SODIUM CHLORIDE:
AN INSECTICIDE ENHANCER FOR CONTROLLING PENTATOMIDS ON SOYBEANS[1]

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ABSTRACT - Field and greenhouse studies were conducted during 1990-1995, to determine the effect of the addition of sodium chloride (NaCl) to insecticides, on the control of pentatomid stink bugs (*Nezara viridula* L., *Piezodorus guildinii* (West.) and *Euschistus heros* (Fab.)) feeding on soybeans (*Glycine max* Merrill). Screening tests were developed applying several chemical insecticides, with and without addition of sodium chloride at 0.5% in water. Insect population was evaluated by the ground cloth sampling method, on several dates after insecticide application. For studying the hypothesis of sodium chloride attractiveness to stink bugs, large soybean fields were split into ca. 1 ha plots, where insecticides with and without salt addition were applied. Stink bug preference for soybean plants sprayed with NaCl solution or distilled water was tested on small cages inside greenhouse, and in small field plots, where several concentrations of NaCl were applied. Results showed that NaCl did not attract stink bugs, but had an arresting effect over the bugs, which preferred salt-sprayed plants, compared to plants receiving distilled water. Addition of NaCl to monocrotophos and metamidophos increased stink bug mortality by insecticides, allowing a reduction of at least 50% of the recommended rate, without reducing the residual effectiveness.

Index terms: *Glycine max*, Hemiptera, stink bugs, *Nezara viridula, Piezodorus guildinii, Euschistus heros*, chemical control.

CLORETO DE SÓDIO:
POTENCIALIZADOR DE INSETICIDAS PARA CONTROLE DE PENTATOMÍDEOS EM SOJA

RESUMO - Experimentos de campo e de casa de vegetação foram conduzidos entre 1990 e 1995, com o objetivo de determinar o efeito de inseticidas sobre percevejos pragas de soja (*Glycine max* Merrill), e em particular o efeito da adição de 0,5% de cloreto de sódio (NaCl) a inseticidas, no controle de pentatomídeos (*Nezara viridula* L., *Piezodorus guildinii* (West.) e *Euschistus heros* (Fab.)). A avaliação dos tratamentos foi efetuada em diversas datas após a aplicação dos inseticidas químicos com ou sem adição de NaCl a 0,5% em água. Para estudar uma possível atratividade da mistura inseticida e cloreto de sódio a percevejos, foram utilizadas parcelas de, aproximadamente, 1 ha de área. Avaliou-se, em casa de vegetação, a preferência de percevejos em relação a plantas que receberam água destilada ou uma solução a 0,5% de NaCl. Os resultados demonstraram que a adição de sal de cozinha a monocrotofós e metamidofós permite uma redução de até 50% na dose do inseticida, sem afetar sua eficiência sobre os percevejos. Foi observado que os percevejos não são atraídos para parcelas com a mistura de inseticida e sal, comparativamente a parcelas exclusivamente com inseticidas, porém os experimentos de casa de vegetação indicam um efeito arrestante do cloreto de sódio sobre os percevejos.

Termos para indexação: *Glycine max*, Hemiptera, percevejos, *Nezara viridula, Piezodorus guildinii, Euschistus heros*, controle químico.

INTRODUCTION

The stink bug complex, composed mainly by *Nezara viridula* (L.), *Piezodorus guildinii* (West.) and *Euschistus heros* (Fab.) (Hemiptera:

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Pentatomidae) is considered one of the most important pest complexes of soybeans in Brazil, from the standpoint of its ability to reducing the yield and quality of soybean seeds (Turnipseed & Kogan, 1976; Gazzoni et al., 1981; Kogan & Turnipseed, 1987). In general, soybeans can largely recover from insect damage, specially leaf feeder insects, before blooming (Gazzoni & Moscardi, 1998). However, from pod set (R3) (Fehr et al., 1971) to complete maturity, the soybean plant is susceptible to many kind of stresses (lack or excess of soil moisture, weed competition, disease infection, low soil fertility), including insect attack.

The stink bug infestation can induce abortion of flowers, pods or seeds, and partially or totally shrink seeds. Attacked seeds that still develop to maturity show different degrees of damage that may reduce yield, vigour and germination The punctures caused by stink bug feeding on the seeds are pathways to fungal or bacterial penetration and infection, especially the fungus *Nematospora corily* Peglion (Corso & Porto, 1978). Seed pathogens affect seed viability, or the emergence of seedlings. Under medium to high levels of attack, soybean plants may not undergo a normal maturation process, thus producing immature stalks and green leaves, which in turn makes the harvest difficult or even impossible.

