Damage level of the two-spotted spider mite *Tetranychus urticae* Koch (Acari: Tetranychidae) in soybeans

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ABSTRACT

Among phytophagous spider mites, the two-spotted spider mite *Tetranychus urticae* Koch, 1836 is one of the most important agricultural pests, not only because of the damage it causes, but also because it has a wide host range, infesting many commercial crops such as leafy greens, cotton, beans, and soybeans, among others. This study was carried out in a greenhouse of the Faculdade de Ciências Agrárias (FCA) of the Universidade Federal da Grande Dourados (UFGD), located in the city of Dourados, state of Mato Grosso do Sul. The experiment was arranged in a randomized block design with 5 treatments and 4 replicates. The treatments consisted of 5 levels in percentage of chlorotic symptoms (indicating mite damage): 0%, 25%, 50%, 75%, and 100%. All of the characteristics evaluated, except for number of pods per plant, the number of seeds per plant, the total weight (productivity), and the weight of 1000 seeds, were significantly influenced by the different levels of chlorotic symptoms. The economic damage level for the two-spotted spider mite *Tetranychus urticae*, according to the equation y = 66.63-0.51 x, based on the price of US$ 11.00 per bag of soybeans and a control cost of US$ 16.00, would be 15.80% chlorotic symptoms. At a price of US$ 29.00 per bag with the same control cost, the economic damage level would be 13% of chlorotic symptoms.

Key words: control level, damage, symptomatology, integrated pest management, economic entomology.

RESUMO

Nível de dano de ácaro-rajado *Tetranychus urticae* Koch (Acari: Tetranychidae) em soja

Dentre os ácaros fitófagos, o ácaro-rajado *Tetranychus urticae*, Koch 1836, é considerado uma das mais importantes pragas agrícolas, não só pelos danos causados, mas também pela ampla variedade de hospedeiros, infestando diversas culturas comerciais, como hortaliças, algodão, feijão, soja, dentre outras. O trabalho foi realizado em casa de vegetação da Faculdade de Ciências Agrárias (FCA), da Universidade Federal da Grande Dourados (UFGD), no município de Dourados, Estado de Mato Grosso do Sul (22º14' Sul, 54º44' Oeste, altitude de 452 m). O delineamento experimental foi o de blocos ao acaso, com cinco tratamentos e quatro repetições. Os tratamentos utilizados foram cinco níveis de sintomas de clorose: 0, 25, 50, 75 e 100%. Dentre as características avaliadas, o número de sementes por planta, o peso total (produtividade) e o peso de 1000 sementes foram significativamente influenciados pelos diferentes níveis de sintomas de clorose, o número de vagens por planta não foi influenciado. Para o ácaro-rajado, o nível de dano econômico causado, conforme a equação y = 66.63-0.51 x, baseada no valor de U$$ 11,00 por saca de soja e no custo de controle de U$$ 16,00, deveria ser de 15,80% de sintomas de clorose. Ao preço de U$$ 29,00 por saca, com o mesmo custo de controle, o nível de dano econômico seria atingido com 13% de sintomas de clorose.

Palavras-chave: nível de controle, prejuízo, sintomatologia, manejo integrado de pragas, entomologia econômica.

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INTRODUCTION

Among phytophagous mites, the two-spotted spider mite *Tetranychus urticae* Koch, 1836, is among the most important agricultural pests, not only because of the damage that it causes, but also because it has a wide host range, infesting many commercial crops such as leafy greens, cotton, green beans, and soybeans, among others (Gallo *et al.*, 2002).

Although the spider mite is considered an occasional pest of soybeans in the United States (Haile & Higley, 2003), this arthropod has increased its occurrence in Brazil. The increase in reports of this soybean pest is probably related to the more common use of magnifying glasses to identify pests in the field, and at the same time, the presence of two-spotted spider mites on leaves has alerted the agricultural community to the problem.

According to Guedes (2007), many factors may be contributing to the increases in spider mite populations in soybeans, mainly changes in the tillage system, such as weed control by the use of a genetically modified, glyphosate-tolerant variety, the commercial herbicide formulation which contains surfactants that may have an indirect effect on spider mites; the occurrence of soybean rust, which results in increased use of fungicides reducing the entomopathogenic fungi that regulate the spider-mite population; and the intensive use of nonselective insecticides/acaricide.

