

**SOYBEAN CULTURE UNDER SOIL MANAGEMENT AND SOWING SYSTEMS**

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ABSTRACT

Modern agriculture longs to increase grain yield without the necessity of opening new areas. In order to do that, techniques such as line spacing manipulation and plant density are being studied with the intention to obtain higher productivity. The aim of this study was to evaluate the influence of different soil management and sowing systems on the Asian rust severity and on the agronomic characteristics of the soybean. The experimental design was a randomized complete block design with 3x3 matrices, corresponding to three soil management systems and three types of soybean sowing, with four replications. This methodology achieved a total of 36 experimental plots shaped by 4 meters wide and 10 meters long, totalizing an area of 40 m². The interaction between direct and densified sowing obtained less severity of Asian rust and showed a tendency to raise plant's height at flowering, maturation and insertion of the first pod and to increase plants' population and productivity.

Palavras-chave:

Caracteres agronômicos

Cerrado Ferrugem asiática

Glycine max

Produtividade

CULTURA DA SOJA SOB SISTEMAS DE MANEJO DO SOLO E SEMEADURA**RESUMO**

A agricultura moderna busca aumento da produtividade dos grãos, sem a necessidade de abertura de novas áreas. Para isso, técnicas como a manipulação no espaçamento entre linhas e a densidade de plantas estão sendo estudadas, a fim de obter maior produtividade. Neste trabalho, objetivou-se avaliar a influência de diferentes sistemas de manejo do solo e semeadura na severidade da ferrugem-asiática e nos caracteres agronômicos da soja. O delineamento utilizado foi o de blocos casualizados, em esquema de faixas 3x3, correspondentes aos três sistemas de manejo do solo e três tipos de semeadura da soja, com quatro repetições, perfazendo um total de 36 parcelas experimentais constituídas de 4 metros de largura por 10 metros de comprimento, totalizando uma área de 40m². A interação entre plantio direto e semeadura adensada obteve menor severidade da ferrugem asiática; maior altura de plantas na floração, maturação e inserção da primeira vagem; maior população de plantas e produtividade.

INTRODUCTION

Brazil is the greatest world soybeans' provider. The soybean demand has increased in order of 5 million tons per year in the last 40 years (GUIMARÃES et al., 2008). Thus, according to CONAB (2015), in the harvest of 2014/15 there was a record production of 86 million tons in 30.17 million hectares.

Soybean is one of the most cultivated crops in the world, and it grows in the majority of the Brazilian territory (REZENDE et al., 2009). Soybean cultivation is among the economic activities that represent the most significant growth in world's agribusiness in the last decades, being surpassed only by corn, wheat and rice. It is stated that the activity has shown greater expansion in production (HIRAKURI & LAZZAROTTO, 2011).

One of the priorities in modern agriculture is to increase grain yield without the necessity to open new areas (PATERNIANI, 2001). Soybean crop in the Brazilian Cerrado region has been cultivated with a high technological level, contributing significantly to the maintenance and increase of the cultivated area in the country. According to Oliveira Júnior et al. (2008) this development is mainly due to favorable topographic conditions in Brazil. However, some aspects can difficult the cultivation, especially regarding to the adoption of management systems that provide the maintenance of soil organic matter.

Monoculture and the adoption of inadequate management practices are some obstacles to soybeans production. The occurrence of diseases is one of the main limiting factors for obtaining higher grain yields (YORINORI, 2007). The establishment of species to maintain the straw, mainly in the off-season, has been prevented in some regions due to the irregular distribution and limitation of the water availability in Cerrado (PACHECO et al., 2008).

According to Lima et al. (2012), several studies have sought to determine a set of cultural practices that achieve better grain yields and facilitate phytosanitary treatments. These studies are directed to the arrangement of plants, using row spacing ranging from 0.15 to 0.70 m and plant populations around 250 to 700 thousand per hectare.