Economic damage levels for stink bugs are very low. Villas Boas et al. (1990) studied the impact of different populations of stink bugs on the yield, quality of seeds and agronomic traits of soybeans. No yield reduction but lower seed viability and vigour were observed when stink bug populations of four specimens per meter of row of soybeans were allowed to develop. Yield reductions started with populations reaching six bugs per meter of row. Villas Boas et al. (1990) also referred to an increase in protein content and a reduction in oil content in soybean seed attacked by stink bugs.

Population of stink bugs on soybean fields is very low or absent while the plants have no pods. A progressive increase in insect density is observed from the pod set to harvest. An exponential increase in population size is observed close to harvesting, due to the adults behaviour of migrating from harvested areas to green fields. The bugs are partially controlled by several natural enemies, including egg and first instars predators, mainly hemipterans and coleopterans (Gazzoni et al., 1981). Adult parasitoids like *Eutrichopodopsis nitens* reach high parasitism rates, but are considered of low efficiency to avoid soybean damage. Egg parasitoids are quite more efficient, in avoiding or reducing the field population build up. Correa-Ferreira & Moscardi (1994, 1996) demonstrated that inoculative releases of the 15,000 adults/ha of the egg parasitoid *Trissolcus basalis* (Woll) reduced the stink bug population by 54-58%.

Pentatomids from the stink bug complex are not easily controlled by insecticides. The first reason is the intrinsic tolerance of the stink bugs to commonly used chemicals, normally requiring high rates of organophosphorous and pyrethroid insecticides. Moreover, when the population quickly increases by adult migration, additional spraying might be necessary to maintain pest population below the economic damage level. Oliveira et al. (1988) screened 52 insecticides for the control of soybean stink bugs, concluding that only 11 provided mortality rates over 80% of the population present in the plots after 48 hours. According to Gazzoni (1994), Brazilian farmers apply an average of 1.2 insecticide application per season, with estimated insecticide costs of US$16 million per year. The host plant resistance (HPR) trait can positively interact with insecticide action, improving its field action, as described by Kea et al. (1978) and Gazzoni (1995). This last author did not observe a triple interaction among HPR, insecticide and NaCl, as higher mortality of nymphs of *N. viridula* feeding on resistant IAC-100 variety was observed when endosulfan was sprayed at lower rates; however, aggregating sodium chloride to the insecticide did not improve the mortality of bugs, compared to ones feeding on susceptible BR-16 variety.

Empirical field observations showed that stink bugs are attracted to human sweat. Concentration of stink bugs adults have been observed around used shirts hung on field stakes, and on sweaty hoe handles, when left close to soybean fields. These observations suggested that substances present on human sweat was attracting and arresting stink bugs. Preliminary investigations proved that inorganic salts like sodium or potassium chloride were linked to the phenomenon.

The objective of this set of experiments was to verify the effect of sodium chloride as an enhancer for insecticides used to control soybean stink bugs.

MATERIAL AND METHODS

From 1991 to 1995, six screening experiments were set up, at the experimental station of Embrapa-Centro Nacional de Pesquisa de Soja (CNPSo) at Londrina, PR, Brazil, to investigate the effect of insecticides on soybean stink bugs, and especially the effect of adding NaCl to insecticides on the mortality of the insects. For all the experiments, soybeans cv. BR-37 (medium maturity cycle) were planted during November, on plots measuring 10 x 15 m, with rows spaced by 50 cm and a density of 20 plants per meter. The experimental design was the randomised block, with four replications. Treatments were applied when plants were on the reproductive stage (R_5 - R_6) (Fehr et al., 1971), and 70-80 cm high. Stink bugs were always sampled before the treatment, to assure an adequate insect population density for experimentation. Insecticides were applied through a CO_2 propelled sprayer, with a 4-nozzle bar delivering 90 L ha^{-1}. Stink bug population was surveyed using the ground cloth method (Boyer & Dumas, 1963). Only the adults and 3rd. to 5th. instar nymphs of the phytophagous stink bugs were counted. Samples were taken on different dates after the application, with four sub-samples per plot.

To test stink bugs preference for soybean plants receiving NaCl versus distilled water, one experiment was set up at Embrapa-CNPSo greenhouse. Small screened cages measuring 0.5 x 0.5 x 1 m were placed over soybean plants grown on pots, placed side by side. Ten cages were used, with one plant receiving an application of 0.5% NaCl solution, while the other was sprayed with distilled water. Ten adults of *N. viridula* were released inside the cages. Eight recordings of the position of each stink bug inside the cages were made after release.