Among the inappropriate insecticides are pyrethroids, which according to Degrande (1998), may contribute to spider-mite outbreaks, causing instability, increasing their incidence on plants, and increasing the severity of symptoms caused by the mites (Barros *et al.*, 2007). According to Degrande (1998), in studies with cotton, the increased population of spider mites is caused by the mortality of their natural enemies, dispersal, stimulation of spider-mite reproduction, physiological and nutritional changes in the plants, and the repellant effect on predators.

Another important factor affecting this increase in spider-mite populations in soybeans is the climate (Haile & Higley, 2003). Hot dry weather favors reproduction and survival of this pest (Wright *et al.*, 2006), because in such conditions the important biological control exerted by entomopathogenic fungi is almost nonexistent (Klubertanz *et al.*, 1991).

The ability to avoid a substantial reduction in soybean performance after defoliation depends on several factors, including the degree of defoliation; the ability of cultivars to tolerate or compensate for defoliation; and environmental factors such as radiation, precipitation, and soil fertility (Pedigo *et al.*, 1986). Increased populations of spider mites on soybeans have also been associated with Indian summer, or periods of dry weather, during the growing season in successive years (Guedes *et al.*, 2007).

On tomatoes, two-spotted spider mites mature from egg to adult in 5 to 20 days for males, and in 5 to 50 days for females. The pre-egg-laying period for females is 1 to 7 days. Each female lays 40 eggs on average, with a range of 1 to 140 eggs. Females live 10 to 30 days, and males live 15 to 40 days. The proportion of sexes during the most favorable growth periods is 53% females and 47% males (Flechtmann, 1985).

In the adult stage, spider mites feed by sucking the cell contents: the chloroplasts of the affected cells disappear and the remaining material coagulates, forming a dead white mass in one end of the cells, causing a circular injury to the surrounding cells, which appears as a chlorotic spot (Gonçalves, 1996).

There is a lack of research in Brazil on the actual economic damage that *T. urticae* causes to soybeans, which leads farmers to control this pest without knowing the effective potential for damage to the crop. Therefore, this study evaluated the effect of different levels of chlorotic symptoms caused by two-spotted spider mite infestation on soybean production.

MATERIAL AND METHODS

Preparation of the pots

The study was carried out in a greenhouse of the Faculdade de Ciências Agrárias (FCA) of the Universidade Federal da Grande Dourados (UFGD), located in the city of Dourados, state of Mato Grosso do Sul. The study was carried out during the 2006-07 growing season, and soybean was sown on November 27, 2006.

The soil used in the experiment was taken from the B horizon of a dystroferric Red Latossol collected at FCA of UFGD. The soil sample was air-dried and then sieved through a 2-mm screen. The soil-chemistry values ($cmol.dm^{-3}$) were: 0.26 (K), 1.91 (Al), 1.4 (Ca), 0.1 (Mg), 11.1 (H+Al), 1.7 (BS), 12.86 (CEC); in mg dm^{-3}: 23.7 (OM); 4.9 (pH H_2O), 4.2 (pH $CaCl_2$). The physical values (in %) were: 80.42 (clay), 9.34 (silt), 10.23 (total sand), 54.47 (total pore volume -TPV); in $g.cm^{-3}$: 1.07 soil apparent density - Ds and 2.35 soil particle density Dp, determined according to Embrapa (1997). The TPV % was estimated from the values of Dp and Ds, and then used in the procedure to control the soil moisture in the pots (about 60% of the TPV of the soil was fillied with water).

The pots were filled with 7.5 kg of soil, which received 3.75 $g.dm^{-3}$ of dolomitic lime (dosage determined utilizing a base saturation of approximately 70%, considered adequate for soybeans), and were incubated for 21 days. After the incubation period for soil correction, the soil was air-dried, sieved through a 2-mm screen to homogenize the sample, and was fertilized as recommended for experiments in greenhouses, according to Novais *et al*., (1991). This fertilizer was applied by means of 50 mL of distilled water using a pipette, onto each soil-filled pot, and all the pots were set out on black polyethylene sheeting. The primary and secondary macronutrients were added separately from the micronutrients.

Each plot consisted of one pot containing one soybean plant. The pots were watered as needed, according to the field capacity.

Maintenance of the stock population of T. urticae

The spider mites were collected from a field and released on potted soybean plants under greenhouse conditions. The stock population was established in order to propagate and acclimate the pests to greenhouse conditions. This population was used to infest the experimental plants. For this stock population, 120 pots containing plants of all stages were assigned.

