EFFECT OF SOIL MANAGEMENT ON THE WHITE GRUB POPULATION AND DAMAGE IN SOYBEAN[1]

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ABSTRACT - To evaluate the effect of soil management systems on population of white grubs, (*Phyllophaga cuyabana* Moser), and on its damage in soybean, experiments were set up under no-tillage and conventional tillage (one disk plow, and a leveling disk harrow) areas. Primary tillage equipment, used in other soil management systems, such as moldboard plow, disk plow, chisel plow and heavy duty disk harrow were also tested. Fluctuation of *P. cuyabana* population and the extent of its damage to soybean was similar under no-tillage and conventional tillage systems. Results comparing a range of primary tillage equipment showed that it affected soil insect populations differently, depending on the time during the season in which tillage was executed. Larval mortality could mostly be attributed to their exposure to adverse factors, soon after tillage, than to changes in soil conditions. Reduction of white grub population was more evident in plots managed by heavier equipment, such as the moldboard plow. Soil tillage could be one component within the soil pest management system in soybean, however, its use can not be generalized.

Index terms: *Glycine max*, Coleoptera, Scarabaeoidea, Melolonthidae, *Phyllophaga cuyabana*, cultural control, pest control.

EFEITO DO MANEJO DE SOLO NA POPULAÇÃO E NOS DANOS DE CORÓS EM SOJA

RESUMO - Foram realizados vários experimentos para avaliar o efeito de diferentes sistemas de manejo de solo na população de corós (*Phyllophaga cuyabana* Moser), e seus danos em soja, em áreas de plantio direto e de preparo convencional do solo (preparo primário com arado de discos e uma gradagem niveladora). Vários implementos utilizados no preparo primário de solo, como arado de aivecas, arado de discos, escarificador e grade aradora também foram avaliados. A flutuação populacional de corós e a intensidade de dano causado por eles foram similares nas áreas de plantio direto e de preparo convencional. Os implementos de preparo primário do solo afetaram a população de corós diferentemente, dependendo da época em que o preparo de solo foi executado. A mortalidade larval pode ser atribuída mais à exposição a fatores adversos logo após o preparo, do que a mudanças nas condições do solo. A redução na população de corós foi mais evidente nas parcelas preparadas com implementos mais pesados, como arado de aivecas. O manejo de solo pode ser um componente dentro do manejo de pragas do solo em soja, porém sua utilização não pode ser generalizada.

Termos para indexação: *Glycine max*, Coleoptera, Scarabaeoidea, Melolonthidae, *Phyllophaga cuyabana*, controle de culturas, controle de pragas.

INTRODUCTION

The soil conservation system is fundamental in the context of sustainable agriculture. However, the reduction or elimination of soil disturbance and the maintenance of mulch change soil structure and the dynamics of edaphic communities associated with these agroecosystems (Rincón et al., 1997).

The soil management system known as no-tillage can increase soil fauna, thereby re-establishing the biological equilibrium, especially in the superficial layers (Winter et al., 1990). In some cases, a certain number of organisms, fed on subterranean plant parts, can reach high population levels and, thus, the condition of crop pests (Stinner & House, 1990).

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This soil management system has been used mainly in the South of Brazil to reduce soil erosion, although, generally, not under ideal conditions, but associated with an intensive use of herbicides that reduces diversity and stability of the system (Garcia, 1991).

Increasing problems with white grubs are reported on literature. *Diloboderus abderus* Sturm (Melolonthidae) is mentioned in the transition of native fields, forests or pastures to agriculture. In such places, changes from intensive soil management systems to a reduction in disturbance soil have occurred (Gassen, 1993; Silva et al., 1994b). Soil compaction can reduce insect survival (Ormerod, 1890, cited by Brown & Gange, 1990) by creating a physical barrier to larval movement in the soil (Strnad & Bergman, 1987). In a review, with data from about 51 arthropod species, Stinner & House (1990) concluded that, with a decrease in soil management operations, there was 28% increase in the number of species and damage caused to crops. Twenty nine percent were not affected and, additionally, there was a 43% decrease with these practices.