In the field, eight concentrations of NaCl were applied to the two central rows of a four row plot, to observe the attractiveness of the stink bug to salt sprayed plants. Also the attractiveness of NaCl to stink bugs following application of an insecticide plus salt for its control, was observed. Two experiments were set up in the experimental station of Embrapa-CNPSo. Test one consisted of eight experimental treatments, which were applied on plots of ca. 3 ha, while test two consisted of 10 treatments, applied on plots of ca. 1 ha. Insect evaluation followed the system described for the screening tests, with samples made before application and six days after.

Experimental data of all tests were submitted to tests of homogeneity and normality of variances, and raw data were transformed by $\sqrt{x+0.5}$, when required. The analysis of variance, was performed using the SANEST statistical package (Zonta et al., 1984) and means were tested by the Tukey's test at $p < 0.05$ level.

RESULTS AND DISCUSSION

Results are presented as aggregated data for all major stink bugs. All species demonstrated to be difficult to control by insecticides, as previously referred by Oliveira et al. (1988). A 50 to 100% increase in stink bug population was observed on almost all experiments, except tests 4 and 5. This rapid increase was mostly due to migrating adults, looking for more appropriate feeding and reproductive sites, and because they are spatially unstable, as they might fly out of an area after some time, if conditions are no longer suitable. This particular behaviour reduces effective control of the insect population. Moreover, the effectiveness of the crop protection against the time (residual action) decreases because of insecticide degradation on the field, falling below minimum effective rates. New individuals entering the area may not have been previously exposed to insecticide sprayed areas. Therefore they could be less susceptible to lower insecticide rates, as insects die due to accumulated insecticide exposure till reaching the lethal rate. The primary solution would be searching for higher rates or for insecticides with slower rates of open field decomposition.

No differences were observed for stink bug mortality among rates of endosulfan, trichlorphon or phosphamidon on experiment 1 (Table 1), which were restricted to differences between insecticides or to the control, with the exception of the observation made four days after application. The full (highest) rate of each insecticide is its recommended rate, selected after screening several rates of the insecticides, under different crop conditions, and repeated for many years (Oliveira et al., 1988), and represents the minimum effective rate, of the insecticide applied alone (without NaCl). The similar insect mortality with lower insecticide rates, when NaCl is added to the insecticide indicated the possibility of reducing the chemical field doses with the same effect on the target pests.

On experiment 2, addition of NaCl to half the recommended rate of monocrotophos and metamidophos produced good control of all species of stink bugs, comparable to each insecticide full rate (Table 2). The effectiveness of the protection extended up to seven days, as migrating insects doubled the control population from seven to twelve days after application. This result indicated that insecticide residual action is not depressed by reducing its rate, when NaCl is added to the insecticide solution, contrarily to application of lower rates in the absence of this salt. According to Oliveira et al.

TABLE 1. Number of large nymphs and adults of stink bugs present on 2 m of row of soybeans, on experiment 1[1].

Insecticide	Rate (g ha⁻¹ a.i.)	NaCl[2] (%)	Days after application: 0	2		4		7		9		14	
			N[3]	N	PE[4]	N	PE	N	PE	N	PE	N	PE
Endosulfan	219	0.5	4.1ab	2.0b	65	1.9b	49	2.4b	56	3.9ab	41	3.8b	62
Endosulfan	329	0.5	5.3ab	2.0b	65	1.3b	65	2.1b	61	4.6ab	30	4.3b	57
Endosulfan	438		4.5ab	1.6b	71	1.5b	59	3.1ab	43	3.6ab	45	3.3b	67
Phosphamidon	150	0.5	5.3ab	2.6b	54	1.8b	51	2.9ab	46	6.1ab	8	9.2a	8
Phosphamidon	300	0.5	7.1a	1.8b	69	2.1b	43	2.8ab	48	4.9ab	26	7.4ab	26
Phosphamidon	450	0.5	5.5ab	1.5b	74	2.5ab	32	3.0ab	44	4.5ab	32	6.1ab	39
Phosphamidon	600		4.3ab	2.9b	49	2.6a	30	3.8ab	30	4.4ab	33	9.2a	8
Trichlorphon	200	0.5	3.9b	2.0b	65	1.9b	49	3.3ab	39	6.1ab	8	8.6a	14
Trichlorphon	400	0.5	4.3ab	1.7b	70	1.4b	62	2.2b	59	4.8ab	27	6.5ab	35
Trichlorphon	600	0.5	6.0ab	1.6b	72	2.3b	38	2.4b	56	3.9ab	41	6.5ab	35
Trichlorphon	800		4.5ab	2.6b	54	1.8b	51	2.9ab	46	3.4b	48	6.6ab	34
Control			5.0ab	5.7a		3.7a		5.4a		6.6a		10.0a	

[1] Means followed by same letter are not different according to the Tukey test at 5% probability.
[2] Addition of 0.5% NaCl to the water-insecticide mixture.
[3] Number of insects.
[4] Percent of mortality.

