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Bioefficacy of *Azadirachta indica* A. Juss and *Jatropha curcas* L. seeds aqueous extracts on *Plutella xylostella* (L.) (Lepidoptera: Plutellidae)

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Abstract

The diamondback moth, *Plutella xylostella* (Lepidoptera: Plutellidae) is an important pest of cruciferous crops in Côte d'Ivoire. It is a destructive pest of cabbage and it is developed resistance to many conventional insecticides. This study was carried out to evaluate the repellency and antifeedant effects of *Azadirachta indica* and *Jatropha curcas* seeds aqueous extracts on *Plutella xylostella* larvae and compared to two insecticides (Decis12 EC® and Cypercal 50 EC®) used by farmers under laboratory conditions. Three concentrations of *Azadirachta indica* seed powders (10.3, 25.9 and 41.5g) and of *Jatropha curcas* seed powders (14.7, 36.9 and 59.1g/L) and one concentration of the insecticides Decis 12EC® (0.042g/L) and Cypercal 50 EC® (0.13g/L) were separately applied on 20 larvae of *Plutella xylostella* for the antifeedent tests. For the repellent effect tests, 20 larvae of *Plutella xylostella* were placed on the middle of Whatman paper which half were uniformly applied with each insecticide or biopesticides. Three replicates were performed for each concentration of the treatments. The results showed that the aqueous extracts of *Azadirachta indica* 25.9 and 41.5g/L and of *Jatropha curcas* 59.1g/L seeds powders have higher antifeedant and repellency effects on *Plutella xylostella* larvae than the insecticides Decis 12 EC® and Cypercal 50 EC® in 72 hours. Antifeedant and repellent effects of these botanical extracts were increased with seeds extracts concentrations. Thus, the aqueous extract of *Azadirachta indica* seed powders 25.9 and 41.5g/L and of *Jatropha curcas* 59.1g/L can be used to protect efficiency cabbage crops against *Plutella xylostella* and the environment.

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Introduction

The cabbage-moth *Plutella xylostella* (L.) (Lepidoptera: Plutellidae) is a major pest of cruciferous plants of the genus Brassica in tropical and subtropical area (Seenivasagan and Paul, 2011; Diabaté *et al.*, 2014). These insect pests are responsible for abundant crop losses and have reduced nutritional and low market values of cabbage (Cartea *et al.*, 2009; Kirsch and Schmutterer, 2009). The larvae feed on the foliage of cruciferous plants and it cause an estimate 90% loss of production despite pesticides application (Cartea *et al.*, 2009; Kirsch and Schmutterer, 2009; Diabaté *et al.*, 2020).

In Côte d'Ivoire, farmers use chemical insecticides for the control of *P. xylostella*. Indeed, recommended application rates are not respected and only 27% of pesticides used by farmers are registered (Doumbia and Kwadjo, 2009). This intensive use of chemical pesticides has led to the development of resistance of *P. xylostella* to a wide range of insecticides (Zhao *et al.*, 2006; Sayyed and Wright, 2006; Pu *et al.*, 2010). However, that are hampered by many attendant problems such as toxicity to humans that consume the product, development of *P. xylostella* resistant strains to pesticides and the cost of procurement (Kirsch and Schmutterer, 2009; Nehare *et al.*, 2010; Shen *et al.*, 2010).

P. xylostella larvae develop physiological, biochemical, or anatomical mechanisms that allow them to reduce the effects of products applied to crops (Dugravot 2004; Zhao *et al.*, 2006; Agboyi *et al.*, 2016; Xue, 2018). These chemical pesticides used by farmers are persistent and accumulate in water, soil, air and in food (Baglieri *et al.*, 2011; Horváth *et al.*, 2013). Traoré *et al.* (2008) showed that the presence of the pesticide organochlorine in fish and in cow's milk in several regions of Côte d'Ivoire where cabbage cultivation where established. In addition, severe damage is caused to the natural enemies of this pest by the chemical insecticides (Shi *et al.*, 2004). Their toxic effects reduce the activity of essential fauna for soil fertility (Baglieri *et al.*, 2011; Horváth *et al.*, 2013). Thus, the control of *P. xylostella* constitutes an ecological, environmental and health threat. The use of more natural methods that can offer compatible control efficiency plus the benefit to the environment is most favoured. The objective of this work was to evaluate the repellency and antifeedant effects of aqueous extracts of Jatropha and neem grain powders on *P. xylostella* larvae (L2) per contact in view of their large scale applicability.

