Effect of Kaolin Particle Film Formulation Against Populations of the Aphid *Lipaphis erysimi Kalt.* (Homoptera: Aphididae) in Cabbage

T.B.C. Alavo* and A.Z. Abagli

Laboratoire d'Entomologie Appliquée, Faculté des Sciences et Techniques, Université d'Abomey-Calavi, BP 215 Godomey, Bénin

Abstract: Infestations of the aphid *Lipaphis erysimi Kalt.*cause a mean yield loss of cabbage that varies from 35.4% to 73.3% depending from agro-climatic conditions. To control this pest insect in Sub-saharan Africa, synthetic chemical insecticides are usually applied. Kaolin is a white, non-abrasive, inert aluminosilicate mineral that has been shown to effectively protect host plants from insect pests including lepidopterans, sucking insects and mites. The present work is aimed to study the effects of kaolin on the population dynamics of *L. erysimi* for the Integrated Management of this insect pest in cabbage. To carry out the present study, kaolin powder was dissolved in water to obtain a concentration of 5% kaolin. The plants were sprayed with kaolin suspension every week and every 4-days in 2 respective experiments. Results showed that kaolin sprays significantly reduced aphid populations density. Nevertheless, more frequent applications (every 4 days) did not improve kaolin efficacy. It is concluded that kaolin technology should be combined with another plant protection measure in order to keep aphids population under control in cabbage.

Keywords: Aphids, *Lipaphis erysimi,* Kaolin, Cabbage, Integrated pest management.

INTRODUCTION

The aphid *Lipaphis erysimi* attacks several vegetable crops including broccoli, cabbage, chinese broccoli, chinese cabbage, mustard cabbage, radish, and tomato. Large colonies can cause deformation to the plants and the leaves curl, shrivel and yellow [1, 2]. *L. erysimi* is also a vector of about 10 non-persistent plant viruses, including cabbage black ring spot and mosaic diseases of cauliflower, radish and turnip [3]. The mean yield loss from aphids infestation varies from 35.4% to 73.3% depending from agro-climatic conditions [4].

To control this pest insect in Sub-saharan Africa, synthetic chemical insecticides are usually applied. Extensive use of chemical insecticides has led to the disruption of the ecosystems because of the death of non-target species, the accumulation of pesticide residues in the environment, and the buildup of pesticide resistance in the target species [5].

Kaolin is a white, non-abrasive, inert aluminosilicate mineral widely used in a variety of industrial applications including paints, cosmetics and pharmaceuticals [6].

Kaolin-based particle film has been developed in the USA for use in agriculture. Studies have shown that hydrophobic formulations of kaolin-based particle films can effectively protect host plants from insect pests including lepidopterans, sucking insects and mites. Kaolin applications serve to repel pests, disrupt feeding and deter oviposition [7, 8].

*Address correspondence to this author at the Laboratoire d'Entomologie appliquée, Faculté des Sciences, Et Techniques (FAST), Université d'Abomey-Calavi (UAC), Bénin; Tel: (229) 97875438;
E-mail: thieryalavo@hotmail.com

The effect of different concentrations of kaolin was tested by recording the population dynamics of *Aphis gossypii* on cotton in West Africa, and results showed that the solution containing 5% kaolin has significantly reduced aphids number [9]. Weekly applications of 5% kaolin significantly reduced populations of the aphid *Aphis craccivora* in cowpea, *Vigna unguiculata* [10]. Here we report results of a study aimed to study the effects of weekly and every 4-days applications of 5% kaolin on the population dynamics of *L. erysimi* for the Integrated Management of this insect pest in cabbage.