TABLE 2. Number of large nymphs and adults of stink bugs present on 2 m of row of soybeans, on experiment 2[1].

Insecticide	Rate (g ha⁻¹ a.i.)	NaCl[2] (%)	Days after application: 0	3		5		7		12	
			N[3]	N	PE[4]	N	PE	N	PE	N	PE
Betacifluthryn	6.25		4.8a	1.5ab	58	2.5ab	22	2.9abc	24	5.1	31
Phoxyn	500		3.1ab	2.9ab	19	3.3a	0	2.6abc	32	4.9	34
Phoxyn	750		3.1ab	2.3ab	36	2.1abcd	34	2.0abc	47	5.3	28
Metamidophos	75	0.5	3.2ab	1.5ab	58	2.4abc	25	3.8a	0	7.6	0
Metamidophos	150	0.5	1.9b	1.5ab	58	1.3bcd	59	2.1abc	18	5.7	23
Metamidophos	225	0.5	2.8ab	0.6ab	83	0.8d	75	1.5c	61	5.4	27
Metamidophos	300		3.2ab	1.7ab	53	2.1abcd	34	2.2abc	42	4.8	35
Monocrotophos	50	0.5	3.3ab	1.3ab	64	1.4bcd	56	1.6c	58	6.1	18
Monocrotophos	100	0.5	2.7ab	0.8b	78	0.8cd	75	1.0c	74	5.4	27
Monocrotophos	150	0.5	2.9ab	1.1b	69	0.7d	78	1.4c	64	5.9	20
Monocrotophos	200		3.8ab	1.2ab	67	2.4abc	25	1.8bc	53	5.5	26
Control			4.4ab	3.6a		3.2a		3.8ab		7.4	

[1] Means followed by same letter are not different according to the Tukey test at 5% probability.
[2] Addition of 0.5% NaCl to the water-insecticide mixture.
[3] Number of insects.
[4] Percent of mortality.

(1988), spraying monocrotophos at 100 g ha^{-1} of a.i. produced only fair control of stink bugs, and eight days after application this rate provided less than 50% control of the bugs.

When the insecticide usual rate was not able to provide good control of stink bugs, adding sodium chloride to the mixture did not improve its performance, as it was proved through applications of methomyl and prophenophos. Oliveira et al. (1988) proved that methomyl failed to control species of stink bugs, testing rates up to 225 g ha^{-1} of a.i., as also occurred with prophenophos at 500 g ha^{-1} of a.i. On experiment 3, applications of methomyl at 65, 86 or 108 g ha^{-1} of a.i. plus sodium chloride or prophenophos at 250 g ha^{-1} of a.i. also failed to control the stink bugs (Table 3). This result emphasised the differences among insecticides with intrinsical effect on stink bugs (endosulfan, metamidophos and monocrotophos) and those providing low mortality of the insects (methomyl and prophenophos), demonstrating that salt addition improves the effect of lower rates of insecticides which can provide good control of pentatomids at full rates.

The insecticide ethofenprox provided fair to poor control of stink bugs, and only on the short time range. Again it was demonstrated that when the chemical alone did not provide a reasonable mortality of stink bugs, the addition of NaCl failed to improve the insect mortality (Table 4). However, comparing the same rates of monocrotophos, with and without addition of NaCl, the differential mortality due to the enhancer became clear. Mortality levels are quite similar, even though when comparing the rate with salt (75 g) to the full rate (150 g), shown on Tables 4 and 5. Results are also equivalent when considering the effect of 300 g ha^{-1} of a.i. of trichlorphon, with and without sodium chloride, where the presence of NaCl yielded a higher and more lasting stink bug mortality.

