Journal of Phytopathology and Pest Management 2(3): 9-17, 2015
pISSN:2356-8577 eISSN: 2356-6507
Journal homepage: http://ppmj.net/

Management of Cabbage Aphid, *Brevicoryne brassicae* L. on Canola Crop Using Neonicotinoids Seed Treatment and Salicylic Acid

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Abstract

Cabbage aphid, *Brevicoryne brassicae* L. is one of the most important pests on canola worldwide and in Egypt. Field experiments were conducted in the Faculty of Agriculture Farm, Suez Canal University, Ismailia Governorate during 2012/13 and 2013/14 seasons. The efficacy of neonicotinoids seed treatment and spraying salicylic acid (SA) alone or in combination against *B. brassicae* and their impact on canola yield were investigated. Results showed that canola seeds treated with Gaucho 70% WS, Cruiser70% WS and Actara 25% WG were not effective for managing of *B. brassicae* in the late of growing season from 15th week to 21st week. However, SA application showed significant difference in reduction of infestation compared to control. Data revealed that seed treatment with neonicotinoid insecticides followed by foliar application with SA was associated with enhanced resistance against *B. brassicae*. Moreover, results showed relatively increase in seed yield/plant (g) and yield/fed. (kg) in this treatment than neonicotinoid insecticides seed treatment alone, or SA alone and control.

Key words: Canola crop, cabbage aphid, neonicotinoids seed treatment, salicylic acid.

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Introduction

Canola, *Brassica napus* L. is one of the most important oil crops (Miri, 2007) and at present, is the third largest source of vegetable oil all over the world (Kandil & Gad, 2012). In Egypt, canola has a bright future to contribute in reducing oil deficiency gap between production and consumption of edible oil; particularly it could be successfully grown during winter season in newly reclaimed land outside the old one of Nile valley to get around the competition with other crops occupied the old cultivated area (Sharaan et al., 2002). Canola crops are most susceptible to damage by a wide range of insect pests from seedling establishment through to seed development. There are several insect pests, which attack canola crop in Egypt, but aphids are the most serious of all the insect pests attack canola (Mahmoud & Shebl, 2014). Cabbage aphid, *Brevicoryne brassicae* is known to be the most abundant and destructive species of aphididae on canola crop during the flowering and podding stage (Mahmoud & Shebl, 2014; Sayed & Teilep, 2013; Aslam et al., 2007). Current management strategies for insects depend largely on chemical control. Seed treatment with systemic insecticide is an integral part of pest management tactics, which is comparatively less pollutant to the environment, cost effective, selective and reported to maintain natural equilibrium (Nault et al., 2004). Fast reproduction of *B. brassicae* represents the most serious threat to canola crops; effective management requires alternative strategy as neonicotinoid insecticides seed treatment and plant resistance as a viable option for reducing aphid damage and preventing outbreaks. Neonicotinoids are predominantly used as seed dressings for a broad variety of crops such as oilseed rape, sunflower, cereals, cotton, sorghum, corn and potatoes. Imidacloprid was the first neonicotinoid seed treatment insecticide used commercially to protect seeds and seedlings against injury by early season insects (El-Naggar & Zidan, 2013; Wilde et al., 2000). It is effective for controlling many insect pests such as, aphids, thrips, jassids, mites, wireworms, and true bug when used as a seed treatment, as soil and foliar applications (El-Naggar & Zidan, 2013; Marghub et al, 2010; Naveed et al., 2010; Prasana et al., 2004). Thiamethoxam is a second-generation neonicotinoid. It provides excellent control of a wide variety of commercially important insect pests on a variety of crops. After seed treatment, imidacloprid and thiamethoxam show systemic and residual toxicity and interfere with the transmission of stimuli or impulses in the nervous system of insect herbivores, and give excellent control against a broad range of commercially important sucking insect pests (Zhang et al., 2011). Plants can suffer from a wide range of abiotic stresses, including drought, flooding, heat, cold, salinity, extreme light intensity and mechanical damage, as well as biotic stresses such as attacks by a wide array of pathogens and insects (Buchanan et al., 2000). Plants possess an innate cell immunity and systemic signals emanating from infection sites (Chisholm et al., 2006). Host plant resistance is one of the most promising methods to reduce the dependence of pesticides. Salicylic acid (SA), a plant hormone plays an important role in induction of plant defense against a variety of biotic and abiotic stresses through morphological, physiological and biochemical mechanisms. It regulates the activities of various enzymes such as, peroxidase (POD), polyphenol oxidase (PPO), superoxide dismutase (SOD), phenylalanine ammonia lyase (PAL) etc., which are the major components of induced plant defense against biotic and abiotic stresses (Hayat et al., 2010; Rajjou et al., 2006; Peng et al., 2004). The objective of the current study is to evaluate the efficacy of the neonicotinoids seed treatment, Gaucho 70% WS, Cruiser70% WS and Actara 25% WG and the elicitor Salicylic acid for managing *Brevicoryne brassicae* L. on canola plants under field conditions, and their impact on canola yield.