MATERIALS AND METHODS

To perform the present study, chinese cabbage plants (Var. Saladeer) were grown in 7 L flower pots placed outdoors in the experimental station of the University of Abomey-Calavi, Benin, West Africa. For the growth and normal development of these plants, seeds were sown in soil fertilized with cow dung. The kaolin formulation called 'Surround' was used for the study. 'Surround' is a kaolin-based particle film formulation used for insect pests management purpose [7-10]. 'Surround' contains 95% kaolin and 5% other ingredients which are not indicated by the manufacturer (Engelhard Corporation, USA). Kaolin powder was dissolved in water to obtain a concentration of 5% kaolin. Eighty (80) plants were treated for each variant (Control and treatment) and a complete randomized block design was used. Plants naturally infested by the aphids *L. erysimi* were sprayed using Berthoud C5 Ultra Low Volume (ULV) sprayer.

During application, the ULV sprayer was kept closer to the plants to make sure that the whole plant surface is covered by kaolin particle film.

1874-4079/11

Two different experiments have been carried out.

Experiment 1: Weekly Application of Kaolin

In this first experiment, kaolin sprays were repeated at an interval of one week, the first having been made when the first leaves appear. Just before the start time of first kaolin application, all aphids living on the experimental plants (control and treatment) were mechanically killed in order to have no aphid individual on them at the beginning of the experiment. The effect of kaolin on the populations dynamics of aphids was assessed. For that, we counted the aphids number on each plant every three days. We stopped the experiment (observations and treatments), once aphid colonies become too dense and hard to be accurately counted on the control plants. Two kaolin applications were performed in this experiment which was carried out during the rainy season in year 2009.

Experiment 2: Every 4-Days Application of Kaolin

In this experiment, kaolin sprays were repeated every 4-days, the first having been made also when the first leaves appear. This experiment was conducted in the same manner as the first one during the rainy season in year 2010.

Statistical Analyses

The square root transformed number of aphids in experiment 1 and 2 as well as that of the number of plants infested with aphids in experiment 1 fulfilled parametric assumptions; we used therefore One way ANOVA to analyse these data. The number of plants infested with aphids in experiment 2 was analysed using non parametric test (Kolmogorov-Smirnov Z), since these data did not fulfill parametric assumptions.

SPSS Statistics Package Version 16.0 was used to carry out the analyses.

RESULTS

Experiment 1

In the first experiment, control plants have been infested by the aphids immediately on day 3 after first treatment. The aphids populations have grown rapidly on the control plants while plants treated with kaolin have attracted less aphid's individuals. The comparison of the number of aphids in the two variants (5% kaolin and control) at the end of the experiment clearly showed that few aphids were able to live on the plants treated with 5% kaolin (Fig. **1**). Statistical analysis revealed that there is a significant difference between 5% kaolin and the control at the end of the experiment on day 12 after first application (Table **1**). The control plants which have been heavily infested by aphids have shriveled and aphids damages were clearly visible on them. The plants treated with 5% kaolin have grown and developed normally.

The percentage of plants infested with aphids at the end of this experiment was 60% and 30% for the control and 5% kaolin, respectively (Fig. **2**). Statistical analysis indicated

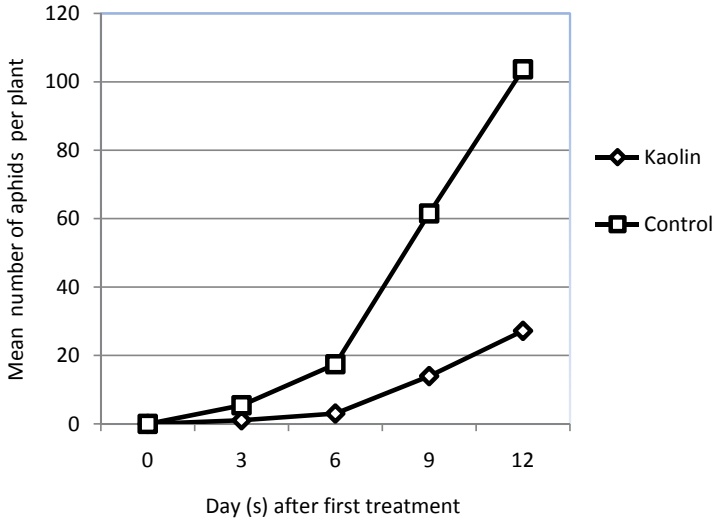

Fig. (1). Population dynamics of *L. erysimi* after two weekly applications of kaolin; (First treatment was applied on day 0).