Insecticidal activity of both imidachloprid and metamidophos can be observed on Table 6. Addition of 0.5% of sodium chloride did not improve insect mortality, except for the last date for imidachloprid. On the other side, adding salt to monocrotophos increased insect mortality on any sampling date. By the screening results, it was possible to conclude that addition of NaCl to effective insecticides allow the reduction of at least 50% of its field rates. The potential economic savings by using this technology to its maximum extent reaches

TABLE 3. Number of large nymphs and adults of stink bugs present on 2 m of row of soybeans, on experiment 3[1].

Insecticide	Rate (g ha^{-1} a.i.)	NaCl[2] (%)	Days after application						
			0	3		6		11	
			N[3]	N	PE[4]	N	PE	N	PE
Endosulfan EC	435		6.6	1.6b	72.4	2.8ab	62.2	3.2b	59
Endosulfan EC	500		4.3	1.5b	74.1	1.3bc	82.4	2.4b	70
Endosulfan SC	438		4.7	2.0b	65.5	2.3ab	68.9	3.2b	59
Endosulfan SC	525		4.9	1.5b	74.1	1.7bc	77.0	3.1b	60
Metamidophos	300		6.5	1.3b	77.6	2.1bc	71.6	3.1b	60
Metamidophos	480		5.6	1.5b	74.1	1.1c	85.1	2.3b	71
Methomyl	65	0.5	6.3	5.2a	10.3	4.9a	33.8	6.9a	12
Methomyl	86	0.5	5.8	4.0a	31.0	3.7ab	50.0	6.1a	22
Methomyl	108	0.5	4.4	3.7ab	36.2	5.6a	24.3	7.3a	6
Monocrotophos	100	0.5	5.4	0.6b	89.7	1.0c	86.5	1.5b	81
Prophenophos	250	0.5	5.5	3.2ab	44.8	6.1a	17.6	5.8a	25
Control			5.0	5.8a		7.4a		7.8a	

[1] Means followed by same letter are not different according to the Tukey test at 5% probability.
[2] Addition of 0.5% NaCl to the water-insecticide mixture.
[3] Number of insects.
[4] Percent of mortality.

US$ 8 million, considering the estimates made by Gazzoni (1994). More benefits can be achieved, considering a lower impact on the environment by less insecticide discharge, the reduced effect on natural enemies and the possibility of reduction of human and animal toxicity.

Large scale farm tests of the new technology arose growers apprehension of possible stink bugs attraction from soybean farms on the vicinity, to ones where NaCl was used together with insecticide. Data shown on Table 7 indicated that stink bug population on plots receiving any salt concentration did not differ from the control, at any sampling date, resulting in absence of evidence of attractiveness of the salt. Plots receiving concentrations of salt over 2% presented phytotoxicity symptoms, and supported the

TABLE 4. Number of large nymphs and adults of *Nezara viridula* on 2 m of row of soybeans, on experiment 4[1].

Insecticide	Rate (g ha^{-1} a.i.)	NaCl[2] (%)	Days after application								
			0	2		4		7		9	
			N[3]	N	PE[4]	N	PE	N	PE	N	PE
Ethofenprox	60		2.6	2.1a	0	1.8a	0	1.0abc	33	0.5ab	58
Ethofenprox	60	0.5	2.1	1.4abc	22	0.9abc	31	0.9abc	40	1.1ab	8
Ethofenprox	105		3.8	1.2abc	33	1.7a	0	1.1ab	27	0.7ab	42
Ethofenprox	120		2.9	0.6bc	67	0.8bc	38	0.8abc	47	0.7ab	42
Monocrotophos	50	0.5	4.3	0.9bc	50	0.6c	54	0.9abc	40	0.2b	83
Monocrotophos	75		4.3	1.2abc	33	0.9abc	31	0.8abc	47	0.6ab	50
Monocrotophos	75	0.5	1.9	0.3c	83	0.3c	77	0.6bc	60	0.4ab	67
Monocrotophos	150		2.0	0.4c	78	0.4c	69	0.3c	80	0.3ab	75
Trichlorphon	300		2.4	0.9bc	50	0.9abc	31	0.8abc	47	0.9ab	25
Trichlorphon	300	0.5	2.6	0.6c	67	0.4c	69	0.3bc	80	0.4ab	67
Control			3.1	1.8ab		1.3ab		1.5a		1.2a	

[1] Means followed by same letter are not different according to the Tukey test at 5% probability.
[2] Addition of 0.5% NaCl to the water-insecticide mixture.
[3] Number of insects.
[4] Percent of mortality.

TABLE 5. Number of large nymphs and adults of *Nezara viridula* on 2 m of row of soybeans, on experiment 5[1].

