Brachiaria ruziziensis AND HERBICIDE ON THE YIELD OF UPLAND RICE[1]

Brachiaria ruziziensis e Herbicida na Produtividade do Arroz de Terras Altas

NASCENTE, A.S.[2], GUIMARÃES, C.M.[2], COBUCCI, T.[2], and CRUSCIOL, C.A.C.[3]

ABSTRACT - The correct management of cover crops in no-tillage aims to obtain greater benefits with its introduction in agricultural systems. The use of forage species such as *Brachiaria*, due to the large amount of biomass and for persisting longer on the ground, has become a good option. In this sense, an important point is the time interval between the cover desiccation with glyphosate and planting of rice in order to obtain higher operating income in the sowing, greater availability of nutrients, greater presence of straw on the soil surface, and lower release of possible allelopathic substances. The objective of this study was to assess the effect of the management of *B. ruziziensis*, with or without herbicide, preceding the crop planting, in the yield components and yield of rice. The trial was conducted in greenhouse conditions and consisted of three types of management of *B. ruziziensis* before sowing rice. *B. ruziziensis* showed linear growth and the presence of large amounts of its dry matter biomass on the soil surface was detrimental to rice yield; *B. ruziziensis* management close to planting caused a significant reduction in rice yield; the management of *B. ruziziensis* with herbicides should be conducted with more than 20 days before planting rice; the management of *B. ruziziensis* for the removal of its leaves with or without herbicide should be carried out with 10 or more days before planting rice, and the correct management of *B. ruziziensis* at the right time allowed for significant increases in the rice yield.

Keywords: soil management, straw, cover crops, no tillage system, glyphosate.

RESUMO - O manejo das plantas de cobertura visa obter maiores benefícios com a sua introdução nos sistemas agrícolas. O uso de espécies forrageiras como as do gênero ***Brachiaria****, devido à grande quantidade de biomassa e ao fato de persistirem por mais tempo sobre o solo, vem se tornando uma boa opção. Quando se almeja maior rendimento operacional no plantio, maior disponibilidade de nutrientes, maior presença de palha na superfície do solo e menor liberação de possíveis substâncias alelopáticas, um ponto importante a ser observado é o intervalo de tempo entre a dessecação da cobertura com glifosato e a semeadura do arroz. O objetivo deste trabalho foi verificar o efeito do manejo de* ***B. ruziziensis****, com ou sem herbicida, antecedendo a semeadura da cultura, nos componentes de produção e na produtividade do arroz. O ensaio foi conduzido em casa de vegetação e consistiu em três tipos de manejo de* ***B. ruziziensis*** *antes da semeadura do arroz. Essa forrageira apresentou crescimento linear, e a presença de grande quantidade de sua matéria seca na superfície do solo foi prejudicial ao arroz. Quando manejada próximo do plantio do arroz,* ***B. ruziziensis*** *causou redução significativa na produtividade dessa cultura; o manejo dessa forrageira com herbicida deve ser realizado com mais de 20 dias antes do plantio do arroz; o manejo dela com retirada da parte aérea, com ou sem herbicida, deve ser realizado com 10 ou mais dias antes do plantio do arroz; e o manejo no momento adequado proporcionou aumento significativo na produtividade do arroz.*

Palavras-chave: manejo do solo, palhada, plantas de cobertura, sistema de plantio direto, glifosato.

[1] Recebido para publicação em 15.8.2011 e aprovado em 17.5.2012.

[2] Embrapa Arroz e Feijão, Rodovia GO-462, Km 12, Zona Rural, Caixa Postal 179, 75375-000 Santo Antônio de Goiás-GO, <adriano@cnpaf.embrapa.br>, <cleber@cnpaf.embrapa.br>, <cobucci@cnpaf.embrapa.br>. [3] Faculdade de Ciências Agronômicas, Universidade Estadual Paulista – FCA/UNESP, Dep. de Agricultura, Fazenda Experimental Lageado, Caixa Postal 237, 18610-307 Botucatu-SP,<crusciol@fca.unesp.br>.

INTRODUCTION

The culture of rice held in Brazil, according to CONAB (National Company of Food Supply) in the 2009/2010 harvest, an area of 2.76 million hectares which allowed for a production of 11.67 million tons of grains and a productivity of 4,218 kg ha^{-1}, considering irrigated and upland ecosystems. The state of Mato Grosso is the largest producer of upland rice and its rice yield is 3,008 kg ha^{-1} (Conab, 2011). This productivity despite being the largest in this ecosystem is still below the productive potential of the culture. It is necessary to develop techniques that enable a sustainable increase in the crop yield once there is a growing demand for food, combined with environmental concern.