Table 1. Result of One-Way ANOVA Performed on Square Root Transformed of the Number of Aphids Present on the Plants at the End of Experiment 1

Sqrt Aphids Number					
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	1048.831	1	1048.831	32.196	0.000
Within Groups	5147.075	158	32.576		
Total	6195.906	159			

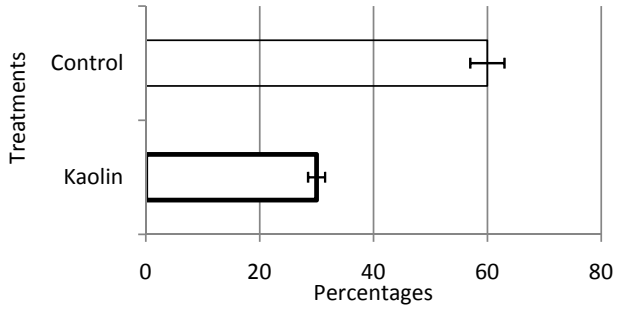

Fig. (2). Percentage of plants infested with *L. erysimi* on day 12 after two weekly kaolin applications.

Table 2. Result of One-way ANOVA Performed on Square Root Transformed of the Number of Plants Infested with Aphids at the End of Experiment 1

ANOVA					
sqrtPlantInfested					
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	5.357	1	5.357	7.048	0.019
Within Groups	10.641	14	0.760		
Total	15.998	15			

that there is a significant difference (Table **2**) between the number of infested plants in treatment and control.

Experiment 2

The trend described for the aphids populations mean density observed here is similar to that observed in the first experiment (Fig. **3**). Here also, statistical analysis revealed that there is a significant difference between 5% kaolin and the control at the end of the experiment on day 12 after first application (Table **3**).

The percentage of plants infested with aphids at the end of this experiment was 85% and 61.7% for the control and

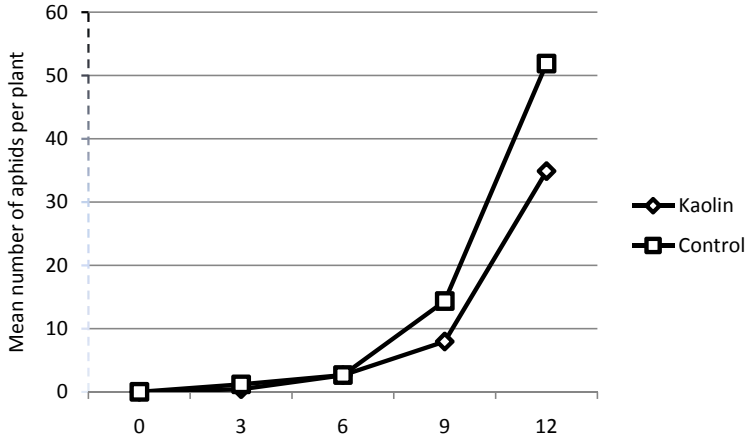

Fig. (3). Population dynamics of *L. erysimi* after every 4-days application of kaolin (First treatment was applied on day 0).

Table 3. Result of One-Way ANOVA Performed on Square Root Transformed of the Number of Aphids Present on the Plants at the End of Experiment 2

SqrtAphidNumber					
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	146.739	1	146.739	12,054	0.001
Within Groups	1923.485	158	12.174		
Total	2070.224	159			

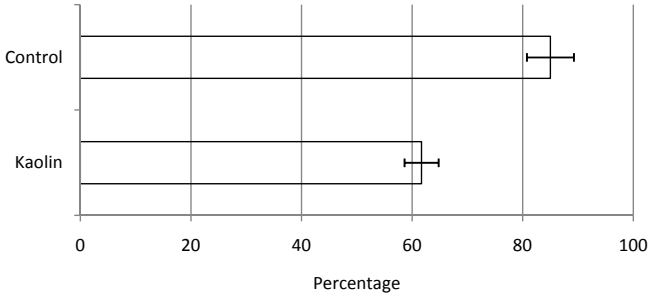

Fig. (4). Percentage of plants infested with *L. erysimi* on day 12 after every 4-days kaolin applications.