Insecticide	Rate (g ha^{-1} a.i.)	NaCl[2] (%)	Days after application												
			0	2		4		7		14		21	
			N[3]	N	PE[4]	N	PE	N	PE	N	PE	N	PE
Cipermethryn	50		2.1	0.2 b	91	0.1b	91	0.1c	94	0.0	100	0.1	80
Metamidophos	150		1.5	0.7 b	68	0.6ab	45	0.8b	56	0.7	0	0.4	20
Metamidophos	150	0.5	2.4	0.4 b	82	0.7ab	36	0.6bc	67	0.3	50	0.6	0
Metamidophos	300		2.5	0.4 b	82	0.2b	82	0.3bc	83	0.4	33	0.1	80
Metamidophos	480		2.3	0.1 b	95	0.2b	82	0.2bc	89	0.1	83	0.3	40
Metamidophos	600		1.9	0.1 b	95	0.1b	91	0.1c	94	0.3	50	0.6	0
Monocrotophos	75		2.3	0.2 b	91	0.6ab	45	0.3bc	83	0.3	50	0.4	20
Monocrotophos	75	0.5	2.3	0.1 b	95	0.1b	91	0.2bc	89	0.3	50	0.2	60
Monocrotophos	150		2.3	0.1 b	95	0.1b	91	0.2bc	89	0.1	83	0.4	20
Control			2.4	2.2 a		1.1a		1.8a		0.6		0.5	

[1] Means followed by same letter are not different according to the Tukey test at 5% probability.
[2] Addition of 0.5% NaCl to the water-insecticide mixture.
[3] Number of insects.
[4] Percent of mortality.

TABLE 6. Number of large nymphs and adults of stink bugs on 2 m of row of soybeans on experiment 6[1].

Insecticide	Rate (g ha⁻¹ a.i.)	NaCl[2] (%)	Days after application 0	2		4		7	
			N[3]	N	PE[4]	N	PE	N	PE
Imidachloprid	25		6.3	3.2bc	61	2.7bcd	63	4.5b	54
Imidachloprid	25	0.5	5.1	1.6cd	81	2.3bcd	68	2.6cd	73
Imidachloprid	49		5.6	2.9bc	65	2.8bc	62	2.6cd	73
Metamidophos	150	0.5	7.3	2.4bcd	71	2.3bcd	68	2.1cd	78
Metamidophos	300	0.5	5.0	1.6cd	81	1.9cd	74	2.2cd	77
Metamidophos	300		4.3	1.8cd	78	1.9cd	74	3.3bc	66
Monocrotophos	75		5.4	3.6b	57	3.6b	51	3.6bc	63
Monocrotophos	75	0.5	4.6	0.9d	89	1.8cd	75	1.3d	87
Monocrotophos	150		5.9	0.8d	90	1.3d	82	1.3d	87
Control			5.6	8.3a		7.3a		9.7a	

[1] Means followed by same letter are not different according to the Tukey test at 5% probability.
[2] Addition of 0.5% NaCl to the water-insecticide mixture.
[3] Number of insects.
[4] Percent of mortality.

TABLE 7. Number of large nymphs and adults of stink bugs on 2 m of row of soybeans, following applications of different concentrations of NaCl.

NaCl (%)	Days after application 0	1	2	4	8	16
0.125	5.7	4.7	5.1	3.6	1.9	1.8
0.25	5.6	4.3	4.2	2.7	1.8	1.1
0.5	4.4	4.8	4.7	3.0	1.6	2.0
1.0	4.7	5.4	4.7	5.1	2.2	1.3
2.0	5.5	4.4	5.3	2.5	1.0	1.7
4.0	4.4	4.8	6.0	4.2	2.0	1.7
8.0	4.3	3.7	3.8	4.3	1.7	2.0
0.0 (Control)	5.2	4.2	4.8	3.4	1.9	1.6

decision of standardising the mixture with 0.5% of NaCl. Results shown on Tables 8 and 9 came from large plots of a soybean field resembling a chessboard of combinations of insecticide application with and without NaCl addition, and also absence of bug control. Monocrotophos was also applied in a different scheme, with the application bar having a closed nozzle followed by an open nozzle, making the distance between nozzles to be 1 m. In this situation, one soybean row received insecticide application followed by a row without application. The rationale was that if bugs moved at random between rows and were arrested on plants receiving insecticide plus salt, then the insect control would be the same than the standard spraying methodology. The evaluation made six days after the application did not support entirely the hypothesis, as mortality was 7-10% lower than the correspondent rate with salt. However, even this treatment was equivalent to the insecticide full rate (Tables 8 and 9). Results indicated the need for more advanced research on the possibility of using this spraying technology.