Plant arrangement can be modified by population variation and row spacing, changing the shape and area of the available space for each plant, which is reflected in a differentiated intra-specific competition (RAMBO, 2003). Theoretically, the best arrangement needs to provide a more uniform distribution of plants per area, allowing better use of light, water and nutrients (BRACHTVOGEL et al., 2009).

The different types of soil management and cultivation alter its physical properties, influencing the plants' growth and development (BERTOL et al., 2001). Guimarães et al. (2008) report that a crop's productivity is defined by the interaction between the genotype of the plant, production environment and management. The adoption of conservation cropping systems, such as direct sowing, has been presented as a viable alternative to ensure the sustainability of agricultural land use (SILVEIRA et al., 2010).

The aim of this study was to evaluate the influence of different soil management and sowing systems on the Asian rust severity and on the soybean agronomic characteristics.

MATERIAL AND METHODS

The present study was conducted in the Institute of Agrarian and Technological Sciences of the Federal University of Mato Grosso, Campus of Rondonópolis experimental area (latitude 16° 28' 15" South; longitude 54° 38' 08" West and altitude of 227 meters). The climate of the region is Aw, characterized by a hot and humid conditions, with rainy summer and dry winter, according to the classification of Köppen adapted by Alvares et al. (2013).

During the experiment, the monthly average climatological data showed variations as average relative humidity of 88 to 95%; average rainfall biweekly from 15 to 189 mm; average maximum temperature of 23 to 38° C and average minimum temperature of 21 to 25° C

The area of the experiment was situated on a Red Oxisol. For chemical characterizations, the soil sample was collected in a 0-0.2 m layer, passed through a 2 mm sieve and homogenized for further analysis (EMBRAPA, 2013) (Table 1).

Table 1. Soil analysis of the experimental area.

pH	MO	P	K	Ca	Mg	H+Al	SB	V
CaCl ₂	g dm ⁻³	---mg dm ⁻³ ---			-----cmol _c dm ⁻³ -----			%
5	24,8	3,7	60	1,9	0,7	3,4	2,8	44,8

Liming and fertilization recommendations were suggested based in the results of the soil analyzes and in the nutritional characteristics of the crop. Correction of the soil with dolomitic limestone (PRNT 80%) was carried out, raising the base saturation to 60%.

Fertilization was performed at the sowing. For conventional sowing, it was used 120 kg ha⁻¹ of P₂O₅, in the form of single superphosphate and 40 kg ha⁻¹ of K₂O, in the form of potassium chloride. For cross and densified sowing the amount of fertilizer was double, due to two passes of the soil sample in the sieve.

The experimental design was a randomized complete block design with 3x3 matrices, corresponding to three soil management systems and three types of soybean sowing, with four replications. This methodology achieved a total of 36 experimental plots shaped of 4 meters wide by 10 meters long, totalizing an area of 40 m².

Conventional tillage system, with two intermediate harrowing and two light harrowing; reduced tillage system, with scarification at a depth of 0.30-0.40 m; and no-tillage system were used. The sowing systems were: conventional (parallel lines, spacing of 0.45 m), cross (seeder passed twice in the same area in perpendicular directions) and densified (spacing of 0.23 m). Soybeans were sown using the cultivar Anta 82 RR super early cycle.

There were used machines and implements as agricultural tractor Massey Ferguson brand, model MF 292 TDA with 105 CV of engine power; Intermediate harrowing Piccin brand, model 16 x 28"; light harrowing Krohn brand, 32 x 22"; subsoiler Krohn brand, model 5 x 5; parabolic shaft with 8 cm wide tips; Mechanical seeder Massey Ferguson brand, MF 407 trawler, with seven seeding units spaced of 0.45 m apart.

The Asian rust measurements were performed by counting the number of pustules per cm². The severity in the plants was evaluated by attributing grades using the visual scale for disease severities as recommended by Juliatti & Santos (1999). The evaluations begin at 41 days after sowing and all

of them were carried out fortnightly, totalizing five evaluations.

