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Sample size for estimating the population of stink bugs in soybean crops[1]

Tamanho de amostra para a estimação da população de percevejos na cultura de soja

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ABSTRACT - It is important to quantify the population of stink bugs in the soybean, in order to determine the actions which are necessary for their control to protect the crop from losses in production, together with a reduction in cost and less environmental impact. The objectives of this study were to determine the sample size (the number of sampling points) needed to estimate the average population density of the bugs, and to verify the variability in sample size for the phases and species of the bugs and the phenological stages of the plants. In an area of 6.16 ha of soybeans, a grid of 154 sampling points, spaced 20 × 20 m apart, was laid out. Population-density data were collected for nymphs and adults of the species *Dichelops furcatus* (Fabricius, 1775), *Piezodorus guildinii* (Westwood, 1873), *Edessa meditabunda* (Fabricius, 1794), *Nezara viridula* (Linnaeus, 1758), *Euschistus heros* (Fabricius, 1794) and *Chinavia* sp. (Say, 1832) employing a vertical beat sheet at 14 different phenological stages. Measurements of central tendency and variability, the Morisita index and the k parameter of negative binomial distribution were all calculated. Homogeneity of variances was verified and the sample size calculated. There is variability in the sample size when estimating the average population density of bugs across the phases and species of bug and the phenological stages of the soybean. Smaller sample sizes are necessary for the nymphs of *P. guildinii* and the final phenological stages (R6, R7.1, R7.3 and R8.2). Thirty-six sampling sites are enough to estimate the average population density of bugs in the final phenological stages (R6, R7.1, R7 .3 and R8.2) at an error of estimation equal to 30% of the estimated mean and at a level of confidence of 95%.

Key words: Sample sizing. Experimental error. Pentatomidae.

RESUMO - É importante quantificar a população de percevejos da soja, para determinar as ações de controle necessárias para proteger a lavoura das perdas na produção, com redução dos custos e menor impacto ambiental. Os objetivos deste trabalho foram determinar o tamanho de amostra (número de pontos amostrais) para a estimação da média de densidade populacional de percevejos e verificar a variabilidade do tamanho de amostra entre as fases e as espécies de percevejos e os estádios fenológicos. Em 6,16 ha de soja, foi demarcado um gride de 154 pontos amostrais, espaçados de 20 × 20 m. Foram coletados dados de densidade populacional de percevejos ninfas e adultos das espécies *Dichelops furcatus* (Fabricius, 1775), *Piezodorus guildinii* (Westwood, 1873), *Edessa meditabunda* (Fabricius, 1794), *Nezara viridula* (Linnaeus, 1758), *Euschistus heros* (Fabricius, 1794) e *Chinavia* sp. (Say, 1832), por meio do pano-de-batida vertical, em 14 estádios fenológicos. Foram calculadas medidas de tendência central e de variabilidade, índice de Morisita e parâmetro k da distribuição binomial negativa. Foi verificada a homogeneidade de variâncias e calculado o tamanho de amostra. Há variabilidade do tamanho de amostra para a estimação da média de densidade populacional de percevejos entre as fases e as espécies de percevejos e entre os estádios fenológicos da soja. Menores tamanhos de amostra são necessários para as ninfas de *P. guildinii* e os estádios fenológicos finais (R6, R7.1, R7.3 e R8.2). Trinta e seis pontos amostrais são suficientes para estimar a média de densidade populacional de percevejos, para um erro de estimação igual a 30% da média estimada, com grau de confiança de 95%, nos estádios fenológicos finais (R6, R7.1, R7.3 e R8.2).

Palavras-chave: Dimensionamento amostral. Erro experimental. Pentatomidae.

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INTRODUCTION

The soybean is one of the most important agricultural products in Brazil, being grown on 25 million hectares, with a production of 66.3 million tons of grain for the harvest of 2011/2012 (COMPANHIA NACIONAL DE ABASTECIMENTO, 2012). Grain-sucking stink bugs are serious insect pests in the cultivation of soybeans (CORRÊA-FERREIRA; AZEVEDO, 2002). They are widespread throughout plantations in Brazil, and by feeding on the grains, reduce their weight and quality (CORRÊA-FERREIRA, 2005). Losses in the soybean caused by these bugs, at a population density of one stink bug m^{-2}, range from 49 to 125 kg ha^{-1} (GUEDES *et al*., 2012). Pest management in the soybean is carried out based on population levels, which should be quantified separately for each plantation, either for seed or grain production. Counting the bugs collected by means of a vertical beat sheet is a suitable method of quantifying the population of stink bugs (STÜRMER *et al*., 2012).

Sampling should be performed at different points throughout the plantation. Insufficient sampling points may lead to errors in the estimation of the average population density of the bugs, resulting in poor decisions being made regarding control of the insect pests, with consequent losses in grain yield or increases in the cost of production (GUEDES *et al*., 2012). Sample size (the number of sampling points) is directly proportional to the variability of the data and the desired level of confidence for the estimate, and inversely proportional to the permitted error of estimation, which is stipulated by the researcher. It therefore becomes necessary to define the number of sampling points, in order to estimate the average population density of bugs with the desired accuracy.

Population surveys and sample sizing of stink bugs in the soybean (COSTA; LINK, 1980; CULLEN *et al*., 2000; GUEDES *et al*., 2006; GUEDES *et al*., 2012; LOURENÇÃO *et al*., 2002; SANTOS, 2008) and of white grubs in areas of native pasture and under cultivation (CARGNELUTTI FILHO *et al*., 2011; SILVA; COSTA, 1998) have been carried out. For quantifying the density of stink bugs in the soybean, the recommendation is for the collection of 6 samples for areas of up to 10 ha, 8 samples for areas of 11-30 ha and 10 samples for areas of 30 to 100 ha. For areas larger than 100 ha, it is recommended to subdivide the area into plots of 100 ha (EMPRESA BRASILEIRA DE PEQUISA AGROPECUÁRIA, 2010). However, this recommendation does not take into account the phases and species of the bugs nor the phenological stage of the soybean. Additionally, no information was found on the estimation error of the mean using these recommendations or on the sample size (number of sampling points) necessary to quantify the population density of stink bugs in the soybean crop.

The objectives of this study were to determine the sample size (number of sampling points) for estimating the average population density of stink bugs, and to check the variability of the sample size across the phases and species of bug, and the stages of soybean.

MATERIAL AND METHODS

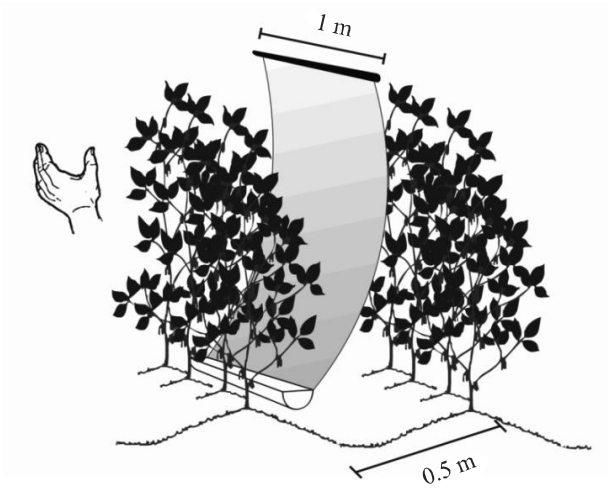
An experiment was carried out on a soybean crop in the agricultural year of 2010/2011, in an area of 6.16 ha, located at 29º42'24'' S, 53º48'42" W and an altitude of 95 m. The soybean cultivar '*BMX Potência RR*' was seeded on 29 October 2010, in rows spaced 0.5 m apart, at a density of 25 plants m^{-2}. Control of weeds and diseases was conducted in accordance with crop-research recommendations (RPS RS-2010). Insecticide for contolling the stink bugs was not used. A grid was marked out, of 154 sampling points, spaced 20 × 20 m apart. Bugs were collected at each of the sample points, using the vertical beat-sheet method of sampling, for 14 phenological stages of the soybean (V7, V9, V11, R1, R2, R3, R4, R5.1, R5.3, R5.5, R6, R7.1, R7.3 and R8.2), defined according to the scale proposed by Ritchie *et al.* (1982).