Materials and methods

Experimental design: The experiment was conducted in Ismailia Governorate, during 2012-2013 and 2013-2014 seasons. Canola, cv. Serw 4 (the most common cultivar grown in Ismailia region) was sown on 20 October 2012 and on 21 October 2013; the most suitable time to become naturally infested with aphids. Plants were thinned to one plant per hill; 20 cm between hills to insure 27.000 plants/fed. Recommended cultural and agronomic practices were adopted from sowing to harvest. No insecticide was sprayed in and around the experimental fields. The experimental area was divided into eight treatment areas including the control. Each treatment included four replicates. The replicates were distributed in a randomized complete block design.

Neonicotinoid seed treatment: Three neonicotinoid seed treatments were tested: Gaucho70% WS (Imidacloprid, 5 g a.i /kg seed), Cruiser 70% WS (Thiamethoxam, 3 g a.i /kg seed) and Actara 25%WG (Thiamethoxam, 3.5 g a.i/kg seed). For treatment, canola seeds were taken in a plastic container with little quantity of fine sand. Then 10 ml of water, few drops of gum (sticker) and required quantity of neonicotinoid insecticides were added and stirred carefully. If necessary more water was added drop by drop and stirred well to get slurry. Lid of the container was tightened and shaken for 30 seconds to get uniform coating of the slurry on the seeds. The seeds were then air dried in shade overnight and sown next day (Jagadish and Gowda, 1994).

Treatments of Salicylic acid: Canola plots were sprayed with Salicylic acid (SA) at the rate of 250 mg^{-L}. SA was dissolved in a few drops of ethanol and then dispersed in water to give required rate. Plants were sprayed after 30 days of sowing by one week interval for three times using hydraulic sprayer. Control plots applied only with distilled water, each treatment was replicated 4 times.

Cabbage aphid count: The experiment was left for natural infestation; data were recorded at weekly interval, from first occurrence of pest at the fifteenth week of plantation till crop harvest (first week of February to third week of March). Aphid counts were recorded from each of the 10 randomly plants on 10 cm terminal shoot length from the main stem in every replicate. A scoring protocol was used to measure both the incidence of cabbage aphid in the crop (percentage of main stems affected) and the level of infestation (depth of colony in centimeters). The rating system was as follows, with scores averaged as a measure over the whole treatments: (Jenkins et al., 2011).

0 = nil present, 1 = 1.0 cm colony, 2 = 2.5 cm colony, 3 = 5.0 cm colony, 4 = 5.0 – 7.5 cm colony and 5 = 10 cm colony or more. Percentage of reduction (% efficacy) was estimated according to the equation of Henderson and Tilton (1955).

Yield: At harvest time, ten individual plants were chosen at random from the middle ridge of each treatment in both seasons and the following data were recorded: seed yield/plant (g) and seed yield/fed (kg).

Statistical analysis: The formula of Henderson and Tilton (1955):

% population reduction (efficacy) = $[1-(T_a/C_a \times C_b/T_b] \times 100$.

Where T_b is infestation in treated plot prior to application; T_a is infestation in treated plot after application; C_b is infestation in control plot prior to application; C_a is infestation in control plot after application. Data obtained in the present study were subjected to one way analysis of variance (ANOVA) in a randomized complete block design (RCBD). In case of significant F-values, treatment means were separated using Fisher Least Significant Difference (FLSD) test at 5% level of significance (SAS Institute, 2004).