In soybean, several authors reported arthropod populations as being more abundant in conservation systems, such as no-tillage, than in conventional tillage (Sloderbeck & Yeargen, 1983; Toxclair Junior & Boethel,1984; Hammond & Stinner, 1987; Smith et al., 1988). However, in some cases, these organisms were associated with the occurrence of a specific type of weed (Shelton & Edwards, 1983). The majority of these studies did not mention increases in economic damage, caused by arthropods in soybean fields where soil conservation practices were adopted (Stinner & House, 1990). Nevertheless, Silva & Klein (1997) observed that the extent of damage caused by *Sternechus subsignatus* Boheman (Curculionidae) in soybean plants was larger under no-tillage system. This was more likely a consequence of the protective habit of the hibernating larvae, i.e., according to Hoffmann-Campo et al. (1991), they live at a depth of 5 to 15 cm in the soil.

Studies conducted by Silva et al. (1994a) showed that soil management system affected the species differently. According to these authors, no-tillage favored the survival of saprophytic and occasionally rhizophagous species, such as *D. abderus*, which needs mulch for oviposition and initial development. In a different way, conventional tillage essentially favored the survival of phytophagous species.

In México, Rincón et al. (1997) observed a larger diversity of white grub species in soil conservation systems, in which the establishment of populations of organic matter consumers can be favored, creating improved stability in the agroecosystem.

The occurrence of white grubs in the states of Paraná, Mato Grosso, Goiás and Minas Gerais has increased in soybean fields. *Phyllophaga cuyabana* (Moser), among several white grub species, has been considered a soybean pest in mid-west Paraná, since the mid-eighties (Oliveira et al., 1992).

From white grub complexes that occur in soybean, several rhyzophagous species have been associated with an increase in the adoption of the no-tillage system. However, there is no concrete data to confirm this hypothesis.

The objective of this research was to evaluate the effect of different soil management systems upon the grub population and the damage caused by *P. cuyabana* in soybean.

MATERIAL AND METHODS

Experimental areas

The practices were set up under no-tillage areas, at least for three years, and conventional tillage areas. These systems were chosen because they were predominantly used in mid-west Paraná, where high populations of *P. cuyabana* usually occur. In this region, no-tillage is characterized by sowing on the previous crop residues but soybean farmers do not use ideal crop rotation, as recommended for no-tillage systems. Usually in the conventional system, the soil is tilled by one plowing, generally with a disk plow, followed by a leveling disk harrow. Normally, the no-tillage system is used for winter crops, independently of the system used for summer crops. The management of the crop was carried out according to the practices adopted by farmers of the region. In all experiments, white grub population was estimated in soil samples measuring 25 cm wide x 50 cm long x 30 cm of deep.

Population sampling and damage evaluation

From November 1993, soon after soybean emergence, until July 1994, sampling was performed periodically. This normally occurred twice a month in commercial soybean fields located at two sites in the Juranda county, State of

Paraná. Two nearby crop fields were selected for each place, one under no-tillage and the other under conventional tillage system, for at least three years. Each area in the field was paired by the soil management system, separated by a roadway, approximately 3 m wide. For every soil management system, in both areas, the population of *P. cuyabana* was estimated from 20 randomly picked soil samples. The sampling area of each management system measured 220 m^2 and means of no-tillage and conventional tillage were compared by using a paired sample t-test.

Soybean was harvested at the end of March and the areas of study were wheat planted under no-tillage at the end of April/May 1994.

In February of 1995, when attack symptoms were visible, patches of damaged (six in tillage and seven in no-tillage commercial areas) and a nearest correspondent undamaged patch were measured, using a paired plots experimental design. The population of larvae was evaluated in the patches, in February and in the harvesting. The height of soybean plants was recorded just before harvesting, and crop yield parameters, as number of pods, number and weight of grains per plants were also evaluated, in a sample of 2 m of row from each patch.

Effect of different types of primary tillage equipment on white grub populations

Two experiments were performed in different seasons in two locations, where no-tillage system has been practiced in the last three years. The first experiment was set up in Rolândia, State of Paraná, when *Phyllophaga* sp. active larvae at 2nd and 3rd instar stages were predominant at 10 to 20 cm depth. The experimental design was in completely randomized blocks, with four replicates, composed of 210 m^2 plots. The experiment was repeated in two localities. Treatments were: no-tillage and conventional soil tillage using moldboard plow, disk plow, chisel plow and heavy duty disk harrow. In all treatments, except the no-tillage, a leveling disk harrow was used to level the soil for sowing immediately after using primary tillage equipment.