Infestation and management of the population on the plants

The soybean cultivar Coodetec 202 was selected because it is widely cultivated in the region. According to its maturation group, it is classified as a precocious cultivar, with a cycle of approximately 110 days.

The soybeans were grown routinely until stage R1. When the plants reached stage R2, all of the experimental plots received a general infestation with spider mites collected from the stock population. The infested leaves were placed homogeneously on all the leaves of the healthy plants.

When the plants showed the desired percentages of chlorotic symptoms, the pest population was killed by chemical control using a specific acaricide. After the pests have been totally controlled, the plants were allowed to continue to grow, free of *T. urticae,* until the end of the experiment, with an extra pulverization, when necessary.

Other pests that occasionally occurred on the soybeans were controlled chemically, and weeds were controlled manually.

The experiment was arranged in a randomized block design, with 5 treatments and 4 replicates. The treatments consisted of 5 levels of chlorotic symptoms: 0% (control), 25%, 50%, 75%, and 100% on soybean leafs per plant. The production factors evaluated were: number of pods per plant, number of seeds per plant, productivity (extrapolated of weight per plot to bag of 60 kg per hectare), and weight of 1000 seeds (extrapolated of the weight of seeds per plot). When F was significant ($P<0.05$) for the levels of chlorotic symptoms, a regression analysis was performed.

RESULTS AND DISCUSSION

The symptoms observed during the rearing of the stock population of spider mites were white dots that appeared dispersed on the upper surface of the leaves, resulting from the feeding of the spider mites; these dots eventually occupied the entire leaf surface. After this initial symptom, the leaves dried up and the spider mites appeared over the entire leaf, including the top and other parts. The attacked leaf dried up, and the spider mites began to colonize the leaf petiole, flowers, tips, stalks, pods, and other green tissues of the plant. Under more intense attacks the soybean plants dried completely, even under irrigation. Flechtmann (1985), studying this pest attacking tomatoes, observed that when the infestation is high, the mites diffuse over the entire plant.

According to Fadini *et al.* (2004), the injury caused by the two-spotted spider mite results from perforation of the lower epidermis cells, and high infestations of mites reduce the rate of photosynthesis, damaging the leaf mesophyll and causing the stomata to close. In the stock population, it was observed that when the mites reached their highest population levels, they moved away from the upper surfaces of the leaves, in a form of dispersal caused by the lack of food.

Among the characteristics evaluated, the number of seeds per plant, productivity, and weight of 1000 seeds were significantly influenced by the different levels of chlorotic symptoms. The number of pods per plant was not affected by the level of chlorotic symptoms (Table 1).

It is probable that the number of pods was not significantly influenced by the different chlorotic symptom levels because the pods were counted without discriminating the normal and the abnormal (without seeds). Also, the infestation was affected at the R2 stage, when the plants had probably already set their pods. The number of seeds per plant, productivity, and weight of 1000 seeds were all significantly influenced by the different levels of chlorotic symptoms.

For the weight of 1000 seeds, the higher the level of chlorotic symptoms, the greater the damage (Figure 1). At the highest level of chlorotic symptoms, the weight of 1000 seeds was reduced in comparison with the control

Table 1. Summary of analyses of variance for the number of pods per plant, number of seeds per plant, productivity, and weight of 1000 seeds (g)

Source of variation	DF	MS	CV (%)
Number of pods/plant	4	2.99 ns	16.05
Number of seeds/plant	4	4.39*	12.17
Productivity	4	1795.44**	22.62
Weight of 1000 seeds	4	8216.77*	23.99

* indicates 5% probability.
** indicates 1% probability.

by about 62%. This reduced weight is related to the lack of stored carbohydrates because of the reduction of the plant's photosynthetic area (Fadini *et al.*, 2004; Pissaia & Costa, 1981) caused by the spider-mite damage.

Spider mites feed by introducing their stylets into the plant tissue, injecting a toxin and growth regulator, and sucking out the cell contents (Flechtmann, 1985). This reduces the productivity and quality of the harvest (Albuquerque *et al.*, 2003).