The vertical beat sheet consisted of a wooden stick at the upper end and a 100 mm tube of chlorinated polyvinyl, cut in half lengthwise, at the lower end, connected by a white fabric of 1 m in length, with its height adjusted to that of the soybean plants. The tube served as a collector for the bugs (Figure 1). To collect the bugs, the cloth was placed vertically between the rows of crops, and the plants from just one row were shaken against the surface of the cloth. This procedure was carried out on two metres of the row of soybeans, in order to sample an area of 1 m^2.

For each of the 2,156 collections (154 sampling points/phonological stage × 14 phonological stages of the soybean) with an area of 1 m^2, the number of stink bug nymphs and adults were counted for the species *Dichelops furcatus* (Fabricius, 1775), *Piezodorus guildinii* (Westwood, 1873), *Edessa meditabunda* (Fabricius, 1794), *Nezara viridula* (Linnaeus, 1758), *Euschistus heros* (Fabricius, 1794) and *Chinavia* sp. (Say, 1832), thereby obtaining 12 variables (2 phases x 6 species). Three more variables were then obtained, i.e. the total nymphs, adults and nymphs + adults, for each phonological stage, regardless of species.

For these 15 variables, for each phenological stage and from the population density of bugs at the 154

Figure 1 - Representation of the vertical beat sheet used for sampling bugs in the soybean crop



Source: Prepared by the authors

sampling points, the following statistics were calculated: minimum, maximum, mean (m), standard deviation (s), variance (s^2) and coefficient of variation. Next, the Morisita index (I_δ) (MORISITA, 1962) and the k parameter of the negative binomial distribution were calculated employing expressions 1 and 2 respectively:

$$I_\delta = \frac{n\left(\sum_{i=1}^{n} x_i^2 - \sum_{i=1}^{n} x_i\right)}{\left(\sum_{i=1}^{n} x_i\right)^2 - \sum_{i=1}^{n} x_i} \quad (1)$$

$$k = \frac{m^2}{(s^2 - m)} \quad (2)$$

where n is the number of sample points (n = 154), x_i is the number of bugs at the i^{th} sampling point, and m is the mean and s^2 the variance of the sample.

The F-test (one-sided) was then applied to the population-density data of the bugs in order to verify the homogeneity of the variances between the two phases of the bug within each combination of species and phenological stage, between the six species within each combination of phase and phenological stage and between the 14 phenological stages of the soybean within each combination of phase and species.

For each of the 15 variables at each phenological stage, taking as a basis the 154 sampling points (n = 154), the sample size was calculated (number of sampling points, η) for the semi-amplitudes of the confidence interval (errors of estimation) equal to 10, 20, 30, 40 and 50% (D) of the estimate of the mean (m) of the population density of the bugs, expressed as bugs m^{-2}, with a level of confidence (1-α) of 95%, by means of the expression: $\eta=(t^2_{\alpha/2}\ S^2)/(Dm)^2$ (BUSSAB; MORETTIN, 2004). In this expression, $t_{\alpha/2}$ is the critical value of the Student's t-distribution, where the area on the right is equal to α/2, i.e. the value of t, such that $P(t > t_{\alpha/2}) = \alpha/2$, with (n-1) degrees of freedom, with α = 5% probability of error and s^2 the estimation of variance. Then, making η equal to 154 sampling points, the error of estimation was calculated as a percentage of the estimate of the mean (m) using expression 3:

$$D = (100\ t_{\alpha/2}\ s)/(\sqrt{\eta}\ m) \quad (3)$$

where s is the estimated standard deviation.

Statistical analyses were carried out employing the Microsoft Office Excel ® software with all decimal places being used in the intermediate calculations.

RESULTS AND DISCUSSION

There was variability in the population densities of the bugs for their phases and species and for the phonological stages of the soybeans (Tables 1, 2 and 3). Nymphs were seen in greater quantities than were adults. *Piezodorus guildinii* predominated over the other species of stink bug. Across the phenological stages, population density increased gradually from the initial stages (V7 and V9) to the final stages (R7.1, R7.3 and R8.2), with the peak population of bugs of 19.34 m^{-2} occurring for R7.3 (Table 3). These results agree with Silva *et al*. (2007) and Maziero *et al.* (2009), who showed that during the reproductive stage of the soybean, the stink-bug population may be made up of more than 70% nymphs compared to adults. A predominance of *P. guildinii* has been found in surveys of stink-bug populations in the soybean (LOURENÇÃO *et al*., 2002). Higher population densities of the bugs were verified by Belorte, Ramiro and Faria (2003) at stages R7 and R8.

The largest stink-bug infestation occurred during the reproductive stage of the soybean, this phase being the most sensitive to the pest. The bugs colonize during the vegetative phase, but the damage is caused when the bugs feed, starting from the R3 stage of the bean. The decrease in the bug population which occurred in the evaluation that took place in R8.2, can be explained by migration to areas of refuge and the crop no longer being a food preference. Close to the bean harvest, the bugs begin their dispersal to host plants and to diapause niches, in which they remain until the next crop (MEDEIROS; MEGIER, 2009).

In general, the coefficients of variation (CV) of stink-bug population density were higher for the species *D. furcatus*, *E. meditabunda*, *N. viridula*, *E. heros* and

Table 1 - Minimum, maximum, mean, standard deviation (s), variance (s^2), coefficient of variation (CV%), Morisita index (I_δ) and k parameter of the negative binomial distribution, of the population density for nymphs of the stink-bug species *Dichelops furcatus*, *Piezodorus guildinii*, *Edessa meditabunda*, *Nezara viridula*, *Euschistus heros* and *Chinavia* sp., expressed as stink bugs m^{-2}, based on 154 points each of 1 m² in area, for 14 phenological stages in the soybean