After obtaining the data, the area under the disease progress curve (AACPD) was calculated through the AVACPD program of the Federal University of Viçosa. According to SHANER & FINLEY (1977), AACPD can be calculated by Equation 1:

$$AACPD = \sum [(Y_i - Y_{i+1})/2 \times (T_{i+1} - T_i)] \quad (1)$$

in which,

Y_i = Proportion of disease in the i-th observation;

T_i = time (days) in the i-th observation and

n = total number of observations.

There were analyzed agronomic characters as number of days for maturity, plant height at flowering, plant height at maturity, height of the first pod's insertion, plant population, grain yield, weight of 100 grains and chlorophyll index.

Chlorophyll index was evaluated using an electronic meter (ClorofiLOG - CFL 1030). Measurements were made at 60 and 75 days after sowing and consisted of three points per leaf in the middle third of the plant and three plants per plot, totalizing nine points per plot.

All data were analyzed statistically by analysis of variance. Tukey's test was used to compare the means, with a 5% of probability, using the SISVAR program (FERREIRA, 2008).

RESULTS AND DISCUSSION

There was a significant effect on the interaction between the soil management and sowing systems for the following variables: area under the disease progress curve (AACPD) of pustules' number per cm² and severity of Asian rust; plant height at flowering, ripening and insertion of the first pod; plants population; and productivity. However, there was no significant effect among weight of 100 grains and chlorophyll index for number of

days to maturation.

Asian rust causes considerable losses of productivity in the soybean crop, once it induces at first a rapid yellowing and later the fall of the leaves. The lowest AACPD for number of pustules per cm² occurred in no-tillage and reduced tillage, both with conventional sowing (spacing of 45 cm), although there was no huge difference from cross-sowing (Table 1).

According to Teixeira et al. (2011), one of the factors that influences the occurrence of Asian rust in soybean is the favorable climatic conditions. The control of the disease is based on the integrated use of cultural practices, combined with fungicide management, mainly to avoid the appearance of less sensitive pathogen's populations to existing fungicides and to provide durability of resistance genes in the host (JULIATTI et al. 2010; WALKER et al., 2011).

There was an increase in the number of pustules per cm² of Asian rust applying the reduced tillage and no-tillage systems, using cross-sowing and densification. This result is based on the fact that the densification can create suitable conditions for some pathogens development. Similar effects were found by Madalosso et al. (2010) evaluating the response of two soybean cultivars with different spacing between rows. There was observed that reduced spacing and shading created better

conditions for the establishment of Asian rust.

The high severity of Asian rust verified in the experiment is due to the favorable climatic conditions and the high infestation of the disease in the region. According to Zambolin (2006), relative moisture higher than 60%, along with constant rainfall and temperatures between 18 and 25 °C, are ideal conditions for the disease's proliferation.

The dense sowing in no-tillage system for the Asian rust severity showed lower values (AACPD), although it did not differ statistically from the reduced soil management. There was no statistical difference between the types of soybean sowing when fix the soil management systems (Table 1).

The relation between the higher severities and reduced spacing due to the greater shading of the areas are in accordance to Dias et al. (2011). Thereby, there is a greater occurrence of Asian rust in soybean in shaded areas of the crop, once the sunlight is a trigger of physiological resistance processes, especially in cultivars with some level of resistance to *Phakopsora pachyrhizi*.

There was observed higher plants' height in flowering at conventional sowing (spacing of 0.45 m) within the three types of soil management system. The same was noticed at no-tillage system for cross and dense sowing, although it did not differ significantly to the reduced tillage system (Table 2).

Table 1. Areas under the disease progress curves (AACPD), number of pustules per cm² and rust severity as a function of soil management and soybean sowing systems

Systems soil tillage	Number of pustules cm ⁻²			Severity		
	Sowing systems			Sowing systems		
	Conventional	Cross-sowing	Dense sowing	Conventional	Cross-sowing	Dense sowing
Conventional	2573,13 aA	3056,28 aA	2938,72 aA	3772,46 aA	3769,99 aA	3796,24 aA
Reduced	2582,49 bA	3143,13 abA	3193,01 aA	3762,49 aA	3781,24 aA	3778,72 aAB
No-tillage	2178,67 bA	3066,93 aA	3371,92 aA	3772,46 aA	3774,97 aA	3763,72 aB

* Means followed by the same capital letter, vertically, and lowercase, horizontally, do not differ by the Tukey test, at 5% of probability.