The test with caged soybean plants, receiving or not NaCl sprayings demonstrated the stink bugs preference for salt sprayed plants, when the plants where placed very close one to another. The bugs were released at the bottom of the cages, and the plants were examined, looking for the place where the insects were located inside the cage. The results (Fig. 1) indicated a clear preference of the bugs for the salt-treated plants, from the 24 h observation to the end of the test, and agree with Panizzi & Oliveira (1993). This marked preference could be attributed to an arresting effect of the salt, elicited 24 h after spraying and relatively long lasting, probably up to the next rain, which would wash the sodium chloride still present on the leaves and pods surfaces. Results obtained by Niva & Panizzi (1996) indicated a trend of the bugs to make more feeding proofs on

TABLE 8. Number of large nymphs and adults of stink bugs on 2 m of row of large soybean plots.

Insecticide	Rate (g ha-1 a.i.)	NaCl[1] (%)	Days after application 0	6	
			N[2]	N	PE[3]
Metamidophos	150	0.5	3.5	1.4	68
Metamidophos	300		3.7	0.8	82
Monocrotophos[4]	120	0.5	4.6	0.6	86
Monocrotophos	120	0.5	3.9	0.3	93
Monocrotophos	200		5.8	0.7	84
Trichlorphon	400	0.5	4.6	0.4	91
Trichlorphon	800		4.3	0.8	82
Control			3.7	4.4	

[1] Addition of 0.5% NaCl to the water-insecticide mixture.
[2] Number of insects.
[3] Percent of mortality.
[4] One open nozzle followed by one closed nozzle.

TABLE 9. Number of large nymphs and adults of stink bugs on 2 m of row of large soybean plots.

Insecticide	Rate (g ha-1 a.i.)	NaCl[1] (%)	Days after application 0	6	
			N[2]	N	PE[3]
Phosphamidon	300	0.5[1]	1.7	0.6	87
Phosphamidon	600		1.9	0.8	83
Metamidophos	150	0.5	2.2	1.4	70
Metamidophos	300		2.2	0.9	81
Monocrotophos[4]	120	0.5	2.8	1.8	62
Monocrotophos	120	0.5	3.7	1.3	72
Monocrotophos	200		2.3	1.9	60
Trichorphon	400	0.5	3.2	1.4	70
Trichlorphon	800		2.4	2.6	45
Control			1.9	4.7	

[1] Addition of 0.5% NaCl to the water-insecticide mixture.
[2] Number of insects.
[3] Percent of mortality.
[4] One open nozzle followed by one closed nozzle.

pods of the salt-treated plants, and demonstrated that the sodium chloride increases the food-touching behaviour, but did not have an attractant or a phagoestimulatory effect for these insects. The modification of the feeding habit through an induction to a more dynamic behaviour can lead to greater insecticide ingestion, or other forms of contact with poisoned plant tissues, and thereby be the more probable explanation for the improved insecticide efficiency.

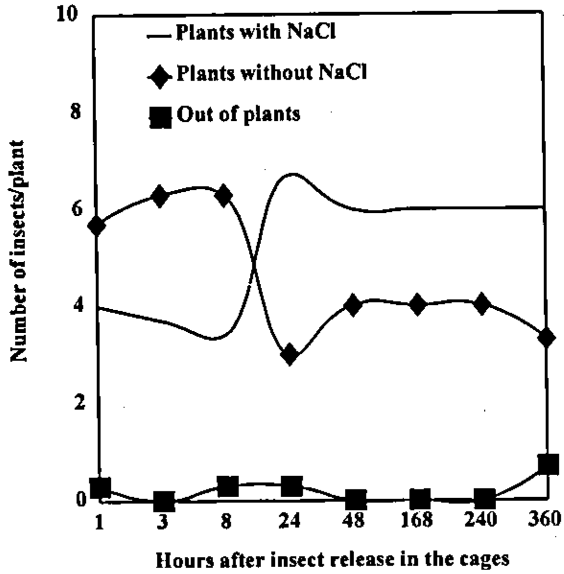

FIG. 1. Insect location inside screen cages containing soybean plants, sprayed with NaCl 0.5% solution or distilled water.

CONCLUSIONS

1. Sodium chloride is an efficient insecticide enhancer for controlling pentatomids on soybeans, leading to the reduction of monocrotophos and metamidophos rates.
2. Insecticides that do not have good activity against stink bugs are not enhanced by NaCl addition.
3. Stink bugs are not attracted to soybeans where an insecticide plus sodium chloride is applied.