Statistic	Phenological stage(1)													
	V7	V9	V11	R1	R2	R3	R4	R5.1	R5.3	R5.5	R6	R7.1	R7.3	R8.2
Dichelops furcatus														
Mínimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	0.00	0.00	1.00	1.00	2.00	2.00	2.00	1.00	2.00	2.00	4.00	5.00	7.00	6.00
Mean	0.00	0.00	0.01	0.04	0.09	0.13	0.08	0.04	0.07	0.07	0.37	0.80	1.06	0.42
s	0.00	0.00	0.11	0.19	0.31	0.37	0.33	0.19	0.28	0.28	0.77	1.14	1.32	1.25
s^2	0.00	0.00	0.01	0.04	0.10	0.14	0.11	0.04	0.08	0.08	0.59	1.30	1.73	1.55
CV(%)	-	-	874.62	498.28	341.28	287.99	428.59	498.28	395.56	395.56	207.10	142.70	123.66	295.22
I_δ	-	-	0.00^{ns}	0.00^{ns}	1.69^{ns}	1.62^{ns}	7.00*	0.00^{ns}	2.80^{ns}	2.80^{ns}	2.61*	1.79*	1.59*	7.40*
k	-	-	-1.99	-1.19	1.55	1.68	0.18	-1.19	0.61	0.61	0.63	1.27	1.69	0.16
Piezodorus guildinii														
Mínimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Maximum	0.00	1.00	1.00	5.00	2.00	5.00	3.00	5.00	2.00	11.00	13.00	33.00	35.00	36.00
Mean	0.00	0.02	0.01	0.08	0.08	0.22	0.19	0.26	0.11	0.32	2.26	7.11	10.31	8.01
s	0.00	0.14	0.08	0.49	0.31	0.64	0.48	0.66	0.35	1.05	2.77	6.12	6.27	4.56
s^2	0.00	0.02	0.01	0.24	0.10	0.41	0.23	0.44	0.12	1.11	7.67	37.47	39.35	20.76
CV(%)	-	711.77	1,240.97	631.65	402.70	289.48	255.93	255.93	320.26	330.71	122.56	86.09	60.84	56.91
I_δ	-	0.00^{ns}	-	30.33*	4.67*	4.94*	2.28*	3.75*	2.26^{ns}	8.90*	2.06*	1.60*	1.27*	1.20*
k	-	-1.49	-	0.04	0.30	0.26	0.81	0.37	0.83	0.13	0.94	1.67	3.66	5.02
Edessa meditabunda														
Mínimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	0.00	0.00	0.00	0.00	0.00	3.00	4.00	2.00	1.00	2.00	5.00	5.00	13.00	4.00
Mean	0.00	0.00	0.00	0.00	0.00	0.04	0.11	0.11	0.05	0.16	0.15	0.24	0.41	0.22
s	0.00	0.00	0.00	0.00	0.00	0.28	0.51	0.39	0.21	0.40	0.56	0.71	1.25	0.60
s^2	0.00	0.00	0.00	0.00	0.00	0.08	0.26	0.15	0.04	0.16	0.31	0.51	1.55	0.36
CV(%)	-	-	-	-	-	711.77	458.08	352.17	459.75	255.51	373.33	297.39	304.38	270.31
I_δ	-	-	-	-	-	30.80*	13.59*	4.53*	0.00^{ns}	1.12^{ns}	8.52*	5.78*	7.89*	3.84*
k	-	-	-	-	-	0.04	0.08	0.30	-1.16	8.94	0.14	0.21	0.15	0.36
Nezara viridula														
Mínimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	0.00	0.00	4.00	0.00	1.00	1.00	2.00	3.00	1.00	3.00	3.00	16.00	15.00	7.00
Mean	0.00	0.00	0.03	0.00	0.07	0.06	0.04	0.09	0.05	0.12	0.14	0.50	0.55	0.31
s	0.00	0.00	0.32	0.00	0.26	0.25	0.23	0.39	0.21	0.41	0.46	1.93	1.80	0.89
s^2	0.00	0.00	0.10	0.00	0.07	0.06	0.05	0.15	0.04	0.17	0.21	3.73	3.23	0.79
CV(%)	-	-	1,240.97	-	361.73	380.71	578.27	423.96	459.75	351.98	324.39	386.20	325.58	290.97
I_δ	-	-	154.00*	-	0.00^{ns}	0.00^{ns}	10.27*	8.46*	0.00^{ns}	5.03*	4.67*	14.00*	9.84*	6.27*
k	-	-	0.01	-	-1.09	-1.10	0.13	0.14	-1.16	0.26	0.28	0.08	0.11	0.19
Euschistus heros														
Mínimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	0.00	0.00	0.00	0.00	1.00	0.00	1.00	2.00	1.00	2.00	4.00	3.00	1.00	4.00
Mean	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.03	0.01	0.01	0.19	0.07	0.05	0.08
s	0.00	0.00	0.00	0.00	0.08	0.00	0.11	0.20	0.11	0.16	0.67	0.35	0.21	0.43
s^2	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.04	0.01	0.03	0.45	0.12	0.04	0.18

Continuation of Table 1

CV(%)	-	-	-	-	1,240.97	-	874.62	755.78	874.62	1,240.97	342.61	483.05	459.75	505.89
I_δ	-	-	-	-	-	-	0.00^{ns}	25.67*	0.00^{ns}	154.00*	7.79*	11.20*	0.00^{ns}	15.79*
k	-	-	-	-	-	-	-1.99	0.05	-1.99	0.01	0.15	0.11	-1.16	0.07
Chinavia sp.														
Mínimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	0.00	0.00	0.00	0.00	2.00	2.00	2.00	3.00	5.00	38.00	28.00	14.00	43.00	9.00
Mean	0.00	0.00	0.00	0.00	0.02	0.07	0.10	0.17	0.18	0.52	0.80	1.06	2.08	1.01
s	0.00	0.00	0.00	0.00	0.18	0.28	0.39	0.47	0.58	3.11	3.13	2.10	4.44	1.69
s^2	0.00	0.00	0.00	0.00	0.03	0.08	0.15	0.22	0.33	9.70	9.80	4.41	19.72	2.86
CV(%)	-	-	-	-	922.54	395.56	402.70	277.61	317.26	599.61	391.86	198.37	213.07	167.02
Iδ	-	-	-	-	51.33*	2.80^{ns}	7.33*	2.84*	5.70*	35.23*	15.13*	3.99*	5.05*	2.80*
k	-	-	-	-	0.03	0.61	0.17	0.56	0.22	0.03	0.07	0.33	0.25	0.55

(1) Developmental stages of the soybean according to Ritchie *et al*. (1982), adapted by Yorinori (1996). * Morisita index different from 1 by the χ2 test at 5%. ^{ns} Non-significant. - Not calculated where no stink bugs, or only 1, were found

Table 2 - Minimum, maximum, mean, standard deviation (s), variance (s^2), coefficient of variation (CV%), Morisita index (I_δ) and k parameter of the negative binomial distribution, of the population density for adults of the stink-bug species *Dichelops furcatus*, *Piezodorus guildinii*, *Edessa meditabunda*, *Nezara viridula*, *Euschistus heros* and *Chinavia* sp., expressed as stink bugs m^{-2}, based on 154 points each of 1 m² in area, for 14 phenological stages in the soybean