In this sense, we have the no-tillage system (NTS). This technology has been consolidated in all regions of Brazil, with an area close to 25 million hectares, of which approx. 40% are in areas of Cerrado (Monquero et al., 2010). NTS consists of a set of technologies that allow for soil conservation, maintenance of soil moisture, reducing weed population density, physical and chemical soil improvement properties, reducing fertilizer loss, greater accumulation of soil organic matter and, therefore, greater longevity and response of crops grown on this system (Borghi & Crusciol, 2007; Pacheco et al., 2011).

In the NTS, the formation of a vegetation cover before crop deployment is extremely important (Correa et al., 2008; Fidalski et al., 2010). And it is necessary to introduce plants that are able to produce a large amount of biomass in the fall/winter, aiming to implement the next summer crop (Monquero et al., 2010). In this context, the use of species such as those of the genus *Brachiaria*, which produce large amounts of biomass and persist longer on the ground especially in times of scarcity of rain, have attracted interest (Lopes et al., 1987; Pacheco et al., 2011; Nascente & Crusciol, 2012).

However, an important factor for the success of the NTS depends on an adequate management of these cover crops. This control is usually done prior to crop sowing and is commonly called a management application or desiccation in pre-seeding and it is performed with systemic non-selective herbicides, especially glyphosate (Souza et al. 2000; Nunes et al., 2009). In this regard, special attention should be given to the time interval between this desiccation and planting crops. The ideal timing of this drying should be set according to the characteristics of the species of weed or cover, population, developmental stage, the herbicide used and the dosage (Marcandalli et al., 2011). Setting the best time management of these cover crops can provide greater availability of nutrients, greater presence of straw on the soil surface, and reduced release of possible allelopathic substances to the soil (Tokura & Nobrega, 2005; Souza et al., 2006; Monquero et al., 2010; Nascente & Crusciol, 2012).

However, despite the importance of the subject, there is information on the soybean crop (Constantin & Oliveira Júnior, 2005; Constantin et al., 2009; Nunes et al., 2009; Monquero et al., 2010; Nascente & Crusciol, 2012) and corn (Constantin & Oliveira Júnior, 2005; Correa et al., 2008; Constantin et al., 2008) but virtually no studies on the drying times of straws in the cultivation of upland rice. Therefore, a test was conducted in a greenhouse to determine the effect of the management of *Brachiaria ruziziensis*, with or without herbicide, preceding the crop planting, in the yield components and yield of rice.

MATERIAL AND METODOS

The trial was conducted in a greenhouse between January and August of 2009. The experimental design was completely randomized factorial 3 (managements) x 4 (times drying or cutting grass) + absolute control, with three replications, totaling 39 experimental units.

The experimental units consisted of a PVC column with 0.25 m in diameter and 1.0 meters tall (0.25 m^3), filled with Brazilian Oxisol soil (Embrapa, 1999) with 35% sand, 12% silt and 53% clay, from a 0-20 cm depth, previously sieved through 5 mm mesh to separate clods, roots, and straws. Chemical analysis showed pH in water = 5.0; Al^{+3}, H^{+} + Al^{+3}, Ca^{+2} and Mg^{+2} was 0.2, 5.00, 0.45 and 0.14 cmol$_c$ dm^{-3}, respectively, P = 9.2 mg dm^{-3}, K 19 mg dm^{-3}, and MO = 16 g dm^{-3}. P and K were extracted by Mehlich 1 extracting solution (0.05M HC1 in 0.0125M H_2SO_4). Phosphorus was determined colorimetrically and K by flame photometry. Ca, Mg, and Al were extracted with 1M KC1. Aluminum was determined by titration with NaOH and Ca and Mg by titration with EDTA.

Three management types, 1 - with *Brachiaria ruziziensis* and herbicide (WBWH), 2- no shoots of *B. ruziziensis* and with herbicide (NBNH), 3- no shoots of *B. ruziziensis* and no herbicide (NBWH) were established. In managing 2 (NBNH), 48 hours after herbicide application, a cut was made in the aboveground removing shoots of *B. ruziziensis*. In the management 3 (NBNH), at the same time, shoots were removed from the grass, with no herbicide application.

