamine salt and glyphosate-potassium salt treatments (Table 1). It was observed that the glyphosate herbicide has difficulty in controlling some weeds with increased tolerance/resistance at an advanced vegetative stage (Placido et al., 2013; Santos, 2014; Christoffoleti et al., 2005).

Table 1. Weed control percentage evaluation, fourteen days after the last desiccant application periods in pre-emergence of conventional soybeans in Palotina municipality – Paraná.

Treatments	Weed control percentage		
	13 DBS	2 DBS	1 DAS
glyphosate-potassium salt	96.25 Aa	98.75 Aa	85.00 Ab
glyphosate-isopropylamine salt	100.00 Aa	93.75 Aab	86.25 Ab
glyphosate + 2,4-D	98.75 Aa	95.00 Aa	95.00 Aa
paraquat + diuron	95.00 Aa	87.50 Aa	86.25 Aa
Average	97.50 a	93.75 b	88.12 c
CV (%)		6.61	

* Averages followed by the same capital letter in the column and lowercase letter in the line, do not significantly differ by the Tukey test ($P \leq 0.05$).

In this experimental area horseweed species (*Conyza* spp. *L*.), sourgrass (*Digitaria insularis L*.), Beggar ticks (*Bidens subalternans L*.), Pigweed (*Amaranthus* sp. L.) and chamomile (*Gnaphalium coarctatum Willd*) were predominant. In Paraná western region, as well as in various grain-producing areas of Brazil, with an indiscriminate and successive historic of the glyphosate molecule use in transgenic crops, it causes a strong selection pressure on the weed flora, by selecting biotypes with increased tolerance or resistance to this molecule, as is the case of horseweed (Trezzi et al., 2010). *Conyza* sp. biotypes collected in Parana and studied by Trezzi et al. (2010) showed higher resistance factors than those already classified as resistant in the country. Moreover, in Cascavel and Tupãssi municipalities *Conyza sumatrensis* (Retz) E. Walker species biotypes with multiple resistances to glyphosate and chlorimuron-ethyl were found (Heap, 2014; Santos, 2014).

As for the remaining treatments they did not differ between seasons, their use not being so intensified, with not so many resistant biotypes cases in the country (Heap, 2014), beyond the fact that they are composed as well of two different action mechanisms, either by commercial mixing (paraquat + diuron) or herbicides combination (glyphosate + 2,4-D), turning them into a more complex system (by different action mechanisms association), in order to hinder the selection of resistant plants (Christoffoleti et al., 2008), providing a better control.

There was no direct negative influence on the booth culture (Table 2), comparing the developments within different treatments and application time periods. Only the treatment means within time periods were different, however we definitely cannot say that this fact is derived from damages caused by the seeding season proximity.

Table 2. Conventional soybean plants booth seven days after seeding, under different desiccants herbicides application periods in pre-emergence, in Palotina municipality - Paraná.

Treatments	Soybean culture plants booth		
	13 DBS	2 DBS	1 DAS
glyphosate-potassium salt	13.75 Aa	12.62 Aa	12.00 Aa
glyphosate-isopropylamine salt	15.75 Aa	13.62 Aa	12.62 Aa
glyphosate + 2,4-D	15.12 Aa	14.12 Aa	13.62 Aa
paraquat + diuron	14.62 Aa	12.62 Aa	12.37 Aa
Average	14.81 a	13.25 ab	12.65 c
CV (%)		13.35	

* Averages followed by the same capital letter in the column and lowercase letter in the line, do not significantly differ by the Tukey test ($P \leq 0.05$).

The initial plant height (Table 3) was higher for application periods with more days preceding the seeding season within the glyphosate + 2,4D treatment. When observing the weed control assessments and the seedling emergence values for the first period (13 DBS) they were numerically higher (Table 1), not significant though, therefore this numerical difference can show a trend that may have significantly reflected on the initial plant height. This glyphosate + 2,4-D treatment decrease can be justified by the fact that the latest application time periods were out of the withdrawal period, which is as per the manufacturers of seven days for these products (Syngenta, 2013; Nortox, 2006).