Prior to tilling the soil at 2, 8, 15, 21, 30 and 45 days after the establishment of treatments, the number of larvae in eight soil samples were recorded in each plot.

The second experiment was developed in Boa Esperança, State of Paraná, before the winter crop of 1994, when diapausing 3rd instar *P. cuyabana* larvae were predominant in the samples. Generally, they were found below 15-20 cm. The treatments were arranged in a complete randomized block, with five replicates. The practices were also repeated in two other places, the treatment being similar to earlier experiments, excluding the treatment with the leveling harrow and the sampling (4 per plot) that was performed to 15 days after soil tillage.

The data obtained in each sampling was submitted to analyses of variance and means compared by the Tukey test at a 5% probability. Larval percentage means, shown in the figures, were corrected with the previous sample, that was considered 100%.

RESULTS AND DISCUSSION

Damage and population of *P. cuyabana* in soybean field under two tillage systems

The size of plant patches on soybean with symptoms of white grub damage varied from 4 m^2 to 25 m^2. There was no significant difference, by the t-test ($t_{0.05} = 1.44$; P=0.18), between patch sizes under no-tillage (average 13.28 ± 2.45 m^2) and conventional tillage (average 8.60 ± 1.60 m^2).

Under no-tillage system, the number of damaged plants was lower than the undamaged ones (Table 1). There were no significant differences in the height of either the damaged or undamaged plants, in the conventional tillage system (Table 2). Regarding the crop yield parameters, the response of plants to the *P. cuyabana* larvae damage was similar in both systems. The number of pods and grains, as well as the total weight of grains harvested per plant, was smaller in plants showing symptoms of damage. The size of the grains, estimated from the weight of each grain, was similar in the damaged and undamaged plants, for the two systems (Tables 1 and 2). The reduction in grain weight per plant caused by the white grubs was similar in soybean produced in no-tillage (50%) and conventional areas (46%) (Tables 1 and 2).

The soil management systems did not appear to affect larval occurrence. The average number of larvae during crop development was similar in the neighboring areas, independently of soil management system (Table 3). The fluctuation of the *P. cuyabana* population in soybean was similar in both systems of soil management (Fig. 1).

Effect of different types of equipments used for tillage practices on white grub population

The average number of larvae in plots on the previous sampling was 24.5/m^2, in the first experiment, where active larvae were found in the 10 to 20 cm

TABLE 1. Means of larvae number, plant height and soybean grain yield in patches damaged and undamaged (control) by larvae of *Phyllophaga cuyabana*, in no-tillage fields. Juranda, PR. Season 1994/1995. n= 7 patches by treatment[1].

Parameter	Mean ± SE		Reduction in relation to control (%)
	Control	Damaged patch	
Plant height (cm)	82.9 ± 3.80	69.2 ± 4.40*	16
Pods/plant (g)	25.8 ± 3.30	15.9 ± 2.70*	38
Grains/plant (nº)	58.1 ± 5.30	35.8 ± 6.60*	38
Weight of one grain (g)	0.17 ± 0.02	0.14 ± 0.01^{ns}	18
Grain weight/plant (g)	9.8 ± 1.30	4.9 ± 1.00*	50
Larvae/0.5 m^2 (nº)	4.3 ± 0.80	10.8 ± 2.00*	-

[1] The Means of control and damaged patches (in the line) was compared by paired sample t test.
^{ns} and * Not significant and significant (P<0.05), respectively.

TABLE 2. Means of larvae number, plant height and soybean grain yield in patches damaged and undamaged (control) by larvae of *Phyllophaga cuyabana*, under conventional soil tillage (one disk plow and one leveling harrow). Juranda, PR. Season 1994/1995. n= 6 patches by treatment[1].