In each column, 10 seeds of *B. ruziziensis* were placed, and fertilization with 5 g of superphosphate (equivalent to 400 kg ha^{-1}) was carried out. At 60 days after germination of the grass, when the plants were approximately three to four tillers, the management of the forage (30 days before rice planting) was started by cutting *B. ruziziensis* leaves or applying herbicide. The application of herbicide glyphosate at 1.8 kg ha^{-1} acid equivalent (ae) was accomplished by using a vacuum pump, stationary, with constant pressure of 207 kPa, equipped with a tip type range (XR Teejet 110.02) at 0.5 m from the target surface, applying the equivalent of 200 L ha^{-1} of spray. The periods of herbicide application or removal of the leaves of *Brachiaria* were -30, -20, -10, and 0 days in relation to the planting of rice. For comparison, an absolute control (AC) was adopted without the presence of *B. ruziziensis* and without glyphosate application.

In each column, ten seeds of rice cultivar BRS Sertaneja were planted at a depth of 2 cm. Fertilization was carried out with 5 g per column of NPK 5 - 30 - 15 and 45 days after rice germination, 2.5 g per column of ammonium sulfate were applied. At 5 days after germination, thinning was performed to standardize three rice plants per column.

The use of different times of application of glyphosate on *B. ruziziensis* was performed in order to verify the hypothesis of the residual effect of herbicide on non-target plants via the decomposition of crop residues or rhizosphere shared, and also to test whether the grass mulch interferes with rice crop yield, reducing these effects when desiccation/cutting of straw is held with a longer period before planting.

The data of the straw produced in each *Brachiaria* management, -30, -20, -10 and 0 days in relation to the planting of rice (growth curve) and the yield and yield components of rice. To assess the amount of straw, *Brachiaria* plants were collected and packed in paper bags, dried in air circulation at 60 ^oC until constant weight. To evaluate the yield, all rice plants in each column were collected, and the number of panicles per plant, grains per panicle, filled grains, and grain weight were determined (data were normalized to the moisture 13%).

Data was explored by the analysis of variance and regression, being the averages of treatments compared by Tukey's test at $p < 0.05$. A comparison from all the treatments with a control treatment was also performed by Dunnett's test at $p < 0.05$ using the SAS Statistical Analysis System (SAS, 1999).

RESULTS AND DISCUSSION

From the data there was a downward trend in rice yields in all the treatments when cover crop management was held next to rice seeding (Figure 1). In the treatments with herbicide and with *Brachiaria* it was found that no significant effect was observed on rice yield components (Table 1). However, in treatments where chemical management was carried out at 0 and 10 days before the planting of rice, there was significant reductions in crop yield and it was statistically different from the management carried out at 20 and 30 days (Table 2).

According to Yamada & Castro (2007), there should usually be a waiting time of around 15 to 20 days after herbicide application before planting annual crops. This is required to prevent the crop plants suffering interference of the herbicide, possible allelopathic effect of cover crops or weeds, shading, etc. This will also allow crops to be able to have an initial rapid and vigorous development. The authors warn that if this period is not considered, the