The number of seeds and seed weight was affected similarly by the two-spotted spider mite; the increase of infestation increased the damage (Figure 2). At the 100% chlorotic level, the average production declined by 75.15%. However, at 25% infestation there was a production increase of 2.57%. This occurrence could be explained by the increase in photosynthetic nutrients and availability for growth of reproductive structures resulted from the better use of light, which can explain the increase in production and seed number caused by the 25% of chlorotic level (Parcianello *et al.*, 2004; Ribeiro & Costa, 2000; Mathew *et al.*, 2000).

In a practical comparison, calculating these production levels for a population of 266,000 plants per hectare, the control plot produced 3598.2 kg per hectare, while the 25% infestation plot exceeded the control treatment, producing 3690.6 kg per hectare. However, as the chlorotic levels increased, production declined (Figure 3).

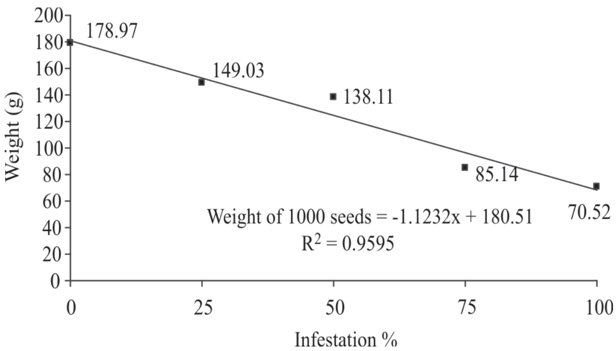

Figure 1. Weight of 1000 seeds (g) as a function of the damage level of spider mites on soybean plants (% of leaf area damaged).

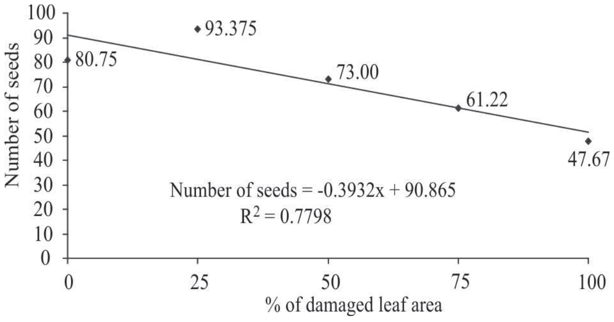

Figure 2. Number of seeds per plant as a function of the spider-mite damage level on soybean plants (% of leaf area damaged).

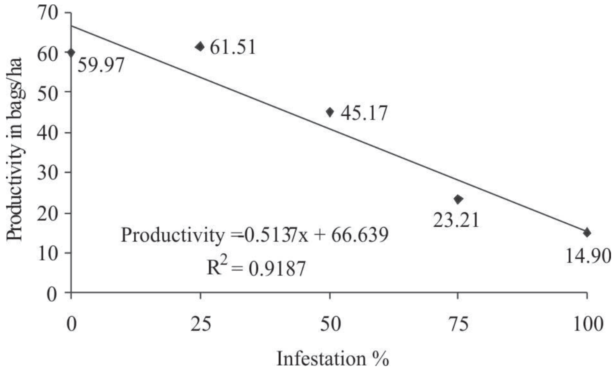

Figure 3. Productivity per hectare as a function of the spider-mite damage level in soybean plants (% of leaf area damaged).

Assuming a price of US$ 11.00 for a bag containing 60 kg of soybeans and with a spider-mite control cost of US$ 16.00 per hectare, the level at which spider mites should be controlled is 15.8% chlorotic symptoms. For a price of US$ 29.00 per bag, with the same control cost, the economic damage level would be 13% chlorotic symptoms.

The range of the spider-mite damage level of 13.00% and 15.80% would be considered acceptable, which is approximately 15% of leaf-area damage tolerated by the soybean crop, according to Embrapa (2006). Haile & Higley (2003) discuss that even before damage is apparent, the feeding of spider mites has already caused physiological changes in the plants. In other words, even though the lesions are difficult to see, the plants have already been affected, which would indicate that the range of 13.00% to 15.80% injured area might indicate greater damage, even though it is not yet visible.

Soybean productivity depends on photosynthesis carried out by the leaves, and any factor that affects leaf area can affect production.

CONCLUSION

For the two-spotted spider mite *Tetranychus urticae*, the economic damage level, according to the equation y = 66.63-0.51 x, based on the value of US$ 11.00 per bag of soybeans and a control cost of US$ 16.00, would be 15.80% chlorotic symptoms. At a price of US$ 29.00 per bag with the same control cost, the economic damage level would be 13% chlorotic symptoms.

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