However, according to Oliveira Neto et al. (2013), the 2,4-D herbicide associated to glyphosate has not a long residual effect, nevertheless the dose used was half of the one used in the previous work, which would also attenuate the residual effect. According to Silva et al. (2011) the 2,4-D application close to V-Max soybean cultivar seeding can cause a

residual phytotoxic effect for a residual period in the first weeks, which reduced the initial seedlings emergence and the plants height. It also reports that this effect can be mitigated in soils with clay texture.

In the second plants height assessment (25 DBE) (Table 3), using the glyphosate-potassium salt molecule, growth declined in the last application season, coinciding with the worst time of weed control, where the initial interference preceding the post-emergence control could have significantly impaired the crop growth.

At 130 days after soybean emergence the plants height was not affected by treatments (Table 3). These results may be related to a possible culture recovery of injuries initially observed, corroborating Procópio et al. (2009), who did not identify a phytotoxic influence due to the glyphosate + 2,4-D treatment application next to the seeding period, in the plants height evaluation at 52 days after the conventional soybeans emergence.

Table 3. Soybean plants height at 15, 25 and 130 days after the culture emergence, at different periods of desiccant herbicides application in pre-emergence, in Palotina municipality - Paraná.

Treatments	Plants Initial Height (cm)		
	13 DBS	2 DBS	1 DAS
glyphosate-potassium salt	9.62 Aa	9.72 Aa	9.85 Aa
glyphosate-isopropylamine salt	9.77 Aa	9.10 Aa	9.60 Aa
glyphosate + 2,4-D	10.45 Aa	10.10 Aab	9.02 Ab
paraquat + diuron	9.82 Aa	10.05 Aa	9.07 Aa
Average	9.92 a	9.74 a	9.39 a
CV (%)		6.64	
Treatments	Height at 25 days after Emergence (cm)		
	13 DBS	2 DBS	1 DAS
glyphosate-potassium salt	19.15 Aab	21.25 Aa	18.80 Ab
glyphosate-isopropylamine salt	20.80 Aa	19.75 Aba	20.05 Aa
glyphosate + 2,4-D	19.25 Aa	20.55 Aba	18.25 Aa
paraquat + diuron	20.25 Aa	18.40 Ba	19.90 Aa
Average	19.85 a	19.99 a	19.27 a
CV (%)		6.81	
Treatments	Final Height (cm)		
	13 DBS	2 DBS	1 DAS
glyphosate-potassium salt	79.31Aa	78.00Aa	82.37Aa
glyphosate-isopropylamine salt	83.50Aa	80.75Aa	80.12Aa
glyphosate + 2,4-D	82.56Aa	80.87Aa	80.12Aa
paraquat + diuron	81.62Aa	80.94Aa	75.69Aa
Average	81.75 a	80.14 a	79.58 a
CV (%)		6.08	

* Averages followed by the same capital letter in the column and lowercase letter in the line, do not significantly differ by the Tukey test ($P \leq 0.05$).

The first pod insertion (Table 4) was affected by the paraquat + diuron treatment application near the seeding period (1 DBS), compared the other periods. The first pod insertion is directly linked to losses at harvest due to the bar cut height, the ideal minimum height for flat soils being 10 to 12 cm and a minimum height of 15 cm in more sloped soils (Sediyama et al., 1999; Mauad et al, 2009), noting that the region where the experiment was conducted has a gently wavy relief. The treatments used did not differ for the number of pods variable, and even the paraquat + diuron treatment, which showed a pod insertion height lower than the others did, have a pod number similar to the remaining ones.

Table 4. First insertion height evaluation and number of pods at R8.2 stage of the conventional soybean culture, under different desiccant application periods in pre-emergence, in Palotina municipality - Paraná.