Statistic	Phenological state(1)													
	V7	V9	V11	R1	R2	R3	R4	R5.1	R5.3	R5.5	R6	R7.1	R7.3	R8.2
Dichelops furcatus														
Mínimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	1.00	2.00	2.00	1.00	3.00	2.00	3.00	2.00	4.00	3.00	2.00	3.00	5.00	5.00
Mean	0.01	0.08	0.06	0.04	0.05	0.12	0.17	0.13	0.18	0.19	0.05	0.24	0.70	0.72
s	0.08	0.29	0.30	0.19	0.29	0.35	0.47	0.37	0.49	0.50	0.25	0.56	1.11	1.13
s^2	0.01	0.09	0.09	0.04	0.08	0.12	0.22	0.14	0.24	0.25	0.06	0.31	1.23	1.29
CV(%)	1,240.97	375.01	454.91	498.28	633.38	283.03	277.61	287.99	270.14	256.35	481.80	233.40	158.17	157.43
I_δ	-	2.33^{ns}	6.84*	0.00^{ns}	22.00*	0.90^{ns}	2.84*	1.62^{ns}	2.85*	2.48*	5.50*	2.31*	2.08*	2.09*
k	-	0.81	0.19	-1.19	0.06	-10.55	0.56	1.68	0.56	0.70	0.25	0.78	0.93	0.92
Piezodorus guildinii														
Mínimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	2.00	1.00	1.00	2.00	2.00	3.00	2.00	3.00	2.00	3.00	4.00	9.00	19.00	13.00
Mean	0.02	0.02	0.01	0.06	0.13	0.15	0.10	0.19	0.22	0.29	0.31	1.08	3.59	3.80
s	0.18	0.14	0.11	0.26	0.41	0.44	0.33	0.48	0.54	0.63	0.65	1.45	3.21	2.74
s^2	0.03	0.02	0.01	0.07	0.17	0.19	0.11	0.23	0.29	0.39	0.43	2.11	10.33	7.53
CV(%)	922.54	711.77	874.62	447.70	313.75	294.33	314.52	255.93	244.26	214.04	209.18	134.81	89.53	72.26
I_δ	51.33*	0.00^{ns}	0.00^{ns}	4.28^{ns}	3.24*	3.04*	1.28^{ns}	2.28*	2.47*	2.18*	2.18*	1.89*	1.52*	1.26*
k	0.03	-1.49	-1.99	0.34	0.47	0.51	3.74	0.81	0.70	0.86	0.86	1.12	1.91	3.86
Edessa meditabunda														
Mínimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	0.00	1.00	0.00	1.00	0.00	1.00	1.00	3.00	1.00	3.00	2.00	2.00	2.00	2.00
Mean	0.00	0.01	0.00	0.01	0.00	0.02	0.03	0.07	0.07	0.08	0.14	0.11	0.18	0.19
s	0.00	0.11	0.00	0.11	0.00	0.14	0.18	0.35	0.26	0.38	0.43	0.37	0.47	0.44
s^2	0.00	0.01	0.00	0.01	0.00	0.02	0.03	0.12	0.07	0.14	0.19	0.14	0.22	0.19
CV(%)	-	874.62	-	874.62	-	711.77	547.67	483.05	361.73	448.21	304.00	336.60	269.93	233.33
I_δ	-	0.00^{ns}	-	0.00^{ns}	-	0.00^{ns}	0.00^{ns}	11.20*	0.00^{ns}	9.87*	3.33*	3.40*	2.63*	1.14^{ns}
k	-	-1.99	-	-1.99	-	-1.49	-1.24	0.11	-1.09	0.12	0.45	0.44	0.63	7.46

Continuation of Table 2

Nezara viridula														
Mínimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	1.00	1.00	1.00	1.00	1.00	3.00	2.00	1.00	1.00	1.00	3.00	3.00	6.00	2.00
Mean	0.01	0.01	0.01	0.01	0.01	0.03	0.02	0.02	0.02	0.05	0.12	0.14	0.18	0.06
s	0.11	0.11	0.08	0.11	0.11	0.27	0.18	0.14	0.14	0.22	0.41	0.42	0.63	0.27
s^2	0.01	0.01	0.01	0.01	0.01	0.07	0.03	0.02	0.02	0.05	0.17	0.18	0.39	0.07
CV(%)	874.62	874.62	1,240.97	874.62	874.62	819.73	922.54	711.77	711.77	428.59	351.98	293.28	357.97	419.45
I_δ	0.00^{ns}	0.00^{ns}	-	0.00^{ns}	0.00^{ns}	46.20*	51.33*	0.00^{ns}	0.00^{ns}	0.00^{ns}	5.03*	2.67*	8.34*	3.42^{ns}
k	-1.99	-1.99	-	-1.99	-1.99	0.03	0.03	-1.49	-1.49	-1.14	0.26	0.62	0.14	0.46
Euschistus heros														
Mínimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	0.00	0.00	0.00	0.00	1.00	2.00	1.00	1.00	1.00	1.00	1.00	1.00	2.00	3.00
Mean	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.01	0.01	0.01	0.04	0.05	0.14	0.21
s	0.00	0.00	0.00	0.00	0.08	0.18	0.11	0.11	0.08	0.11	0.19	0.22	0.39	0.55
s^2	0.00	0.00	0.00	0.00	0.01	0.03	0.01	0.01	0.01	0.01	0.04	0.05	0.15	0.30
CV(%)	-	-	-	-	1,240.97	922.54	874.62	874.62	1,240.97	874.62	498.28	428.59	270.56	255.68
I_δ	-	-	-	-	-	51.33*	0.00^{ns}	0.00^{ns}	-	0.00^{ns}	0.00^{ns}	0.00^{ns}	1.33^{ns}	2.92*
k	-	-	-	-	-	0.03	-1.99	-1.99	-	-1.99	-1.19	-1.14	3.12	0.53
Chinavia sp.														
Mínimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	0.00	1.00	0.00	0.00	0.00	0.00	0.00	1.00	2.00	2.00	1.00	3.00	3.00	1.00
Mean	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.05	0.07	0.05	0.03	0.08	0.09	0.03
s	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.21	0.28	0.25	0.16	0.36	0.42	0.16
s^2	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.04	0.08	0.06	0.03	0.13	0.17	0.03
CV(%)	-	874.62	-	-	-	-	-	459.75	395.56	481.80	614.37	427.25	459.75	614.37
I_δ	-	0.00^{ns}	-	-	-	-	-	0.00^{ns}	2.80^{ns}	5.50*	0.00^{ns}	7.90*	11.85*	0.00^{ns}
k	-	-1.99	-	-	-	-	-	-1.16	0.61	0.25	-1.32	0.16	0.10	-1.32

(1) Developmental stages of the soybean according to Ritchie *et al*. (1982), adapted by Yorinori (1996). * Morisita index different from 1 by the $\chi 2$ test at 5%. ^{ns} Non-significant. - Not calculated where no stink bugs, or only 1, were found

Table 3 - Minimum, maximum, mean, standard deviation (s), variance (s^2), coefficient of variation (CV%), Morisita index (I_δ) and k parameter of the negative binomial distribution for the population density of nymphs, adults, and nymphs and adults of the stink bug, irrespective of species *Dichelops furcatus*, *Piezodorus guildinii*, *Edessa meditabunda*, *Nezara viridula*, *Euschistus heros* and *Chinavia* sp., expressed as stink bugs m^{-2}, based on 154 points each of 1 m² in area, for 14 phenological stages in the soybean

Statistic	Phenological stage(1)													
	V7	V9	V11	R1	R2	R3	R4	R5.1	R5.3	R5.5	R6	R7.1	R7.3	R8.2
Nymphs														
Mínimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	2.00
Maximum	0.00	1.00	4.00	5.00	4.00	5.00	4.00	6.00	5.00	40.00	28.00	34.00	54.00	44.00
Mean	0.00	0.02	0.05	0.12	0.27	0.53	0.53	0.69	0.47	1.19	3.92	9.78	14.47	10.05
s	0.00	0.14	0.35	0.52	0.59	0.89	0.92	1.07	0.83	3.53	4.16	6.92	7.45	5.57
s^2	0.00	0.02	0.12	0.27	0.35	0.80	0.84	1.15	0.70	12.47	17.27	47.86	55.54	31.00
CV(%)	-	711.77	768.75	447.70	223.32	170.05	174.17	154.65	178.31	295.57	106.12	70.74	51.51	55.39
I_δ	-	0.00^{ns}	44.00*	13.08*	2.25*	2.00*	2.14*	1.96*	2.05*	8.89*	1.87*	1.40*	1.20*	1.21*
k	-	-1.49	0.03	0.09	0.81	1.01	0.88	1.05	0.96	0.13	1.15	2.51	5.10	4.82