Parameters	Mean ± SE		Reduction in relation to control (%)
	Control	Damaged patch	
Plant height (cm)	60.0 ± 7.30	52.0 ± 5.60^{ns}	13
Pods/plant (g)	31.7 ± 5.70	19.8 ± 3.20*	37
Grains/plant (nº)	64.3 ± 10.40	40.5 ± 6.80*	37
Weight of one grain (g)	0.18 ± 0.20	0.15 ± 0.01^{ns}	17
Grain weigh/ plant (g)	12.1 ± 2.90	6.4 ± 1.50*	47
Larvae/0.5 m^2 (nº)	1.6 ± 0.80	8.4 ± 1.20*	-

[1] The means of control and damaged patches (in the line) was compared by paired sample t test.
^{ns} and * Not significant and significant (P<0.05), respectively.

TABLE 3. Number of *Phyllophaga cuyabana* larvae/20 soil samples (50 cm x 30 cm x 30 cm depth) in commercial soybean fields maintained under no-tillage and conventional soil tillage systems. Juranda, PR. Season 1993/1994[1].

Soil tillage system	Sampling means[2] (± SE)	
	Place 1	Place 2
Conventional	5.2 ± 2.02a	19.4 ± 5.21a
No-tillage	5.9 ± 1.44a	19.6 ± 7.72a

[1] Fortnightly sampling from the end of November, 1993, until March, 1994 .
[2] Means followed by the same letter on the column did not differ significantly by student t-test, at 5% probability.

layer. Population was mainly reduced by tilling deeper the soil (Fig. 2).

From the date of soil tillage up to 45 days, the population decreased in all treatments. The largest reduction occurred in the plot tilled with moldboard plow (85.9%), but the average reduction in population was also high in the no-tillage plot (63.0%). For up to 21 days, the population in the plot tilled with the moldboard plow, disk plow and chisel plow was significantly lower than in the no-tillage plots. After 45 days, a significant difference was observed only between the moldboard and disk plow plots (Tukey test, P<0.5).

In the previous sample from the second experiment, the average number of larvae was