Results

There was a significant difference ($P \leq 0.0000$) in the mean number of aphids/10 cm terminal length stem of plants between treatments and control throughout the seven weeks of investigation in 2013 and 2014 seasons. Data showed that control plots had higher numbers of aphids than treated plots. Actara + SA had lower numbers of aphid (0.8, 1.4, 2.6, 5.8, 12.0, 25.2 and 30.4) and (0.2, 0.5, 1.5, 2.9, 8.8, 13.9 and 19.9), followed by Gaucho + SA (1.0, 2.5, 3.4, 8.4, 15.0, 30.2 and 38.5) and (0.0, 1.2, 1.5, 3.4, 9.8, 16.6 and 27.2) in both seasons during the seventh weeks of investigation, respectively (Tables 1 and 2). Moreover, results showed that the mean number of aphids increased in control and treatments gradually with investigation time from 15th week till 21th week in both seasons. Finally, statistical analysis at $P \leq 0.05$ level showed highly significant differences between SA, Gaucho + SA, Cruiser + SA and Actara + SA, whereas the significant differences between Gaucho, Cruiser, Actara and control were recorded only in the 15th week and 16th week (Tables 1 and 2). The mean efficacy of the seven weeks of investigation to the treatments of neonicotinoids, SA and the combination between them in reduction of *B. brassicae* infestation is illustrated in (Figures 1 and 2). Actara was markedly efficient in reducing the *B. brassicae* (%) than Gaucho and Cruiser in the growing seasons of canola 2012/13 and 2013/14. It was produced 22.32% and 17.42% reduction on average within 7 weeks in both seasons, respectively. While Gaucho was produced 13.71% and 11.15%, then Cruiser by 3.19% and

2.64% efficacy. SA was more efficient in reduction of aphids when applied alone, it produced 84.0% and 87.79% in both seasons, but its efficacy relatively increased when applied on plants treated with the neonicotinoides insecticides as seed treatment, particularly with Gaucho and Cruiser. The efficacy was 92.34% and 94.75% in 2012/13 and 89.58% and 93.1% in 2013/14 season, respectively.

Table 1: Effects of neonictinoid insecticides seed treatment and salicylic acid on the mean number of cabbage aphid, *Brevicoryne brassicae* on canola throughout the growing season of 2012/13.

Treatments	Mean number of aphids/ 10 cm terminal shoot length stem of plants*						
	15th week	16th week	17th week	18th week	19th week	20th week	21th week
Control	11.0 a	19.6 a	49.0 a	55.5 a	168.0 a	294.0 a	393.0 a
Gaucho 70% WS	8.2 ab	16.2 ab	42.0 a	50.5 a	146.0 a	276.0 a	351.0 a
Cruiser 70% WS	10.2 a	19.2 a	47.5 a	53.5 a	166.0 a	287.0 a	382.0 a
Actara 25% WG	7.4 abc	14.7 abc	36.0 a	44.5 a	128.0 a	257.0 a	331.0 a
Salicylic acid	1.8 bc	4.7 bc	6.9 b	10.4 b	21.5 b	36.5 b	53.7 b
Gaucho + Salicylic acid	1.0 c	2.5 bc	3.4 b	8.4 b	15.0 b	30.2 b	38.5 b
Cruiser + Salicylic acid	1.4 bc	3.8 bc	5.4 b	9.4 b	20.0 b	33.7 b	50.7 b
Actara +Salicylic acid	0.8 c	1.4 c	2.6 b	5.8 b	12.0 b	25.2 b	30.4 b
P ≤	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

*Means followed with the same letters (column wise) are not significantly different (FLSD; P ≤ 0.05)

Table 2: Effects of neonictinoid insecticides seed treatment and salicylic acid on the mean number of cabbage aphid, *Brevicoryne brassicae* on canola throughout the growing season of 2013/14.