Continuation of Table 3

Adults														
Mínimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	2.00	2.00	2.00	2.00	3.00	4.00	4.00	6.00	4.00	4.00	5.00	9.00	21.00	14.00
Mean	0.04	0.14	0.08	0.12	0.19	0.34	0.34	0.47	0.57	0.69	0.69	1.71	4.88	5.01
s	0.25	0.36	0.32	0.35	0.54	0.68	0.70	0.86	0.85	0.89	0.94	1.79	3.68	3.07
s^2	0.06	0.13	0.10	0.12	0.29	0.46	0.49	0.73	0.72	0.79	0.88	3.21	13.55	9.41
CV(%)	648.47	266.04	381.91	283.03	275.77	197.60	206.58	183.28	148.19	129.22	136.49	104.99	75.47	61.20
I_δ	20.53*	0.73^{ns}	3.95*	0.90^{ns}	3.54*	2.01*	2.32*	2.23*	1.45*	1.22^{ns}	1.41*	1.52*	1.36*	1.17*
k	0.06	-3.91	0.37	-10.55	0.40	1.00	0.77	0.82	2.24	4.61	2.44	1.94	2.74	5.71
Nymphs + adults														
Mínimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	2.00	5.00
Maximum	2.00	2.00	4.00	5.00	5.00	7.00	6.00	9.00	6.00	40.00	28.00	35.00	56.00	51.00
Mean	0.04	0.16	0.13	0.24	0.46	0.87	0.86	1.16	1.04	1.88	4.60	11.49	19.34	15.06
s	0.25	0.40	0.47	0.63	0.91	1.20	1.24	1.50	1.23	3.58	4.17	7.41	8.42	6.68
s^2	0.06	0.16	0.22	0.39	0.83	1.45	1.54	2.24	1.50	12.78	17.42	54.92	70.92	44.56
CV(%)	648.47	255.51	359.78	260.88	197.04	138.25	143.85	128.80	117.95	189.87	90.65	64.51	43.53	44.31
I_δ	20.53*	1.12^{ns}	6.48*	3.70*	2.73*	1.76*	1.91*	1.80*	1.43*	4.06*	1.60*	1.33*	1.14*	1.13*
k	0.06	8.94	0.19	0.38	0.58	1.31	1.10	1.25	2.33	0.33	1.65	3.04	7.26	7.70

(1) Developmental stages of the soybean according to Ritchie *et al*. (1982), adapted by Yorinori (1996). * Morisita index different from 1 by the $\chi 2$ test at 5%. ^{ns} Non-significant. - Not calculated where no stink bugs, or only 1, were found

Chinavia sp. compared to those observed for *P. guildinii* (Tables 1 and 2). These results suggest that to estimate the average population density of *P. guildinii* will require less sample points. In relation to the phase of the bugs, the higher CV scores for adults suggest the need for a larger sample size compared to that of the nymphs (Tables 1, 2 and 3). These results therefore suggest that sample size varies between the species and stages of the bugs.

The coefficient of variation decreased gradually towards the initial stages (V7 and V9) in relation to the final stages (R7.1, R7.3 and R8.2) (Tables 1, 2 and 3). This behaviour was inversely proportional to that discussed previously for the average population density of stink bugs. These results suggest that to obtain estimates with the same precision, larger sample sizes (number of sampling points) will be needed in the initial stages (larger CVs and lower population densities), with a gradual decrease toward the final stages of the soybean crop (smaller CVs and higher population densities). Moreover, estimates obtained from a single sample size demonstrate less precision in the initial stages and more precision in the final stages.

In practice, the definition of a sample size (number of sampling points) of the desired precision, taken from population densities close to the control level (higher density), is appropriate because it is then the decision is made for the need to control the pest. At lower population densities, it is possible to allow less precision due to the population density being relatively far from the control level, with the risk of damage being thus lower. As soon as the population of stink bugs increased there was a trend towards homogeneity in the area, resulting in a decrease in the coefficient of variation and consequently fewer sampling points being required when sampling. Similar results were obtained by Cargnelutti Filho *et al*. (2011), i.e. the absence of white grubs at some sampling points (lower population densities) contributed to high coefficients of variation.

The F-test, applied between the variances for population density of stink-bug nymphs and adults, for each species and phenological stage (61 cases), revealed heterogeneous variances ($P \leq 0.05$) in 50 cases (81.97 %) (Table 4). This should be interpreted as demonstrating that in these 50 cases, the sample size for estimating the average population density of the bugs is different for nymphs and adults. Between the variances for the species for each phase and phonological stage, the F-test revealed heterogeneous variances ($P \leq 0.05$) in 100% of the cases, revealing the need to determine the sample size for each species. The variances for the phenological stages, for each stage and species, were heterogeneous ($P \leq 0.05$) in 12 cases. In general therefore, the results indicate the need to use the largest variance, having an acceptable error and fixed level of confidence, to determine a single sample size for these species, phases and phonological stages. On the other hand, the existing variability enables the identification of species and phases of bugs and phenological stages with a higher and lower sample size than that required to estimate the average population density.

Table 4 - Variance of population density of stink-bug nymphs and adults of the species *Dichelops furcatus*, *Piezodorus guildinii*, *Edessa meditabunda*, *Nezara viridula*, *Euschistus heros* and *Chinavia* sp., expressed as stink bugs m^{-2}, based on 154 points each of 1 m² in area, for 14 phenological stages in the soybean, and values of the F-test for variance homogeneity (F = greater variance/smaller variance)