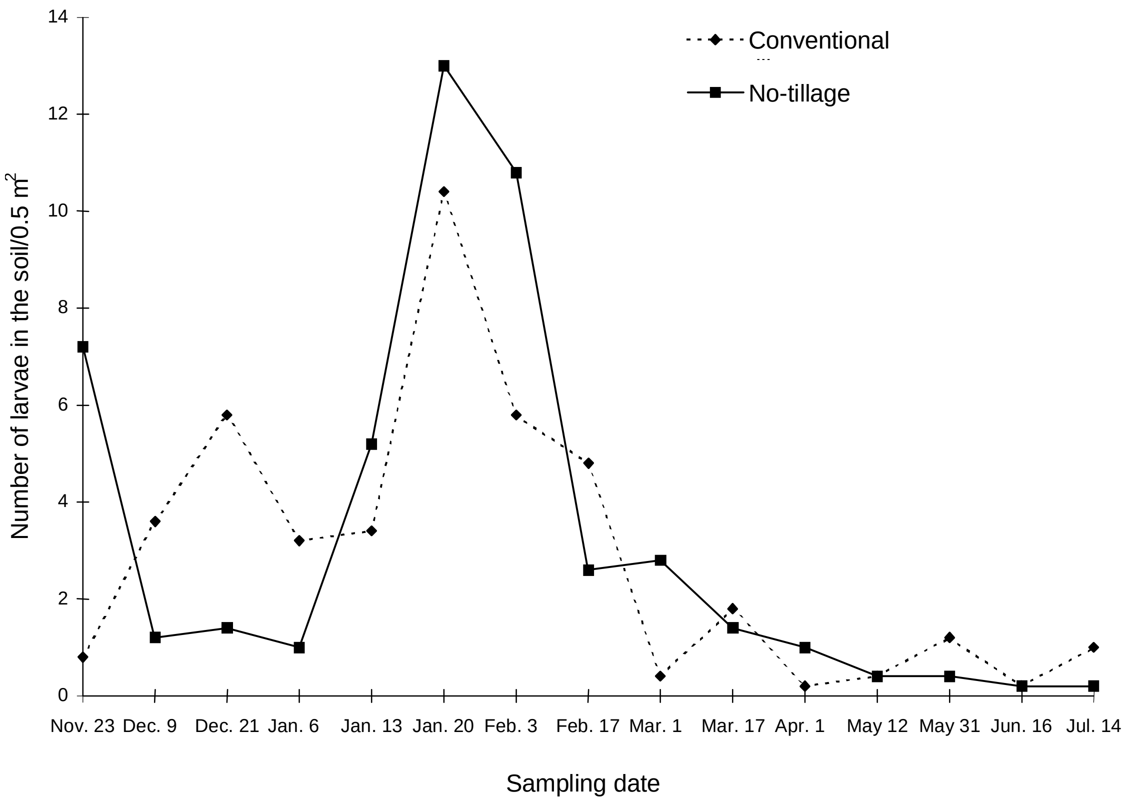

FIG. 1. Variation of the *Phyllophaga cuyabana* larvae population in the soil, in soybean fields maintained under two soil management systems: no-tillage and conventional (one disk plow and one leveling harrow). Mean of two sites. Juranda, PR. Season 1993/1994.

12.0/m^2. The fluctuating larval population (Fig. 3) observed in trials performed before the winter crop (end of April) showed predominance of diapausing larvae, located 20 cm below soil surface. This indicated that soil tillage had little effect on the reduction of white grub populations. However, two days after tillage, the moldboard plowing brought about significant effects (Tukey test, P<0.05) on the reduction of the insect population, in comparison to the no-tillage system.

White grub *versus* soil management

Although the occurrence of insects of different species can be higher in a soil that has not been disturbed by farm equipment (Alvarado, 1979; Stinner & House, 1990; Silva et al., 1994a, 1994b), in this study it did not occur. In contrast, the extent of damage caused by white grubs on soybeans was similar in no-tillage and plowed areas. Probably, the no-tillage system used in the areas studied, was not the same reduced tillage system that had been developed in England and the United States during fifties and sixties, in which no-tillage was carried out with no soil tillage operation (IAPAR, 1976). Because of the manner in which they were performed, that is, one disk harrowing with no crop rotation, in the largest part of the region, the two systems differed only in plowing operation for the conventional tillage system.

In the mid-west region of Paraná soil tillage was generally performed in October, when the diverse