Treatments	First pod insertion (cm)		
	13 DBS	2 DBS	1 DAS
glyphosate-potassium salt	16.56 Aa	16.06 Aa	16.06 Aa
glyphosate-isopropylamine salt	19.93 Aa	15.06 Aa	15.68 Aa
glyphosate + 2,4-D	15.31 Aa	15.44Aa	13.81 Aa
paraquat + diuron	20.12 Aa	15.81 Aab	13.62 Ab
Average	17.98 a	15.59 bc	14.80 c
CV (%)		19.45	
Treatments	Number of pods		
	13 DBS	2 DBS	1 DAS
glyphosate-potassium salt	29.87 Aa	25.44 Aa	29.18 Aa
glyphosate-isopropylamine salt	28.06 Aa	28.62 Aa	25.62 Aa
glyphosate + 2,4-D	29.56 Aa	25.06 Aa	26.50 Aa
paraquat + diuron	26.00 Aa	26.00 Aa	25.87 Aa
Average	28.37 a	26.28 a	26.80 a
CV (%)		12.83	

* Averages followed by the same capital letter in the column and lowercase letter in the line, do not significantly differ by the Tukey test ($P \leq 0.05$).

The mass of 100 seeds and productivity variables were not affected by treatments (Table 5). These results may be related to a possible cultivation recoverability, mentioned above, under these experimental conditions. However, other studies show a negative influence of some desiccants applied next to the seeding season, requiring further studies concerning this issue (Constantin and Oliveira Jr., 2005a; Constantin and Oliveira Jr., 2005b).

Table 5. Mass of hundred seeds (g) and productivity (kg ha^{-1}) of conventional soybeans, under different desiccants application periods in pre-emergence, in Palotina municipality - Paraná.

Treatments	Mass of hundred seeds (g)		
	13 D.B.S	2 D.B.S	1 D.A.S
glyphosate-potassium salt	11.75 Aa	11.52 Aa	11.27 Aa
glyphosate-isopropylamine salt	12.02 Aa	11.57 Aa	11.90 Aa
glyphosate + 2,4-D	11.45 Aa	11.97 Aa	12.40 Aa
paraquat + diuron	10.72 Aa	12.22 Aa	11.40 Aa
Average	11.49 a	11.82 a	11.74 a
CV (%)		7.62	
Treatments	Productivity (kg ha^{-1})		
	13 D.B.S	2 D.B.S	1 D.A.S
glyphosate-potassium salt	1709 Aa	1602 Aa	1452 Aa
glyphosate-isopropylamine salt	1518 Aa	1516 Aa	1651 Aa
glyphosate + 2,4-D	1659 Aa	1603 Aa	1426 Aa
paraquat + diuron	1462 Aa	1284 Aa	1588 Aa
Average	1587.52 a	1501.47 a	1529.74 a
CV (%)		11.79	

* Averages followed by the same capital letter in the column and lowercase letter in the line, do not significantly differ by the Tukey test ($P \leq 0.05$).

Results of Constantin et al. (2009) demonstrated better results performing an anticipated weeds management in the off season with sequential application of glyphosate (30

DBS) and paraquat + diuron (2 DBS) compared to the plant system application (2 DBS) for the mass of hundred seeds and productivity variables. According to Constantin et al., (2005b) the vegetation cover in the soil has great influence on drying, in which high vegetation cover areas desiccated very close to the seeding date, tend to lose productivity compared to areas managed further in advance.

Therefore, desiccation at pre-seeding in high vegetation cover areas should preferably be performed sequentially, in the management of weeds high infestation at a more advanced vegetative stage. In a second application close to seeding period should prioritize herbicides with rapid degradation coverage and low residual effect, which can be more easily accomplished through a products mixture. However, further researches are needed to better set up weed management strategies in herbicides applications (with or without mixtures) applied in pre-emergence soybean cultures.

Conclusions

The management desiccation with glyphosate only next to the seeding period showed a decrease in the weed control percentage. The glyphosate + 2,4-D use led to a decrease in the early growth of the crop due to the proximity to seeding.

Paraquat + diuron use near the seeding season caused a lower insertion of the culture first pod. There were no significant differences between treatments for soybean production components, under these experimental conditions.

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