Species	Size	Phenological state(1)														
		V7	V9	V11	R1	R2	R3	R4	R5.1	R5.3	R5.5	R6	R7.1	R7.3	R8.2	F(4)
D. furcatus	nymph	-	-	0.013	0.038	0.096	0.140	0.112	0.038	0.080	0.080	0.588	1.299	1.734	1.553	134.4*
D. furcatus	adult	0.006	0.085	0.087	0.038	0.083	0.122	0.220	0.140	0.241	0.249	0.063	0.314	1.230	1.288	198.3*
F(2)		-	-	6.8*	1.0ns	1.2ns	1.1ns	2.0*	3.7*	3.0*	3.1*	9.4*	4.1*	1.4*	1.2ns	
P. guildinii	nymph	-	0.019	0.006	0.242	0.098	0.408	0.232	0.442	0.125	1.107	7.671	37.471	39.353	20.765	6,060.4*
P. guildinii	adult	0.032	0.019	0.013	0.068	0.166	0.193	0.107	0.232	0.291	0.391	0.425	2.112	10.335	7.534	801.0*
F(2)		-	1.0ns	2.0*	3.5*	1.7*	2.1*	2.2*	1.9*	2.3*	2.8*	18.0*	17.7*	3.8*	2.8*	
E. meditabunda	nymph	-	-	-	-	-	0.077	0.256	0.151	0.044	0.159	0.311	0.511	1.551	0.356	35.5*
E. meditabunda	adult	-	0.013	-	0.013	-	0.019	0.032	0.119	0.067	0.143	0.189	0.138	0.224	0.193	17.4*
F(2)		-	-	-	-	-	4.0*	8.1*	1.3ns	1.5*	1.1ns	1.6*	3.7*	6.9*	1.8*	
N. viridula	nymph	-	-	0.104	-	0.067	0.061	0.051	0.149	0.044	0.169	0.215	3.729	3.229	0.789	85.4*
N. viridula	adult	0.013	0.013	0.006	0.013	0.013	0.071	0.032	0.019	0.019	0.050	0.169	0.176	0.394	0.074	60.7*
F(2)		-	-	16.0*	-	5.2*	1.2ns	1.6*	7.7*	2.3*	3.4*	1.3ns	21.2*	8.2*	10.6*	
E. heros	nymph	-	-	-	-	0.006	-	0.013	0.039	0.013	0.026	0.445	0.119	0.044	0.182	68.6*
E. heros	adult	-	-	-	-	0.006	0.032	0.013	0.013	0.006	0.013	0.038	0.050	0.149	0.300	46.2*
F(2)		-	-	-	-	1.0ns	-	1.0ns	3.0*	2.0*	2.0*	11.8*	2.4*	3.4*	1.6*	
Chinavia sp.	nymph	-	-	-	-	0.032	0.080	0.154	0.220	0.333	9.702	9.796	4.408	19.725	2.863	610.7*
Chinavia sp.	adult	-	0.013	-	-	-	-	-	0.044	0.080	0.063	0.025	0.130	0.175	0.025	13.5*
F(2)		-	-	-	-	-	-	-	5.0*	4.2*	154.9*	384.7*	33.9*	112.9*	112.4*	
D. furcatus	nymph	-	-	0.013	0.038	0.096	0.140	0.112	0.038	0.080	0.080	0.588	1.299	1.734	1.553	134.4*
P. guildinii	nymph	-	0.019	0.006	0.242	0.098	0.408	0.232	0.442	0.125	1.107	7.671	37.471	39.353	20.765	6,060.4*
E. meditabunda	nymph	-	-	-	-	-	0.077	0.256	0.151	0.044	0.159	0.311	0.511	1.551	0.356	35.5*
N. viridula	nymph	-	-	0.104	-	0.067	0.061	0.051	0.149	0.044	0.169	0.215	3.729	3.229	0.789	85.4*
E. heros	nymph	-	-	-	-	0.006	-	0.013	0.039	0.013	0.026	0.445	0.119	0.044	0.182	68.6*
Chinavia sp.	nymph	-	-	-	-	0.032	0.080	0.154	0.220	0.333	9.702	9.796	4.408	19.725	2.863	610.7*
F(3)		-	-	16.0*	6.4*	15.2*	6.7*	19.8*	11.7*	25.8*	373.5*	45.6*	314.8*	901.1*	113.9*	
D. furcatus	adult	0.006	0.085	0.087	0.038	0.083	0.122	0.220	0.140	0.241	0.249	0.063	0.314	1.230	1.288	198.3*
P. guildinii	adult	0.032	0.019	0.013	0.068	0.166	0.193	0.107	0.232	0.291	0.391	0.425	2.112	10.335	7.534	801.0*
E. meditabunda	adult	-	0.013	-	0.013	-	0.019	0.032	0.119	0.067	0.143	0.189	0.138	0.224	0.193	17.4*
N. viridula	adult	0.013	0.013	0.006	0.013	0.013	0.071	0.032	0.019	0.019	0.050	0.169	0.176	0.394	0.074	60.7*
E. heros	adult	-	-	-	-	0.006	0.032	0.013	0.013	0.006	0.013	0.038	0.050	0.149	0.300	46.2*
Chinavia sp.	adult	-	0.013	-	-	-	-	-	0.044	0.080	0.063	0.025	0.130	0.175	0.025	13.5*
F(3)		5.0*	6.6*	13.4*	5.3*	25.6*	10.1*	17.0*	18.0*	44.8*	30.3*	16.7*	42.6*	69.2*	295.9*	

(1) Developmental stages of the soybean according to Ritchie *et al*. (1982), adapted by Yorinori (1996). (2) * Variances between the phases of stink bug within each combination of species and phenological stage are heterogeneous by one-sided F test at 5% probability. ns homogeneous variances. (3) * Variance between species within each combination of phase and phenological stage are heterogeneous by one-sided F-test at 5%. (4) * Variances between phenological stages within each combination of phase and species are heterogeneous by one-sided F-test at 5%. - Not calculated where no stink bugs were found

In most cases relating to the population density of stink-bug nymphs and adults of the six bug species, and to the total number of bugs for each phenological stage, the variance was higher than the mean, the Morisita index

(MORISITA, 1962) was higher than one ($P \leq 0.05$), and the k parameter of the negative binomial distribution tended toward zero ($-10.55 \leq k \leq 8.94$) (Tables 1, 2 and 3). These results indicate that the stink bugs were distributed as aggregates in the area. When the spatial distribution of insects is aggregate, Cargnelutti Filho *et al*. (2011) demonstrated that both the expression presented by Karandinos (1976), commonly used for sample-sizing in the area of entomology, and the expression used in this work give the same estimates of sample size, confirming the suitability of both methods.

The sample size (number of sampling points) in estimating the mean (m) of the population density of stink bugs in combinations of phase and bug species and phenological stage, with the semi-amplitude of the confidence interval equal to 10% of the estimated mean and level of confidence of 95 % , ranged from 127 sampling points (*P. guildinii*, nymph - R8.2) and 60,106 sampling points (*P. guildinii*, nymph - V11, *N. viridula*, nymph - V11, *E. heros*, nymph - R2 and R5.5, *D. furcatus*, adult - V7, *N. viridula*, adult - V11 and , adult - R2 and R5.3) (Tables 5 and 6) . In practice, collecting bugs at 60,106 sampling points is difficult. Smaller sample sizes (number of sampling points) have therefore been determined using permitted lower precisions (semi-amplitudes of the confidence interval equal to 20, 30, 40 and 50% of the mean). These sample sizes serve as a basis when planning sampling for specific studies to estimate the mean population density of stink-bug nymphs and adults of the species *D. furcatus*, *P. guildinii*, *E. meditabunda*, *N. viridula*, *E. heros* and *Chinavia* sp. for the phenological stages of the soybean. The number of sampling units is dependent on the degree of accuracy required, which varies with the purpose of the research: population dynamics, crop damage, levels of economic loss and pest control (SILVA; COSTA, 1998).

The maximum acceptable error is debateable, leaving the user to choose the desired precision based on the availability of time and labour. Cargnelutti Filho *et al*. (2011) observed that for the estimation of a population of white grubs, the sample size for high accuracy was large and difficult to implement. A large sample size increases the time and cost of sampling, whereas smaller sample sizes can result in less precision, which is also undesirable. It is recommended to use sample sizes that result in high precision while saving time and resources.

To estimate the average population of stink bugs with the same precision, fewer sampling points are needed for the species *P. guildinii* in relation to the other five species (Tables 5 and 6). A larger sample size is required for quantification of adult bugs in relation to nymphs (Tables 5, 6 and 7). This difference may be explained by the lower variability of *P. guildinii* and of the nymphs respectively. The nymphs do not display great mobility in the area, because they are devoid of wings. According Fucarino *et al*. (2004) the newly-hatched nymphs remain on the egg mass and only after the third instar do they begin their dispersion.

The sample size obtained was higher for the early and intermediate stages of soybean development, and lower for the final stages (R7.1, R7.3 and R8.2). These results therefore confirm previous inferences that there is variability in the sample size (number of sampling points) when estimating the average population density for the phases and species of stink bug and phenological stages. Employing the net method in the soybean, Costa and Link (1980) found that in larger populations of *P. guildinii* and *N. viridula*, smaller sizes of sampling unit were defined. Cullen *et al*. (2000) found that for a greater density of *E. heros* in the tomato, the sample size was smaller. Lúcio *et al*. (2009), studying the sample size for mites in the yerba mate, found a variation in the number of samples as a result of the period of evaluation and the degree of pest infestation.