Table 2. Height of plants at flowering and height of the first pod's insertion according to soil management and soybean sowing systems

Systems soil tillage	Height of flowering plants			Height of insertion of the first pod		
	Sowing systems			Sowing systems		
	Conventional	Cross-sowing	Dense sowing	Conventional	Cross-sowing	Dense sowing
Conventional	23,33 aA	22,75 aB	20,66 B	10,50 bB	9,83 bA	11,41 aA
Reduced	23,16 aA	24,58 aAB	23,50 aAB	9,42 bC	10,25 aA	10,58 aB
No-tillage	26,58 aA	27,66 aA	24,33 aA	11,31 aA	10,58 aA	11,17 aAB

* Means followed by the same capital letter, vertically, and lowercase, horizontally, do not differ by the Tukey test, at 5% of probability.

The height at the flowering period indicates the vegetative period of the crop. A short vegetative period, with plants of short stature, indicates low productivity. Furthermore, low values of height at flowering plants result in low productivity, due to the lower photosynthetic area, although they prevent incidence and severity of diseases, as a result of the less microclimate formation and reduction of bedding losses (BARROS *et al.*, 2011).

Sowing at no-tillage system presented the highest height of flowering plants, within the three sowing systems analyzed. The cross-sowing differed from the conventional soil management, indicating a positive effect of the straw presence in the initial development of the plants.

Regarding the insertion height, higher values were observed in no-tillage and conventional tillage systems, cross-sowing with reduced tillage and no-tillage and conventional sowing with no-tillage system (Table 2).

The results obtained are in accordance with Peluzio *et al.* (2002). They reported that the insertion of the plants' height and first pod are characteristics that suffer variations as a function of plant's density. Thus, the larger populations stimulated the growth of the plants and the elevation of the first pod's insertion height.

Almeida *et al.* (2011), point out that the use of high plants (> 80 cm) and with low insertion height of the first pod (<10 cm) might lead to losses in the mechanized harvest. In the present study, the systems that stood out the most were the systems combined with conventional and no-tillage; cross-sowing with reduced tillage and no-tillage; and conventional sowing with no-tillage. These systems presented the height of first pod insertion around 10 to 11 cm.

For the height of plants at maturation, higher

averages in dense-sowing with no-tillage (93.86 cm) was observed, although it did not differ statistically from conventional tillage.

Regarding the management of sowing, it was observed high values in all soil management systems, however, not differing only from conventional sowing (Table 3).

According to Silva *et al.* (2013) plant's height is significantly influenced by the spacing between the rows, once there is a strong decrease in plant's height with increased spacing between rows above 0.5 m.

The highest heights were found in the cross and dense-sowing systems of soybean crop, representing an adaptation to luminosity competition among the plants, an effect characterized as plant's etiolation. Similar results were found by Lima *et al.* (2012).

The height averages found were superior to the recommendations of Silva *et al.* (2010). According to them, the plants' height must be around 65 cm, representing direct and indirect effects on the production. This is related to the control of invasive plants, bedding and mechanical harvesting.

For grain yield (kg ha⁻¹), the system of conventional and no-tillage, with the three sowing systems, and reduced tillage with densified sowing, were not statistically different from conventional tillage system (Table 3).

Productivity is a characteristic influenced by several factors, such as: climatic conditions, management and cultural dealings. Another factor that may have been preponderant for the productivities achieved was the high rust severity on the crop. According to Petter *et al.* (2012), the edaphological conditions interfere in the soybean responses to the management adopted, reflecting in the components of yield and productivity.