5% kaolin, respectively (Fig. **4**). Statistical analysis indicated that there is a significant difference (Table **4**) between the number of infested plants in treatment and control.

Table 4. Result of Two-Sample Kolmogorov-Smirnov Test Performed on the Number of Plants Infested with Aphids at the End of Experiment 2

Test Statistics[a]		
		PlantsInfested
Most Extreme Differences	Absolute	0.750
	Positive	0.750
	Negative	0.000
Kolmogorov-Smirnov Z		1.500
Asymp. Sig. (2-tailed)		0.022

[a]Grouping Variable: 1=Kaolin, 2= Control
Total N=16.

DISCUSSIONS

In experiment 1, aphids mean density was 27.21 and 103.66 in kaolin treated plants and control, respectively. In experiment 2, aphid density was 34.88 and 51.88 for treatment and control, respectively. Less aphids individuals were therefore encountered in control plants of experiment 2, in comparison to the control in experiment 1. This may be explained by the fact that, while observing plants during the experiment 2, we have encountered many individuals of the coccinella *Cheilomenes sulfurea* (Coleoptera: Coccinellidae) in the control plants. Since this species is aphids predator in the study area [1].

The effects of kaolin against aphid species such as *Aphis craccivora* [10] and *Aphis gossypii* [9] have been investigated. As in the present study, these works have showed that the solution containing 5 % kaolin powder has significantly reduced aphids' population density. These experiments revealed that higher kaolin concentration have left a large deposit of kaolin particle on cotton leaves thus handicapping chlorophyll synthesis and the proper growth and development of the plants. It was therefore concluded that 5 % kaolin powder and adequate application method that provides a full and continuous coverage of the plants with kaolin particle film should be used [9]. Nevertheless, one week interval application of this concentration does not completely suppress populations of *A. craccivora* and *A. gossypii* [9,10]. The present work has revealed that even more frequent kaolin applications do not improve the product efficacy against *L. erysimi.*

Bergel *et al.,* [11] evaluated the effect of kaolin against the aphid *Dysaphis plantaginea*, a major pest of apple. During the experiments, the authors found that significantly few alatae were placed on branches of apple trees treated with kaolin and aphids have also led very few females on the plants. Nevertheless, they noted that kaolin failed to maintain the density of the aphid *D. plantaginea* below the economic threshold throughout the season, since increasing the concentration of kaolin does not improve the product efficacy. Wyss and Daniel [12] have studied the effect of kaolin and pyrethrin on *D. Plantaginea*; these authors have concluded that the two products used in an integrated manner in apple trees reduced significantly the aphids number.

Showler and Armstrong have studied the effect of kaolin-based particle film on the cotton aphid in south Texas and have concluded that applications of kaolin can exacerbate the pest infestation [13]. In contrast to their work, frequent kaolin applications significantly reduced the number of *L. erysimi* in the present study. In Showler and Armstrong experiments [13], kaolin solution was weekly sprayed 30 cm over the top of cotton rows using tractor-mounted boom sprayer and no spraying was carried out after rainfall which removes a considerable amount of kaolin from the plants. Their application method visibly does not provide a full and continuous coverage of plant material with kaolin particle film. Therefore, failure of kaolin to control aphids in their study may be attributable to the application method they have used, since better application methods and frequent treatments are required to cover newly expanding foliage [14].

Kaolin is a white, non-abrasive, inert aluminosilicate mineral which serve to reduce insect pest populations by repellency, disruption of feeding and oviposition [6]. In view of the present study, we may conclude that kaolin technology can be combined with another plant protection measure in order to keep aphids population under control in cabbage.