When making a decision about the control of stink bugs in the soybean, it is important to consider the total number of stink bugs. Another aspect to consider is that at population densities close to the control level, quantification should be more accurate, since the wrong estimate at that time can cause a reduction in bean yield. On the other hand, at lower population densities, errors which result in over-estimation are tolerable. Thus, based on the total number of stink bugs (nymphs + adults), the sample size was larger for the initial and intermediate stages of the crop (V7, V9, V11, R1, R2, R3, R4 and R5.1, R5.3 and R5.5), with values ranging between 61 and 1,824 sampling points (error of estimation of 30 %) (Table 7). In the final stages (R6, R7.1, R7.3 and R8.2), the sample sizes which were calculated were smaller and ranged from 9 to 36, which may be explained by the higher population densities of the bugs (between 4.60 and 19.34 bugs m^{-2}) during this period (Table 3). Thirty-six samples are therefore sufficient when estimating the average population density of stink bugs for these 4 phenological stages when there is a greater incidence of bugs .

In general, only a few producers sample a sufficient number of points when quantifying the population of stink bugs in the soybean. Without the correct procedure to determine the density of the infestation, applications of insecticide are made either preventively or at random. This practice has several negative aspects, such as applications not being made at the appropriate time (before the recommended density and control level or with populations that damage the beans) and the increased use of insecticides, with an increase in the cost of production and deleterious effects on natural enemies and other non-target organisms.

Table 5 - Sample size (number of sampling points) to estimate the average population density of stink-bug nymphs of the species *Dichelops furcatus*, *Piezodorus guildinii*, *Edessa meditabunda*, *Nezara viridula*, *Euschistus heros* and *Chinavia* sp., for errors of estimation equal to 10, 20, 30, 40 and 50 % of the estimated mean and semi-amplitude of the confidence interval (Error %), based on 154 points each of 1 m² in area, for 14 phenological stages

Error of estimation	Phenological stage[(1)]													
	V7	V9	V11	R1	R2	R3	R4	R5.1	R5.3	R5.5	R6	R7.1	R7.3	R8.2
Dichelops furcatus														
10%	-	-	29,857	9,691	4,546	3,238	7,170	9,691	6,107	6,107	1,675	795	597	3,402
20%	-	-	7,465	2,423	1,137	810	1,793	2,423	1,527	1,527	419	199	150	851
30%	-	-	3,318	1,077	506	360	797	1,077	679	679	187	89	67	378
40%	-	-	1,867	606	285	203	449	606	382	382	105	50	38	213
50%	-	-	1,195	388	182	130	287	388	245	245	67	32	24	137
Error (%)	-	-	139.24	79.32	54.33	45.85	68.23	79.32	62.97	62.97	32.97	22.72	19.69	47.00
Piezodorus guildinii														
10%	-	19,774	60,106	15,573	6,330	3,271	2,557	2,557	4,004	4,269	587	290	145	127
20%	-	4,944	15,027	3,894	1,583	818	640	640	1,001	1,068	147	73	37	32
30%	-	2,198	6,679	1,731	704	364	285	285	445	475	66	33	17	15
40%	-	1,236	3,757	974	396	205	160	160	251	267	37	19	10	8
50%	-	791	2,405	623	254	131	103	103	161	171	24	12	6	6
Error (%)	-	113.31	197.56	100.56	64.11	46.08	40.74	40.74	50.99	52.65	19.51	13.71	9.68	9.06
Edessa meditabunda														
10%	-	-	-	-	-	19,774	8,190	4,841	8,250	2,549	5,440	3,452	3,616	2,852
20%	-	-	-	-	-	4,944	2,048	1,211	2,063	638	1,360	863	904	713
30%	-	-	-	-	-	2,198	910	538	917	284	605	384	402	317
40%	-	-	-	-	-	1,236	512	303	516	160	340	216	226	179
50%	-	-	-	-	-	791	328	194	330	102	218	139	145	115
Error (%)	-	-	-	-	-	113.31	72.93	56.06	73.19	40.68	59.43	47.34	48.46	43.03
Nezara viridula														
10%	-	-	60,106	-	5,108	5,657	13,052	7,016	8,250	4,836	4,108	5,822	4,138	3,305
20%	-	-	15,027	-	1,277	1,415	3,263	1,754	2,063	1,209	1,027	1,456	1,035	827
30%	-	-	6,679	-	568	629	1,451	780	917	538	457	647	460	368
40%	-	-	3,757	-	320	354	816	439	516	303	257	364	259	207
50%	-	-	2,405	-	205	227	523	281	330	194	165	233	166	133
Error (%)	-	-	197.56	-	57.59	60.61	92.06	67.49	73.19	56.03	51.64	61.48	51.83	46.32
Euschistus heros														
10%	-	-	-	-	60,106	-	29,857	22,295	29,857	60,106	4,582	9,107	8,250	9,989
20%	-	-	-	-	15,027	-	7,465	5,574	7,465	15,027	1,146	2,277	2,063	2,498
30%	-	-	-	-	6,679	-	3,318	2,478	3,318	6,679	510	1,012	917	1,110
40%	-	-	-	-	3,757	-	1,867	1,394	1,867	3,757	287	570	516	625
50%	-	-	-	-	2,405	-	1,195	892	1,195	2,405	184	365	330	400
Error (%)	-	-	-	-	197.56	-	139.24	120.32	139.24	197.56	54.54	76.90	73.19	80.54
Chinavia sp.														
10%	-	-	-	-	33,218	6,107	6,330	3,008	3,929	14,033	5,994	1,536	1,772	1,089
20%	-	-	-	-	8,305	1,527	1,583	752	983	3,509	1,499	384	443	273
30%	-	-	-	-	3,691	679	704	335	437	1,560	666	171	197	121
40%	-	-	-	-	2,077	382	396	188	246	878	375	96	111	69
50%	-	-	-	-	1,329	245	254	121	158	562	240	62	71	44
Error (%)	-	-	-	-	146.87	62.97	64.11	44.20	50.51	95.46	62.38	31.58	33.92	26.59

[(1)] Developmental stages of the soybean according to Ritchie *et al*. (1982), adapted by Yorinori (1996). - Not calculated where no stink bugs were found

Table 6 - Sample size (number of sampling points) to estimate the average population density of stink-bug adults of the species *Dichelops furcatus*, *Piezodorus guildinii*, *Edessa meditabunda*, *Nezara viridula*, *Euschistus heros* and *Chinavia* sp., for errors of estimation equal to 10, 20, 30, 40 and 50 % of the estimated mean and semi-amplitude of the confidence interval (Error %), based on 154 points each of 1 m² in area, for 14 phenological stages