Treatments	Mean number of aphids/ 10 cm terminal shoot length stem of plants*						
	15th week	16th week	17th week	18th week	19th week	20th week	21th week
Control	6.2 a	13.5 a	40.5 a	45.0 a	108.0 a	216.0 a	240.0 a
Gaucho 70% WS	4.7 abc	12.5 ab	34.5 a	40.0 a	92.0 a	208.0 a	235.0 a
Cruiser 70% WS	6.0 ab	13.5 a	39.5 a	44.0 a	104.0 a	211.0 a	229.0 a
Actara 25% WG	4.3 abc	10.5 ab	32.0 a	36.0 a	94.0 a	202.0 a	219.0 a
Salicylic acid	0.8 abc	2.2 ab	3.4 b	5.6 b	12.0 b	22.0 b	33.9 b
Gaucho + Salicylic acid	0.0 c	1.2 ab	1.5 b	3.4 b	9.8 b	16.6 b	27.2 b
Cruiser + Salicylic acid	0.2 bc	2.0 ab	3.0 b	5.9 b	13.3 b	17.8 b	30.6 b
Actara +Salicylic acid	0.2 bc	0.5 b	1.5 b	2.9 b	8.8 b	13.9 b	19.9 b
P ≤	0.0008	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000

*Means followed with the same letters (column wise) are not significantly different (FLSD; P ≤ 0.05)

Canola plots, particularly their edges were severely impacted by cabbage aphids both in incidence (e.g., 100% of flowering main stems affected), and level of infestation (e.g., colonies in excess 10 cm in depth). Figures 3 and 4 showed that SA application alone or with neonictinoid insecticides seed treatment caused reduction in infestation percentage (main stems affected in both seasons percentage). The infestation percentages were 100, 30, 50, 35, 20, 15, 20 and 10% in control, Cruiser, Actara, Gaucho, SA, Cruiser + SA, Actara + SA and Gaucho + SA, respectively. Also, data showed that application of SA was more efficient on reduction of depth (0.4 and 0.5 cm) followed by Gaucho + SA (0.5 and 1.0 cm), Cruiser + SA (1.0 and1.2 cm) and Actara + SA 1.5 and 2.2 cm) in 2013 and 2014 seasons, respectively.

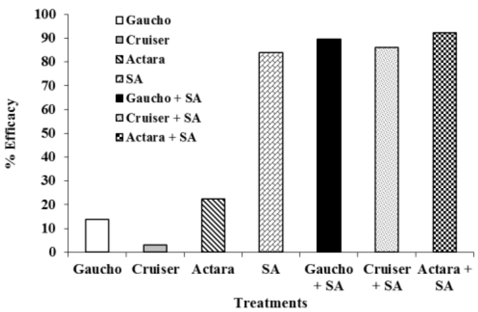

Figure 1: Efficacy of treatments on aphid infestation reduction on canola during the 2012/13 growing seasons.

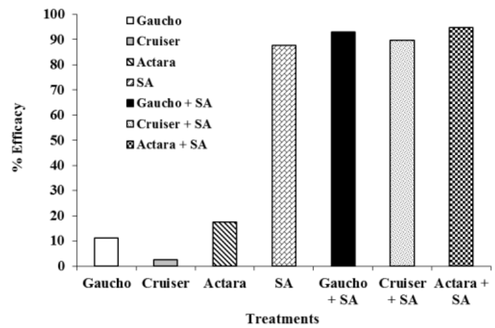

Figure 2: Efficacy of treatments on aphid infestation reduction on canola during the 2013/ 14 growing seasons.

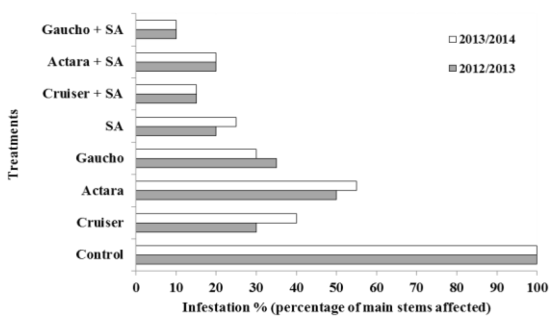

Figure 3: Effects of treatments on aphid infestation % (percentage of main stems affected) on canola crop during the 2012/13 and 2013/14 growing seasons.