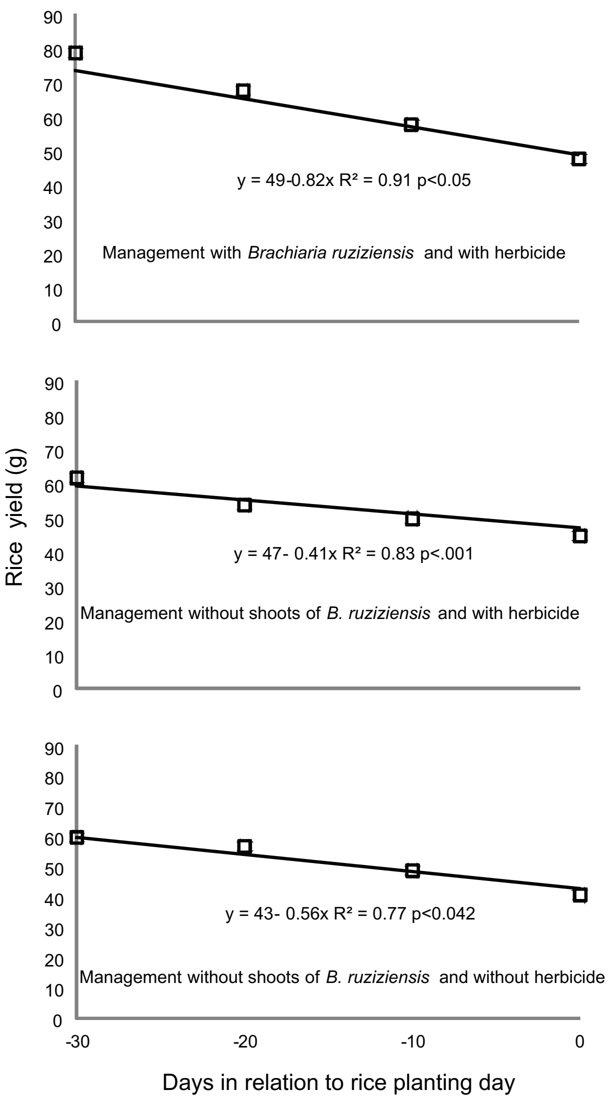

Figure 1 - Evaluation of rice yield considering different managements of *Brachiaria ruziziensis* before rice planting. Santo Antônio de Goiás-GO, Brazil, 2009.

herbicide can cause some damage to the commercial crop.

Besides that, Monquero et al. (2010) warn that large amounts of green cover crops could hamper planting operations. In this context, Constantin et al. (2008) add that due to the systemic and low nature of the effect of glyphosate on plants, coverage takes several days to die completely. When using the system "plant-and-apply" (plant the crop and apply the herbicide on the same day), cover plants are not fully dried and can affect the initial crop development.

Additionally, Nascente & Crusciol (2012) reported that chemical management of *Panicum maximum* and *Brachiaria brizantha* near to the

Table 1 - Evaluation of yield components of upland rice in the presence or absence of *Brachiaria ruziziensis* and whether or not applied the herbicide glyphosate in plants of *Brachiaria* preceding the planting of rice. Santo Antônio de Goiás-GO, Brasil, 2009

Days in relation rice planting	With *B. ruziziensis*	Without shoots of *B. ruziziensis*	
	With herbicide	With herbicide	Without herbicide
Number of panicles			
-30 days	25 a*	25 a	25 a
-20 days	20 a	25 a	24 a
-10 days	24 a	24 a	26 a
0 days	22 a	23 a	24 a
Number of grains per pots			
-30 days	2.294 a	2.318 a	2.374 a
-20 days	2.601 a	2.123 b	2.094 a
-10 days	2.893 a	2.016 b	1.855 a
0 days	2.110 a	1.727 c	1.768 a
% viable grains			
-30 days	80 a	88 a	87 a
-20 days	88 a	86 a	86 a
-10 days	83 a	87 a	88 a
0 days	80 a	89 a	87 a
Weight of 1,000 grains			
-30 days	30 a	29 a	29 a
-20 days	30 a	30 a	30 a
-10 days	29 a	29 a	30 a
0 days	28 a	30 a	30 a

* Same letter lower case vertically doesn't differ by Tukey test at p< 0.05.

Table 2 - Evaluation of the rice yield (g pot^{-1}) due the presence or absence of *Brachiaria ruziziensis* and whether or not applied the herbicide glyphosate in plants of *Brachiaria* preceding the planting of rice. Santo Antônio de Goiás-GO, Brasil, 2009

Days in relation of rice planting	With *B. ruziziensis*	Without shoots of *B. ruziziensis*	
	With herbicide	With herbicide	Without herbicide
-30 days	79 a A*	62 a AB	56 a B
-20 days	67 ab A	57 a B	55 a B
-10 days	59 bc A	51 ab A	49 ab A
0 days	48 c A	47 b A	46 b A

* Same letter lower case vertically or upper case horizontally doesn't differ by Tukey's test at p < 0.05.

soybean sowing date (10 days or less) caused significant damage in soybean yield. Silva et al. (2006) showed that for soybeans, herbicide application 14 days before planting or more did not hinder the development of culture nor of mycorrhizal fungi. On the other hand shorter than 14 days significantly reduced the association of the fungus with the roots of soybeans. Corroborating these results, Nunes et al. (2009) showed that between the cover crop desiccation and soybean planting should be an interval of at least seven days. The "plant-and-apply" operation, in addition to affecting the development of crop, could also promote a negative effect on the activity of microorganisms in the soil. In this study, it was found that rice cultivation also seems to require an interval between herbicide applications and planting of around 20 days, according to the data obtained (Table 2).