Error of estimation	Phenological stage[1]													
	V7	V9	V11	R1	R2	R3	R4	R5.1	R5.3	R5.5	R6	R7.1	R7.3	R8.2
Dichelops furcatus														
10%	60,106	5,489	8,077	9,691	15,658	3,127	3,008	3,238	2,849	2,565	9,061	2,127	977	968
20%	15,027	1,373	2,020	2,423	3,915	782	752	810	713	642	2,266	532	245	242
30%	6,679	610	898	1,077	1,740	348	335	360	317	285	1,007	237	109	108
40%	3,757	344	505	606	979	196	188	203	179	161	567	133	62	61
50%	2,405	220	324	388	627	126	121	130	114	103	363	86	40	39
Error (%)	197.56	59.70	72.42	79.32	100.83	45.06	44.20	45.85	43.01	40.81	76.70	37.16	25.18	25.06
Piezodorus guildinii														
10%	33,218	19,774	29,857	7,823	3,843	3,382	3,861	2,557	2,329	1,789	1,708	710	313	204
20%	8,305	4,944	7,465	1,956	961	846	966	640	583	448	427	178	79	51
30%	3,691	2,198	3,318	870	427	376	429	285	259	199	190	79	35	23
40%	2,077	1,236	1,867	489	241	212	242	160	146	112	107	45	20	13
50%	1,329	791	1,195	313	154	136	155	103	94	72	69	29	13	9
Error (%)	146.87	113.31	139.24	71.27	49.95	46.86	50.07	40.74	38.88	34.07	33.30	21.46	14.25	11.50
Edessa meditabunda														
10%	-	29,857	-	29,857	-	19,774	11,707	9,107	5,108	7,841	3,608	4,422	2,844	2,125
20%	-	7,465	-	7,465	-	4,944	2,927	2,277	1,277	1,961	902	1,106	711	532
30%	-	3,318	-	3,318	-	2,198	1,301	1,012	568	872	401	492	316	237
40%	-	1,867	-	1,867	-	1,236	732	570	320	491	226	277	178	133
50%	-	1,195	-	1,195	-	791	469	365	205	314	145	177	114	85
Error (%)	-	139.24	-	139.24	-	113.31	87.19	76.90	57.59	71.35	48.40	53.59	42.97	37.15
Nezara viridula														
10%	29,857	29,857	60,106	29,857	29,857	26,227	33,218	19,774	19,774	7,170	4,836	3,358	5,002	6,867
20%	7,465	7,465	15,027	7,465	7,465	6,557	8,305	4,944	4,944	1,793	1,209	840	1,251	1,717
30%	3,318	3,318	6,679	3,318	3,318	2,915	3,691	2,198	2,198	797	538	374	556	763
40%	1,867	1,867	3,757	1,867	1,867	1,640	2,077	1,236	1,236	449	303	210	313	430
50%	1,195	1,195	2,405	1,195	1,195	1,050	1,329	791	791	287	194	135	201	275
Error (%)	139.24	139.24	197.56	139.24	139.24	130.50	146.87	113.31	113.31	68.23	56.03	46.69	56.99	66.78
Euschistus heros														
10%	-	-	-	-	60,106	33,218	29,857	29,857	60,106	29,857	9,691	7,170	2,858	2,552
20%	-	-	-	-	15,027	8,305	7,465	7,465	15,027	7,465	2,423	1,793	715	638
30%	-	-	-	-	6,679	3,691	3,318	3,318	6,679	3,318	1,077	797	318	284
40%	-	-	-	-	3,757	2,077	1,867	1,867	3,757	1,867	606	449	179	160
50%	-	-	-	-	2,405	1,329	1,195	1,195	2,405	1,195	388	287	115	103
Error (%)	-	-	-	-	197.56	146.87	139.24	139.24	197.56	139.24	79.32	68.23	43.07	40.70
Chinavia sp.														
10%	-	29,857	-	-	-	-	-	8,250	6,107	9,061	14,732	7,125	8,250	14,732
20%	-	7,465	-	-	-	-	-	2,063	1,527	2,266	3,683	1,782	2,063	3,683
30%	-	3,318	-	-	-	-	-	917	679	1,007	1,637	792	917	1,637
40%	-	1,867	-	-	-	-	-	516	382	567	921	446	516	921
50%	-	1,195	-	-	-	-	-	330	245	363	590	285	330	590
Error (%)	-	139.24	-	-	-	-	-	73.19	62.97	76.70	97.81	68.02	73.19	97.81

[1] Developmental stages of the soybean according to Ritchie *et al.* (1982), adapted by Yorinori (1996). - Not calculated where no stink bugs were found

Table 7 - Sample size (number of sampling points) to estimate the average population density of stink-bug nymphs, adults, and nymphs and adults, irrespective of species *Dichelops furcatus*, *Piezodorus guildinii*, *Edessa meditabunda*, *Nezara viridula*, *Euschistus heros* and *Chinavia* sp., for errors of estimation equal to 10, 20, 30, 40 and 50 % of the estimated mean and semi-amplitude of the confidence interval (Error %), based on 154 points each of 1 m² in area, for 14 phenological stages

Error of estimation	Phenological stage[(1)]													
	V7	V9	V11	R1	R2	R3	R4	R5.1	R5.3	R5.5	R6	R7.1	R7.3	R8.2
Nymphs														
10%	-	19,774	23,066	7,823	1,947	1,129	1,184	934	1,241	3,410	440	196	104	120
20%	-	4,944	5,767	1,956	487	283	296	234	311	853	110	49	26	30
30%	-	2,198	2,563	870	217	126	132	104	138	379	49	22	12	14
40%	-	1,236	1,442	489	122	71	74	59	78	214	28	13	7	8
50%	-	791	923	313	78	46	48	38	50	137	18	8	5	5
Error (%)	-	113.31	122.38	71.27	35.55	27.07	27.73	24.62	28.39	47.05	16.89	11.26	8.20	8.82
Adults														
10%	16,413	2,763	5,693	3,127	2,969	1,524	1,666	1,312	858	652	728	431	223	147
20%	4,104	691	1,424	782	743	381	417	328	215	163	182	108	56	37
30%	1,824	307	633	348	330	170	186	146	96	73	81	48	25	17
40%	1,026	173	356	196	186	96	105	82	54	41	46	27	14	10
50%	657	111	228	126	119	61	67	53	35	27	30	18	9	6
Error (%)	103.23	42.35	60.80	45.06	43.90	31.46	32.89	29.18	23.59	20.57	21.73	16.71	12.02	9.74
Nymphs + Adults														
10%	16,413	2,549	5,053	2,657	1,516	746	808	648	543	1,407	321	163	74	77
20%	4,104	638	1,264	665	379	187	202	162	136	352	81	41	19	20
30%	1,824	284	562	296	169	83	90	72	61	157	36	19	9	9
40%	1,026	160	316	167	95	47	51	41	34	88	21	11	5	5
50%	657	102	203	107	61	30	33	26	22	57	13	7	3	4
Error (%)	103.23	40.68	57.28	41.53	31.37	22.01	22.90	20.51	18.78	30.23	14.43	10.27	6.93	7.05

[(1)] Developmental stages of the soybean according to Ritchie *et al*. (1982), adapted by Yorinori (1996). - Not calculated where no stink bugs were found

Any integrated pest management in the soybean requires that planning be based on solid foundations, such as the diagnosis of the species of bug, identification and registering of age throughout the crop cycle, and above all, the quantification of the number of individuals present in the cultivated areas. Thus, a correct, accurate and speedy quantification of the population of pentatomidae in the soybean is the only indicator that can determine the actions necessary for control, and is therefore the way to protect the crop from losses in production, with lesser costs and lower environmental impact.

Knowing the exact number of sampling points in order to obtain the average population density of stink bugs is therefore the first step when planning, followed by carrying out sampling in the field and diagnosis of the population density, which will indicate to producers, technical assistants and administrators the correct time to make the decision about management.

CONCLUSION

There is variability in the sample size (number of sampling points) when estimating the average population density of stink bugs, between the phases and species of the bugs and between the phenological stages of the soybean. Smaller sample sizes are needed for the nymphs of *P. guildinii* and final phonological stages (R6, R7.1, R7.3 and R8.2) compared to the adults of *D. furcatus*, *E. meditabunda*, *N. viridula*, *E. heros* and *Chinavia* sp. and the initial (V7, V9 and V11) and intermediate phenological stages (R1, R2, R3, R4, R5.1, R5.3 and R5.5) of the soybean respectively. Thirty-six sampling sites are sufficient to estimate the average population density of stink bugs in the final phenological stages (R6, R7.1, R7.3 and R8.2) at an error of estimation equal to 30% of the estimated mean and at a level of confidence of 95%.

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