ACKNOWLEDGEMENTS

This study has been supported by the Third World Academy of Sciences (TWAS). Kaolin was kindly supplied by Engelhard Corporation, USA.

CONFLICT OF INTEREST

None declared.

REFERENCES

[1] James B, Atcha-Ahowé C, Godonou I*, et al.* Gestion intégrée des nuisibles en production maraîchère: Guide pour les agents de vulgarisation en Afrique de l'Ouest. Institut International d'Agriculture Tropicale (IITA), Ibadan, Nigéria. 2010; 120p. ISBN 978-978-50004-4-3.

[2] Appert J, Deuse J. *Les Ravageurs des Cultures Vivrières et Maraîchères sous les Tropiques*, ed. G-P. Maisonneuse et Larose: Paris 1982; 137-8. ISBN 2-7068-0814-4.

[3] Blackman R.L and Eastop VF. Aphids on the World's Crops: An identification and information guide. John Wiley and Sons: Chichester, New York, Brisbane, Toronto, Singapore 1984; pp. 466.

[4] Kanrar S, Venkateswari J, Kirti PB, Chopra VL. Transgenic Indian Mustard (*Brassica juncea*) with resistance to the mustard aphid (*Lipaphis erysimi Kalt.*). Plant Cell Rep 2002; 20 (10): 976-81.

[5] Devonshire AL. Resistance of Aphids to Insecticides. In: World Crop Pests. Ch. Ed. Helle W. Aphids, their biology, natural enemies and control, Eds. Minks AK, Harrewijn P. 1989; 2C: 123-40.

[6] Unruh TR, Knight AL, Upton J, Glenn DM, Puterka GJ. Particle films for suppression of the Codling Moth (Lepidoptera: Tortricidae) in apple and pear orchards. J Econ Entomol 2000; 93(3): 737-43.

[7] Alavo TBC, Yarou BB, Atachi P. Field effects of kaolin particle film formulation against major cotton lepidopteran pests in North Benin, West Africa, Int J Pest Manag 2010; 56 (4): 287-90.

[8] Alavo TBC. Biological control agents and eco-friendly compounds for the integrated management of cotton bollworm, Helicoverpa armigera Hubner (Lepidoptera: Noctuidae): Perspectives for pyrethroid resistance management in West Africa. Arch Phytopathol Plant Protect 2006; 39(2): 105-11.

[9] Alavo TBC , Abagli AZ, Tégbéssou KJC, Dunphy GB. Kaolin potential for the integrated management of *Aphis gossypii Glov*. (*Homoptera: Aphididae*) on cotton. Arch Phytopathol and Plant Protect 2011; 44(8): 764-70.

[10] Alavo TBC. Effet répulsif du kaolin contre les populations d'*Aphis craccivora* (*Homoptera*: *Aphididae*) sur le niébé (*Vigna unguiculata)*. Int J Biol Chem Sci 2010; 4(2): 407-14.

[11] Bergel K, Wyss E, Daniel C. Effects of autumn kaolin treatments on the rosy apple aphid, *Dysaphis plantaginea* (Pass) (*Homoptera : Aphididae*) and possible modes of action. J Appl Ent 2005; 129 (6): 311-4.

[12] Wyss E, Daniel C. Effects of autumn kaolin and pyrethrin treatments on the spring population of *Dysaphis plantaginea* (Pass) (*Homoptera : Aphididae*) in apple orchards. J Appl Ent 2004; 128: 147-9.

[13] Showler AT, Armstrong JS. Kaolin particle film associated with increased cotton aphid infestations in cotton. Entomol experiment et applic 2007; 124(1): 55-60.

[14] Larentzaki E, Shelton AM, Plate J. Effect of kaolin particle film on Thrips tabaci (*Thysanoptera: Thripidae*), oviposition, feeding and development on onions: a lab and field case study. Crop Protect 2008; 27(3-5): p. 727-34.

Received: September 02, 2011 Revised: October 10, 2011 Accepted: October 14, 2011