REFERENCES

BOYER, W.B.; DUMAS, W.A. Soybean insect survey as used in Arkansas. **Cooperative Economic Insect Report**, n.13, p.91-92, 1963.

CORREA-FERREIRA, B.S.; MOSCARDI, F. Biological control of soybean stink bugs by inoculative releases of *Trissolcus basalis*. **Entomologia Experimentalis et Applicata**, v.79, p.1-7, 1996.

CORREA-FERREIRA, B.S.; MOSCARDI, F. Seasonal occurence and host spectrum of egg parasitoids associated with soybean stink bugs. **Biological Control**, v.5, p.196-202, 1994.

CORSO, I.C.; PORTO, M.D.M. Relação entre o efeito associado de percevejos e fungos da produção e teores de óleo e proteína de sementes de soja. [*Glycine max* (L.) Merrill). **Agronomia Sulriograndense**, v.14, p.41-46, 1978.

FEHR, W.R.; CAVINESS, C.E.; BURMOOD, D.T.; PENNINGTON, J.S. Stage of development description for soybeans (*Glycine max* (L.) Merrill). **Crop Science**, v.11, p.929-931, 1971.

GAZZONI, D.L. Efeito associado de cultivar e inseticida no controle de percevejos (Heteroptera: Pentatomidae) que atacam a soja. **Anais da Sociedade Entomológica do Brasil**, v.24, p.105-114, 1995.

GAZZONI, D.L. **Manejo de Pragas da Soja:** uma abordagem histórica. Londrina: Embrapa-CNPSo, 1994. 72p. (Embrapa-CNPSo. Documentos 78).

GAZZONI, D.L.; MOSCARDI, F. Effect of defoliation levels on recovery of leaf area, on yield and agronomic traits of soybeans. **Pesquisa Agropecuária Brasileira**, v.33, n.4, p.411-424, 1998.

GAZZONI, D.L.; OLIVEIRA, E.B. de; CORSO, I.C.; FERREIRA, B.S.C.; VILLAS BOAS, G.L.; MOSCARDI, F.; PANIZZI, A.R. **Manejo de pragas da soja.** Londrina: Embrapa-CNPSo, 1981. 44p. (Embrapa-CNPSo. Circular Técnica, 5).

KEA, W.C.; TURNIPSEED, S.G.; CARNER, G.R. Influence of resistant soybeans on the susceptibility of lepidopterous pests to insecticides. **Journal of Economic Entomology**, v.71, p.58-60, 1978.

KOGAN, M.; TURNIPSEED, S.G. Ecology and management of soybean arthropods. **Annual Review of Entomology**, v.32, p.507-538, 1987.

NIVA, C.C.; PANIZZI, A.R. Efeitos do cloreto de sódio no comportamento de *Nezara viridula* (L.) (Heteroptera: Pentatomidae) em vagens de soja. **Anais da Sociedade Entomológica do Brasil**, v.25, p.251--257, 1996.

OLIVEIRA, E.B. de; GAZZONI, D.L.; CORSO, I.C.; VILLAS BOAS, G.L.; HOFFMANN-CAMPO, C.B. **Pesquisa com inseticidas em soja:** sumário dos resultados alcançados entre 1975 e 1987. Londrina: Embrapa-CNPSo, 1988. 260p. (Embrapa--CNPSo. Documentos, 30).

PANIZZI, A.R.; OLIVEIRA, N. **Atração do cloreto de sódio (sal de cozinha) aos percevejos pragas da soja.** Londrina: Embrapa-CNPSo, 1993. p.71-76, (Embrapa-CNPSo. Documentos, 58).

TURNIPSEED, S.G.; KOGAN, M. Soybean entomology. **Annual Review of Entomology**, v.21, p.247--282, 1976.

VILLAS BOAS, G.L.; GAZZONI; D.L.; OLIVEIRA, M.C.N.; COSTA, N.P. da; ROESSING, A.C.; FRANÇA NETO, J.B. **Efeito de diferentes populações de percevejos sobre o rendimento e seus componentes, características agronômicas e qualidade de semente de soja**, Londrina: Embrapa-CNPSo, 1990. 43p. (Embrapa-CNPSo. Boletim de Pesquisa, 1).

ZONTA, E.P.; MACHADO, A.A.; SILVA JUNIOR, P. **SANEST - Sistema de Análise Estatística**: relação dos módulos disponíveis. Pelotas: UFPEL, 1984. 48p.