Table 3. Height of plants at maturation and yield (kg ha⁻¹) as a function of soil management and soybean sowing systems

Systems soil tillage	Height of plants at maturity			Productivity kg ha ⁻¹		
	Sowing systems			Sowing systems		
	Conventional	Cross-sowing	Dense sowing	Conventional	Cross-sowing	Adensado
Conventional	72,08 bA	85,75aA	85,91 aAB	1513,93 aA	823,94 aA	1907,33 aA
Reduced	74,83 bA	86,75 aA	85,16 aB	2128,53 abA	988,81 bA	2468,13 aA
No-tillage	79,75 bA	86,25 abA	93,86 aA	1950,54 aA	941,70 aA	2213,04 aA

* Means followed by the same capital letter, vertically, and lowercase, horizontally, do not differ by the Tukey test, at 5% of probability.

Similar results were observed by Freitas et al. (2010), which verified that the increase in seeding density did not provide higher yields for the soybean crop. Ormond et al. (2015) obtained different results in which the cross-sowing system stands out with greater productivity in relation to the conventional.

Mattioni et al. (2008) and Komatsu et al. (2011) verified higher grain yields at spacing of 0.45 m compared to larger and smaller spacing, respectively. This result diverges from the results found in this study, in which there was no difference between the types of sowing regarding plant density.

CONCLUSIONS

- Greater incidence of Asian rust occurred with reduced line spacing.
- The interaction between direct and densified sowing showed a tendency to raise plant's height at flowering, maturation and insertion of the first pod and to increase plants' population and productivity.

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REFERENCES

- ALMEIDA, R.D.; PELUZIO, J.M.; AFFÉRI, F.S. Divergência genética entre cultivares de soja, sob condições de várzea irrigada, no sul do Estado Tocantins. **Revista Ciência Agronômica**, Fortaleza, v.42,n.1, p.108-115, 2011.
- ALVARES, C.A., STAPE, J.L., SENTELHAS, P.C., DE MORAES, G., LEONARDO, J., & SPAROVEK, G. Köppen's climate classification map for Brazil. *Meteorologische Zeitschrift*, v.22, n.6, p.711-728, 2013.
- BARROS, L.S.; POLIZEL, A.C.; SOLINO, A.J.S.; RUDNICK, V.A.S. Genótipos de soja de ciclo semi precoce/médio quanto à doenças fungicas foliares e caracteres agronômicos. **Enciclopédia Biosfera**, Goiânia, v.7, n.12, p.01-08, 2011.
- BERTOL, I.; BEUTLER, J.F.; LEITE, D.; BATISTELA, O. Propriedades físicas de um Cambissolo Húmico afetadas pelo tipo de manejo do solo. **Scientia Agrícola**, Piracicaba, v.58, p.555-560, 2001.
- BRACHTVOGEL, E.L.; PEREIRA, F.R.S. da; CRUZ, S.C.S.; BICUDO, S.J. Densidades populacionais de milho em arranjos espaciais convencional e equidistante entre plantas. **Ciência Rural**, Santa Maria, v.39, n.8, p.2334-2339, 2009.
- CONAB – Companhia Nacional de Abastecimento. **Acompanhamento da Safra Brasileira de Grãos 2014/2015: Sétimo Levantamento – Abril/2015**. Brasília: Conab, v.2, n.7, p.100, 2015.
- DIAS, A.P.S.; LI, X.; HARMON, P.F.; HARMON, C.L.; YANG, X.B. Effects of shade intensity and duration on asian soybean rust caused by phakopsora pachyrhizi. **Plant Disease**, St. Paul, v.95, n.4, p.485-489, 2011.
- EMBRAPA-EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA. **Sistema brasileiro de classificação de solos**. 3 ed. rev. ampl. Brasília, 2013. 353p.
- FERREIRA, D.F. Sisvar: um programa para análises e ensino de estatística. **Revista Científica Symposium**, Lavras, v.6, p.36-41, 2008.
- FREITAS, M.D.C.M.; HAMAWAKI, O.T.; BUENO, M.R.; MARQUES, M.C. Época de semeadura e densidade populacional de linhagens de soja UFU de ciclo semitardio. **Bioscience Journal**, Uberlândia, v.26, p.698-708, 2010.
- GUIMARÃES, F.D.S.; REZENDE, P.M.D.; CASTRO, E.M.D.; CARVALHO, E.D.A.; ANDRADE, M.J.B.D.; CARVALHO, E.R. Cultivares de soja [Glycine max (L.) Merrill] para cultivo de verão na região de Lavras-MG; **Ciência e Agrotecnologia**, Lavras, v.32, n.4 p.1099-1106, 2008.
- HIRAKURI, M.H.; LAZZAROTTO, J.J. **Evolução e perspectivas de desempenho econômico**