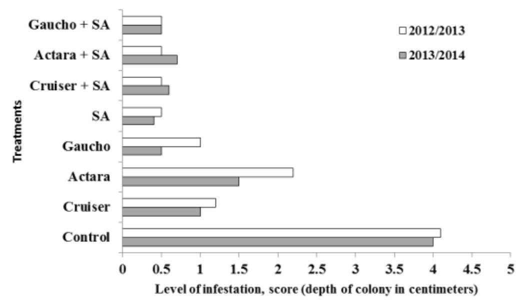

Figure 4: Effects of treatments on level of aphid infestation score (depth of colony in centimeters) on canola crop during the 2012/13 and 2013/14 growing seasons.

In the present study, the application of Gaucho, Cruiser and Actara as seed treatments and SA as elicitor against *B. brassicae* increased the seed yield/plant (e.g., 31.99, 31.45, 31.89 and 38.40 g, respectively) and, subsequently, yield/fed (e.g. 863.86, 849.28, 861.23 and 1036.80 kg, respectively). Interaction effect between insecticides seed treatments and SA was significant of the two characters studied. Results showed that application of SA on plants treated with the neonicotinoides seed treatments, Gaucho, Cruiser and Actara gave the highest rate of seed yield/plant (39.66, 38.57 and 41.49 g) and seed yield/fed (1070.82, 1041.39 and 1119.15) than the application of insecticides seed treatments and SA alone. Also, data of yield revealed that all treatments enhance significantly yield relative to control (Table 3).

Table 3: Effect of insecticides seed treatment, Salicylic acid and their combination on seed yield/plant (g) and yield/fed. (kg) as average of the two growing seasons of canola 2012/13 and 2013/14*.

Treatments	Seed yield/plant (g)	Yield/fed. (kg)
Control	30.94 ± 0.15 e	835.38 ± 4.18 e
Gaucho 70% WS	31.99 ± 0.19 d	863.87 ± 5.29 d
Cruiser 70% WS	31.45 ± 0.24 de	849.29 ± 6.71 de
Actara 25% WG	31.89 ± 0.27 d	861.23 ± 7.49 d
Salicylic acid	38.4 ± 0.18 c	1036.80 ± 4.89 c
Gaucho + Salicylic acid	39.66 ± 0.21 b	1070.82 ± 5.61 b
Cruiser + Salicylic acid	38.57 ± 0.16 c	1041.39 ± 4.54 c
Actara +Salicylic acid	41.45 ± 0.17 a	1119.15 ± 4.64 a
LSD $_{0.05}$	0.563	15.214

*Means ± SE followed with the same letters (column wise) are not significantly different (LSD; P ≤ 0.05).

Discussion

In the present study, the foliar application of SA on canola plants treated with the tested neonicotinoids as seed treatments during 2012/13 and 2013/14 seasons leads to a significant increase in crop yield and significant reduction of aphid infestation. These results are in agreement with those obtained by (Noureddini and Sharafzadeh 2014) who stated that foliar application of 1.2 mM salicylic acid before flowering resulted in the highest value of plant height, ear height, stem diameter, ear diameter, ear length and kernel yield at maize plants cultivar Single Cross 704. Mahmoud (2013) reported that application of potassin-F and salicylic acid separately or in combination on sesame plants in the reclaimed soil had enhanced the growth rates, yield and reduced aphid infestation. Khodary (2004) reported that fresh and dry weight of shoot and root plants increased by usage of SA, because of increasing of antioxidant reaction which protect plants from different stresses. SA is recognized as a novel group of phytohormones to regulate the plant growth, stomatal closure, protein synthesis and transpiration at very low amounts and increase the function of photosynthetic machinery in plants, consequently may increase the yield of plants. In the current study, neonicotinoids seed treatment did not significantly effect on cabbage aphid in comparison with SA application, but when used these treatments together, they effect significantly on aphid reduction and canola yield. Johnson et al. (2008) reported that the thiamethoxam seed treatment, targeting bean leaf beetles, did not significantly effect aphid population growth or protect yield. The results of this study signify the role of neonicotinoid seed treatment and SA in reduction infestation of aphids on canola. Also, suggest that application of SA alone or in combination with neonicotinoid insecticides acts as a potential growth enhancer to improve plant defense, and reduce aphid infestation. It is recommended to apply Neonicotinoid seed treatment followed by SA as foliar application, in order to obtain more efficient ameliorate the adverse effects, increase the canola production and induce plant resistance to aphid infestation.

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