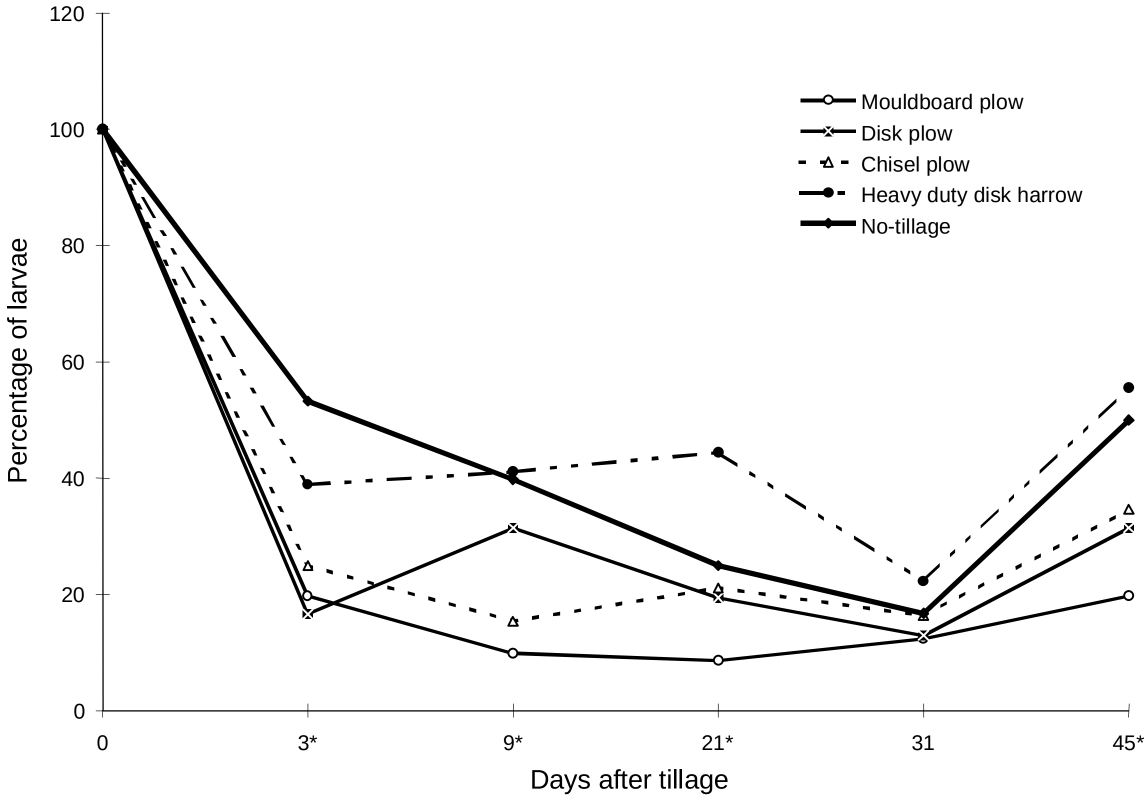

FIG. 2. Percentage of larvae, in relation to previous sampling, in areas of soybean-wheat succession, where soil management was performed when active 2nd and 3rd instar *Phyllophaga* larvae were predominant at a depth of 10 cm to 20 cm. Mean of two sites. Rolândia, PR. (*Indicates significant difference between means of treatments of the date of sampling, by Tukey test, P<0.05).

stages of development of *P. cuyabana* (diapause larvae, pupae and adults in pre-reproductive phase) could be found mostly below 15 cm in the soil. Probably, only small portion of insects was affected by the action of disk plow, used by most farmers. This confirmed the hypothesis raised by Oliveira (1997), in which the efficiency of soil tillage upon *P. cuyabana* larvae should be related to the depth reached by the equipment and the localization of larvae in the area. Studies performed by Oliveira & Hoffmann-Campo (1996) indicated that the population of rhizophagous white grubs was reduced only where the plow reached the deeper soil layers.

The results of the experiments comparing different tillage equipments demonstrated that they can affect insect population, depending on the period of tillage. The mortality of larvae could be mostly attributed to exposure of the larvae to adverse factors, soon after tillage, than to changes in soil conditions.

In the region of white grub occurrence, several farmers observed the presence of predator birds, attacking white grub larvae, during the tillage operations. The mortality appeared to be associated with the number of larvae reached by the equipment, or those exposed to sun and to predators. The mortality can, thus, be related to the depth of larval localization at the time of soil tillage operations.