associadas com a produção de soja nos contextos mundial e brasileiro. Londrina: Embrapa-Soja, 2011. 68p. (Documentos, 319).

JULIATTI, F.C.; BALARDIN, R.S.; MARTINS, J.A.S.; REZENDE, A.A.; LENTZ, G. Resistência genética da soja à *Phakopsora pachyrhizii* uso de fungicidas no manejo sustentável da doença. **Revisão Anual de Patologia de Plantas**, Passo Fundo, v.8, n.1, p.77-118, 2010.

JULIATTI, F.C.; SANTOS, M.A. Métodos de avaliação de doenças de plantas induzidas por fungos e nematóides. **Revisão Anual de Patologia de Plantas**, Passo Fundo v.7, p.407-455, 1999.

KOMATSU, R.A.; GUADAGNIN, D.D.; BORGIO, M.A. efeito do espaçamento de plantas sobre o comportamento de cultivares de soja de crescimento determinado. **Campo Digital**, Campo Mourão, v.5, n.1, p.50-55, 2011.

LIMA, S.F.D.; ALVAREZ, R.D.C.F.; THEODORO, G.D.F.; BAVARESCO, M.; SILVA, K.S. Efeito da semeadura em linhas cruzadas sobre a produtividade de grãos e a severidade da ferrugem asiática da soja. **Bioscience Journal**, Uberlândia, v.28, n.6, p.954-962, 2012.

MADALOSSO, M.G.; DOMINGUES, L.S.; DEBORTOLI, M.P.; LENZ, G.; BALARDIN, R.S. Cultivares, espaçamento entrelinhas e programas de aplicação de fungicidas no controle de *Phakopsora pachyrhizii* Sidow em soja. **Ciência Rural**, Santa Maria, v.40, n.11, p.2256-2261, 2010.

MATTIONI, F.; CORRÊA, L.A.V.; GOMES, J.C.C.; WÜNCH, J. Arranjos espaciais, plantas concorrentes e características agrônomicas da soja (*Glycine max* (Linn) Merrill) em cultivo orgânico. **Revista Brasileira de Agrociência**, Pelotas, v.14, n.3, p.21-32, 2008.

OLIVEIRA JUNIOR, A.; PROCHNOW, L.I.; KLEPKER, D. Eficiência agrônômica de fosfato natural reativo na cultura da soja. **Pesquisa Agropecuária Brasileira**, Brasília, v.43, n.5, p.623-631, 2008.

ORMOND, A.T.S.; VOLTARELLI, M.A.; PAIXÃO, C.S.S.; GÍRIO, L.A.S.; ZERBATO, C.; DA SILVA, R.P. Características agrônomicas da soja em semeadura convencional e cruzada. **Revista agro@ambiente on-line**, Boa Vista, v.9, n.4, p.414-422, 2015.

PATERNIANI, Ernesto. Agricultura sustentável nos trópicos. Estudos avançados, São Paulo, v. 5, n.43, p.303-326, 2001.

PACHECO, L.P.; PIRES, F.R.; MONTEIRO, F.P.; PROCÓPIO, S.D.O.; ASSIS, R.D.; CARMO, M.D.; PETTER, F.A. Desempenho de plantas de cobertura em sobressemeadura na cultura da soja. **Pesquisa Agropecuária Brasileira**, Brasília, v.43, n.7, p.815-823, 2008.