Yamada & Castro (2007), Constantin et al. (2008) and Nascente & Crusciol (2012) reported that the injury caused by the cover crop due to herbicide application close to planting the following crop can be aggravated by the higher dry matter production of this coverage. In this trial, the cover crop biomass was the equivalent of 4.64 tons per hectare of *Brachiaria* (Figure 2), being sufficient to cover about 80% of the soil (Lopes et al., 1987). It is noteworthy considering that the species of *Brachiaria* have the potential to produce 15–20 t ha^{-1} (Timossi et al., 2007). This low amount of biomass can be explained by the slow initial growth of *Brachiaria ruziziensis* (Portes et al. 2000; Silva et al., 2005), and in this trial *Brachiaria* was allowed to develop at most 90 days (management accomplished on the rice planting day), in other words, this grass can grow much more, and could cause damage in the crop if the proper management is not performed.

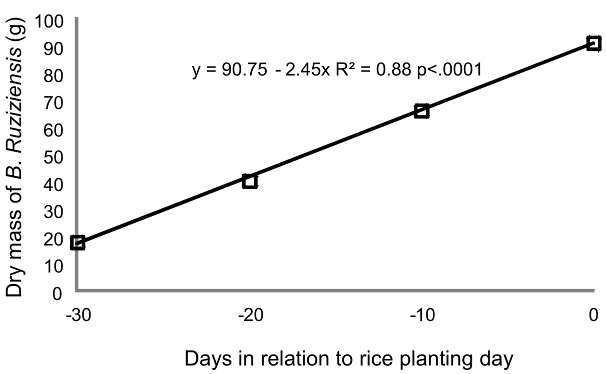

Figure 2 - Dry mass accumulation from plants of *Brachiaria ruziziensis* (grams per pot), considering days in relation of rice planting day. Santo Antônio de Goiás-GO, Brasil, 2009.

In this sense, according to Constantin & Oliveira Júnior (2005), the presence of large amount of plant mass on the ground on the day of sowing, may hinder the early crop development and may lead to falling income. This can be caused by shading, demand for nitrogen by decomposing microorganisms, allelopathic effects or other aspects not yet defined. Corroborating this information, it was found by statistical analysis that there was a highly significant correlation between the amount of biomass produced by *Brachiaria* and rice grains yield, with the value - 0.71315 (Table 3). The same also happened with all yield components in relation to this production of biomass. Therefore, rice plants seem not to have good development on big amount of cover crops biomass.

Regarding treatments without the *Brachiaria* shoots and with herbicide (herbicide application and two days later removed grass shoots). It was observed that when herbicide application was made on the day of rice planting it caused a significant drop in the rice yield and also differed from the management at 20 and 30 days (Table 2). Again there was evidence of the required management of the cover crop in advance of crop planting to prevent drops in

Table 3 - Pearson correlation coefficients and p-value among the yield components and yield of rice and dry matter production of *Brachiaria* at the management day. Santo Antônio de Goiás-GO, Brasil, 2009

Feature	Management Day	Number of grains	% viable grains	Weight of grains	Number of panicles	Yield of Rice
Dry matter of *Brachiaria*	-0.63483	-0.43528	-0.02592	-0.10141	-0.23035	-0.71315
	<.0001	0.0056	0.8755	0.539	0.1583	<.0001

crop productivity. Constantin et al. (2009) report that when managing the cover crops before planting the crop with the use of herbicide or mowing, a series of advantages such as reduced competition for water in the early development of the crop may be obtained; it also promotes the decomposition of cover crop residues or weeds, which can provide nutrients to the crop plants; improves crop uniformity; reduces possible allelopathic effects of cover crops or weeds; and helps to increase the crop yield. This was observed in this trial for all treatments (Table 2), when cover crop management was accomplished before rice sowing day, higher rice yields by harvest were always observed.

In treatments without *Brachiaria* and without herbicide, when shoots were removed simulating mowing, the lowest rice grain yield was obtained among all management (Table 2). In addition, the management on the day of rice planting was the most damaging to the rice grain yield, being statistically inferior to the management at 20 and 30 days. This result can be explained because the management adopted did not eliminate the plant cover completely. When forage leaves were removed, the plants were able to re-establish themselves and still compete with the main crop for water and nutrients and perhaps producing allelopathic substances. In addition, rice plants are very sensitive to competition, and cannot grow very well with other plants in the same area (Menezes et al., 2001; Filizadeh et al., 2007). In addition, it can be observed that mowing *Brachiaria* (due to its aggressive development) in rice crop is not recommended and could cause serious damage to the rice yield.