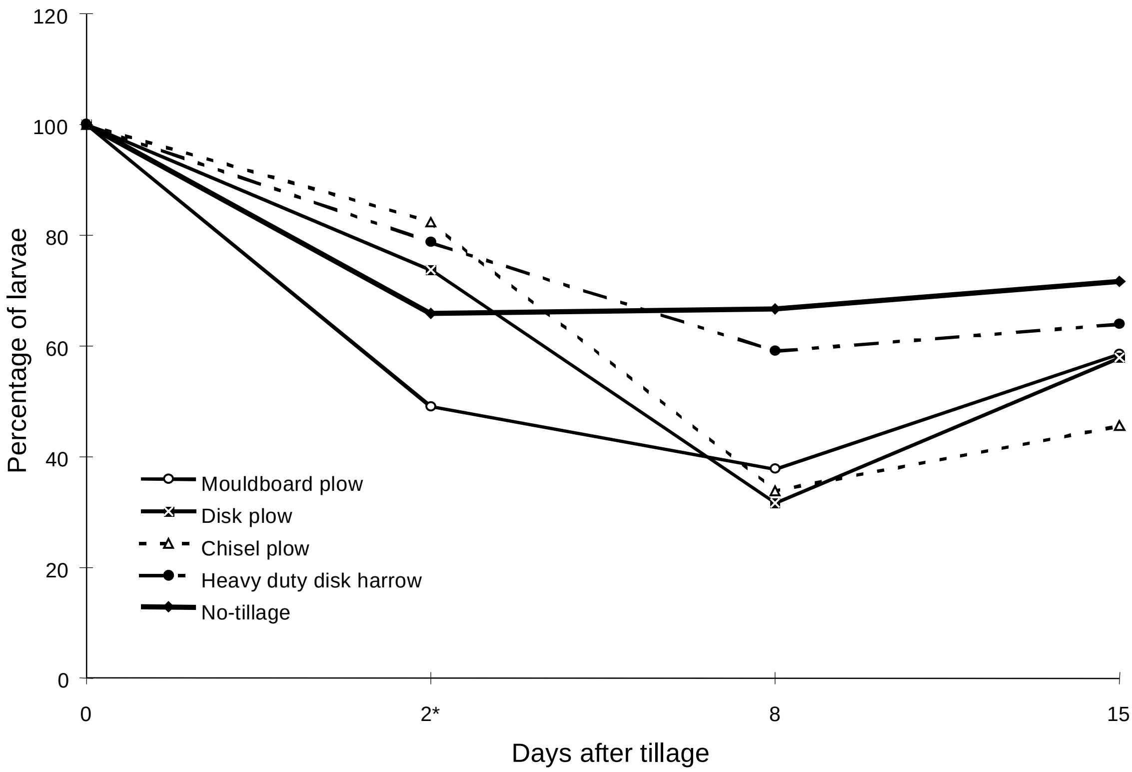

FIG. 3. Percentage of larvae, in relation to previous sampling, in areas of soybean-wheat succession, where soil management was performed when diapausing 3rd instar *Phyllophaga* larvae were predominant, below a depth of 20 cm. Mean of two sites. Boa Esperança, PR. (*Indicates significant difference between means of treatments of the date of sampling, by Tukey test, P<0.05).

Soil tillage could be one component within the subterranean insect pest management system in soybean. However, its utilization can not be generalized, because its efficacy to reduce larval population depends on many factors, such as: period of soil tillage, stage of insect development, population level and larval distribution in the soil profile.

The results of this research could be useful for choosing the correct time and the most appropriate equipment to be used in soil tillage operations for reducing the larval population, in areas where tillage systems are normally used or recommended for other reasons, such as disease control or soil fertility correction.

CONCLUSIONS

1. Disturbing the soil in no-tillage areas for the sole purpose of controlling rhizophagous white grubs is not justified in soybean.
2. In tillage system areas the white grub mortality is related to the depth of larval localization at the time of soil tillage procedures.

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REFERENCES

ALVARADO, L. **Comparación poblacional de "gusanos blancos" (larvas de Coleópteros Scarabaeidae) en tres situaciones de manejo**. Pergamino : INTA/EERA, 1979. 5p. (INTA/EERA. Generalidades. Carpeta de Producción Vegetal. Información, 16).

BROWN, W.R.; GANGE, A.C. Insect herbivore below ground. **Advances in Ecological Research**, San Diego, v.20, p.1-58, 1990.

GARCIA, M.A. Arthropods in tropical corn field: effects of weeds and insecticides on community composition. In: PRICE, P.; LEWINSOHON, T.M.; FERNANDES, W.; BENSON, W.W. (Eds.). **Plant-animal interactions:** evolutionary ecology in tropical and temperate regions. New York : J. Wiley, 1991. p.619-634.

GASSEN, D.N. Corós associados ao sistema de plantio direto. In: ALDEIA NORTE (Passo Fundo, RS) (Ed.). **Plantio direto no Brasil**. Passo Fundo : Embrapa-CNPT/Fundacep Fecotrigo/Fundação ABC, 1993. p.141-149.

HAMMOND, R.B.; STINNER, B.R. Seedcorn maggots (Diptera: Anthomyiidae) and slugs in conservation tillage systems in Ohio. **Journal of Economic Entomology**, Lanham, v.80, p.680-684, 1987.

HOFFMANN-CAMPO, C.B.; PARRA, J.R.P.; MAZZARIN, R.M. Ciclo biológico de *Sternechus subsignatus* Boheman, 1836 (Coleoptera: Curculionidae) em soja no norte do Paraná. **Revista Brasileira de Biologia**, Rio de Janeiro, v.51, p.615-621, 1991.