PELUZIO, J.M.; BARROS, H.B.; SANTOS, M.M.; REIS, M.S.R. Comportamento de duas cultivares de soja em diferentes populações de plantas, sob condições de várzea irrigada, no sul do Estado do Tocantins. **Revista Agricultura Tropical**, Cuiabá, v.6, n.1, p.69-80, 2002.

PETTER, F.A.; PACHECO, L.P.; ALCÂNTARA NETO, F.; SANTOS, G.G. Respostas de cultivares de soja à adubação nitrogenada tardia em solos de cerrado. **Revista Caatinga**, Mossoró, v.25, n.1, p.67-72, 2012.

RAMBO, L.; COSTA, J.A.; PIRES J.L.F.; PARCIANELLO, G.; FERREIRA, F.G. Rendimento de grãos da soja em função do arranjo de plantas. **Ciência Rural**, Santa Maria, v.33, n.3, p.405-411, 2003.

REZENDE, P.M.; CARVALHO, E.R.; SANTOS, J.P.; ANDRADE, M.J.B.; ALCANTARA, H.P. Enxofre aplicado via foliar na cultura da soja [*Glycine max* (L.) Merrill]. **Ciência e Agrotecnologia**, Lavras, v.33, n.5, p.1255-1259, 2009.

SHANER, G.; FINLEY, R.F. The effects of nitrogen fertilization on the expression of slow-mildewing in knox wheat. **Phytopathology**, St Paul, v.67, n.8, p.1183-86, 1977.

SILVEIRA, D.C.; MELO FILHO, J.F.; SACRAMENTO, J.A.S.; SILVEIRA, E.S.P. Relação umidade versus resistência à penetração para um Argissolo Amarelo distrocoeso no recôncavo da Bahia. **Revista Brasileira Ciência do Solo**, Viçosa, v.34, n.3, p.659-667, 2010.

SILVA, J.B.; LAZARINI, E.; SILVA, A.M.; RECO, P.C. Ensaio comparativo de cultivares de soja em época convencional em Selvíria, MS: características agrônômicas e produtividade. **Bioscience Journal**, Uberlândia, v.26, n.5, p.747-754, 2010.

SILVA, W.B.; PETTER, F.A.; LIMA, L.B.; ANDRADE, F.R. Desenvolvimento inicial de *Urochloa ruziziensis* e desempenho agrônômico da soja em diferentes arranjos espaciais no cerrado Mato-Grossense. **Bragantia**, Campinas, v.72, n.2, p.146-153, 2013.

TEIXEIRA, L.M.; MELO JUNIOR, H.B.; FERNANDES, J.J. Efeito das condições

climáticas na ocorrência da ferrugem asiática da soja na entressafra de 2009, em Uberlândia-MG. **Enciclopédia Biosfera**, Goiânia, v.7, n.12, 2011.

WALKER, D.R.; BOERMA, H.R.; PHILLIPS, D.V.; SCHNEIDER, R.W.; BUCKLEY, J.B.; SHIPE, E.R.; MUELLER, J.D.; WEAVER, D.B.; SIKORA, E.J.; MOORE, S.H.; HARTMAN, G.L.; MILES, M.R.; HARRIS, D.K.; WRIGHT, D.L.; MAROIS, J.J. Evaluation of USDA soybean germplasm accessions for resistance to soybean rust in the southern United States. **Crop Science**, Madison, v.51, n.2, p.678-693, 2011.

YORINORI, J.T. Soja: ferrugem asiática avança e exige cuidados mais intensos. **Correio agrícola**, São Paulo, v.1, p.3-6, 2007.

ZAMBOLIM, L. Manejo Integrado da Ferrugem Asiática da Soja. Em: Zambolim, L. (Org.). Ferrugem Asiática da Soja. Suprema Gráfica e Editora, Visconde do Rio Branco. p.73-98, 2006.