For Menezes et al. (2001) and Tokura & Nobrega (2005), there are many advantages in using cover crops in comparison leaving the area in fallow before planting rice, but there must be a focus on the choice of cover crops species to be used for each crop, since some types of coverage may cause a reduction in seedling emergence of following crops due to physical effects of straw, allelopathic or biological issues (reduced soil microbial population). Corroborating the result, Constantin et al. (2008) reported etiolating of maize plants sown in NTS on straw formed by *B. decumbens*, due to excessive shading of the soil caused by the forage. Souza et al. (2006) also found that residues of *Brachiaria decumbens* hindered the development of rice seedlings in the NTS, due to lower nitrogen availability at the time of the greatest crop demand.

It was found that management without the leaves of *Brachiaria* with or without herbicide at 0 and 10 days before the planting caused similar reductions (Table 2). In the yield components, it was observed that the number of grains per plot was the feature most affected in the treatments without shoot of Brachiaria, and without herbicide application (Table 1). Therefore, corroborating with other authors (Constantin et al., 2008; Nunes et al., 2009; Monquero et al., 2010; Nascente and Crusciol, 2012), also in rice it was found that the cover crop management with minimum interval of 10 days before crop planting favored the higher yields (Table 2).

In the test of Dunnet, harmful effects on the rice yield and its components when management was performed near rice planting (Table 4). However, despite the possible allelopathic or problems caused by the application of the herbicide in the forage, the importance of using cover crops in order to protect soil, nutrient cycling, moisture conservation, reduced seed bank of weeds and other things must be emphasized. Therefore, the use of cover crops should not be discarded in areas of upland rice, but special attention is required in the period before rice planting wherein the management of the cover crops should be carried out. Once again, when *Brachiaria* management was done within the correct time, it enabled good results in the rice yield.

Summarizing, based on the results, it can be concluded that *B. ruziziensis* showed linear growth, and the presence of large amounts of its dry matter biomass on the soil surface was detrimental to the rice yield; *B. ruziziensis* management close to crop planting caused a significant reduction in the rice grains yield; the management of *B. ruziziensis* with glyphosate should be conducted more than 20 days before planting rice; the management of *B. ruziziensis* for the removal of its leaves with or without herbicide should be carried out 10 or more days before planting rice, and the correct management of *B. ruziziensis* at the

Table 4 - Evaluation of yield components and yield of rice grown in greenhouse under different treatments.Santo Antônio de Goiás-GO, Brasil, 2009

Treatment	Management	Number of panicles	Number of grains	% viable grains	Weigh of 100 grains (grams)	Rice yield per pots (grams)
WBWH	0 DAH	22(ns)	2.110(ns)	80(ns)	2.83(ns)	48 (-)
WBWH	-10 DAH	24(ns)	2.893 (ns)	83 (ns)	2.88 (ns)	59 (-)
WBWH	-20 DAH	20(ns)	2.601 (ns)	88 (ns)	2.98 (ns)	67 (ns)
WBWH	-30 DAH	25(ns)	2.294 (ns)	80 (ns)	2.97 (ns)	79 (ns)
NBWH	0 DAH	23(ns)	1.727 (-)	89 (ns)	3.01 (ns)	47 (-)
NBWH	-10 DAH	24(ns)	2.016 (ns)	87 (ns)	2.90 (ns)	51 (-)
NBWH	-20 DAH	25(ns)	2.123 (ns)	86 (ns)	3.01 (ns)	57 (-)
NBWH	-30 DAH	25(ns)	2.318 (ns)	88 (ns)	2.91 (ns)	62(ns)
NBNH	0 DAH	24(ns)	1.768 (-)	87 (ns)	3.03 (ns)	46 (-)
NBNH	-10 DAH	26(ns)	1.855 (-)	88 (ns)	3.00 (ns)	49 (-)
NBNH	-20 DAH	24(ns)	2.094 (ns)	86 (ns)	3.04 (ns)	55 (-)
NBNH	-30 DAH	25(ns)	2.374 (ns)	87 (ns)	2.93 (ns)	56 (-)
NBNH (absolute control)		30	2.922	90	3.08	82
Coefficient of variation		19.64	19.25	6.90	4.50	10.40
Least significant difference		11.72	1.054	14.57	0.329	20.80

Means in column followed by, (-) are lower than the absolute control, and (ns) do not differ from absolute control by Dunnett's test at $p < 0.05$. WBWH – Treatments with *B. ruziziensis* and with herbicide. NBNH – Treatments without shoots of *B. ruziziensis*, only its roots and without herbicide. NBWH – Treatments with herbicide and after two days take out shoots of *B. ruziziensis*. DAH – Days when apply herbicide and before rice planting.

right time allowed for significant increases in the rice yield compared to the "plant-and-apply" operation.

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