IAPAR (Londrina, PR). **Manual agropecuário para o Paraná**. Londrina, 1976. v.1.

OLIVEIRA, L.J. **Ecologia comportamental e de interações com plantas hospedeiras em *Phyllophaga cuyabana* (Moser) (Coleoptera: Melolonthidae, Melolonthinae) e implicações para o seu manejo em cultura de soja**. Campinas : Unicamp, 1997. 148p. Tese de Doutorado.

OLIVEIRA, L.J.; HOFFMANN-CAMPO, C.B.; AMARAL, M.L.B. do; NACHI, C. **Coró pequeno da soja**. Londrina : Embrapa-CNPSo. 1992. 4p. (Embrapa-CNPSo. Documentos, 51).

OLIVEIRA, L.J.; HOFFMANN-CAMPO, C.B. Sistemas de preparo de solo: efeito sobre populações de larvas de escarabeídeos e *Sternechus subsignatus*. In: EMBRAPA. Centro Nacional de Pesquisa de Soja (Londrina, PR). **Resultados de pesquisa de soja 1990/91**. Londrina, 1996. p.464-468. (Embrapa-CNPSo. Documentos, 99).

RINCÓN, M.B.N.; TISCAREÑO, M.; VELÁSQUEZ, M. Diversidad y abundancia de Melolonthidae y Scarabaeidae (Insecta: Coleoptera) asociados a diferentes sistemas de labranza y porcentajes de cobertura vegetal en agrosistemas de maíz del Estado de Michoacan, México. In: REUNIÓN LATINOAMERICANA DE ESCARA-BEIDOLOGIA, 3., 1997, Xalapa. **Memórias**. Xalapa : Instituto de Ecologia, 1997. p.18-19.

SHELTON, M.D.; EDWARDS, C.R. Effects of weeds on the diversity and abundance of insects on soybeans. **Environmental Entomology**, Lanham, v.12, p.296-298, 1983.

SILVA, M.T.B. da; GRUTZMACHER, A.D.; RUEDELL, J.; LINK, D.; COSTA, E.C. Influência de sistemas de manejo de suelos y de culturas sobre insectos subterraneos. **Ciência Rural**, Santa Maria, v.24, p.247-251, 1994a.

SILVA, M.T.B. da; KLEIN, V.A. Efeito de diferentes métodos de preparo do solo na infestação e danos de *Sternechus subsignatus* (Boheman) em soja. **Ciência Rural**, Santa Maria, v.27, p.533-536, 1997.

SILVA, M.T.B. da; KLEIN, V.A.; LINK, D.; REINERT, D.J. Influência de sistemas de manejo de solos na oviposição de *Diloboderus abderus* Sturm (Coleoptera: Melolonthidae). **Anais da Sociedade Entomológica Brasileira**, Londrina, v.23, p.543-548, 1994b.

SLODERBECK, P.E.; YEARGEN, K.V. Green cloverworm (Lepidoptera: Noctuidae) populations in conventional and double-cropped, no-till soybeans. **Journal of Economic Entomology**, Lanham, v.76, p.785-791, 1983.

SMITH, A.W.; HAMMOND, R.B.; STINNER, B.R. Influence of rye-cover crop management on soybean foliage arthropods. **Environmental Entomology**, Lanham, v.17, p.109-114, 1988.

STINNER, B.R.; HOUSE, G.J. Arthropods and other invertebrates in conservation-tillage agriculture. **Annual Review of Entomology**, Palo Alto, v.35, p.299-318, 1990.

STRNAD, S.P.; BERGMAN, M.K. Movement of first-instar western corn rootworms (Coleoptera: Chrysomelidae) in soil. **Environmental Entomology**, Lanham, v.16, p.975-978, 1987.

TOXCLAIR JUNIOR, N.N.; BOETHEL, D.J. The influence of tillage practices and row spacing on soybean insect populations in Louisiana. **Journal of Economic Entomology**, Lanham, v.77, p.1571-1579, 1984.

WINTER, J.P.; VORONEY, R.P.; AINSWORTH, D.A. Soil microarthropods in long-term no-tillage and conventional tillage corn production. **Canadian Journal of Soil Science**, Ottawa, v.70, p.641-653, 1990.