Materials and methods

Collection of Plutella. xylostella larvae at L2 stage

The *Plutella xylostella* larvae (L2) used for the laboratory bioassay were collected from untreated cabbage plots of the entomological farm of INPHB Yamoussoukro. Laboratory bioassays were conducted at 25 ± 1°C and at 75 ± 5% rh to determine the repellency and antiappetent effect of the aqueous extracts of neem *Azadirachta indica* and *Jatropha curcas* seed powders by contact, and to compare them with those of the insecticides Decis 12 EC® and Cypercal 50 EC® commonly used by farmers.

Preparation of aqueous extracts of neem and Jatropha grain powders, and insecticides

Insecticides (synthetic pyrethroids)

The insecticides used in this study were Cypercal® (50 EC, AF- CHEM SOFACO, Côte d'Ivoire) and Decis® (12 EC, AF- CHEM SOFACO, Côte d'Ivoire). The active ingredients of Cypercal 50 EC® and Decis 12 EC® were 50g/L of cypermethrin and 12.5g/L of deltamethrin, respectively. They belong to the family of synthetic pyrethroids and EC formulation. They were foliar insecticides acting by contact and ingestion. The concentrations commonly used in the farm for these different insecticides were used in these bioassays (Table 1).

Preparation of aqueous extracts of neem and Jatropha grain powders

The neem *A. indica* and *J. curcas* seeds harvested were shade-dried for four weeks at room temperature (30 ± 2° C) and at a relative humidity of 72 ± 5%.

For biopesticide preparation, 200, 500 or 800 grams of neem *A. indica* or *J. curcas* seeds were cleaned, de-shelled and the kernels and hulls were separated manually, respectively.

Then the kernels were grounded to fine powders using a sieve of 500 µm. Each fine powder was macerated in 10 L of tap water in a bucket during 24 hours. The products were manually stirred and after 24 hours of maceration, the solutions were filtered and were distributed in 20 L canisters, labeled and sealed, respectively. These filtrates constituted the different treatments for the bioassays (Table 1).

Table 1. Concentrations of biopesticides and insecticides used in the bioassays.

Aqueous seed extracts		Insecticides	
Azadirachta indica	*Jatropha curcas*	Decis® 12 EC	Cypercal®50 EC
41.5g/L (T1)	59.1g/L (T2)	0.042g/L (T4)	0.13g/L (T7)
25.9g/L (T5)	36.9g/L (T6)	-	-
10.3g/L (T''1)	14.7g/L (T''2)	-	-

T1: Neem seed powders 41.5g/L; T5: Neem seed powders 25.9g/L; T1: Neem seed powders 10.3g/L; T2: Jatropha seed powders 59.1g/L; T6: Jatropha seed powders 36.9g/L; T2: Jatropha seed powders 14.7g/L, Decis T4: 0.042g/L deltamethrin, Cypercal T7: 0.13g/L cypermethrin

Yield of Azadirachta indica and Jatropha curcas seed powders

To determine the seed powder yields (Y), four samples of 200 g, 500 g and 800 g of neem *A. indica* and *J. curcas* seeds were used. The masses of *A. indica* or *J. curcas* seed powders obtained were weighed, respectively. The yields were calculated using the following formula:

$$Y = \frac{Mp * 100}{\text{Mg}} \quad (1)$$

With:

Y = Yield of seed powders (%)

Mp = Mass of seed powders (g)

Mg = Mass of the seeds (g)

Evaluation of the repulsive effect of aqueous extracts of A. indica and J. curcas seed powders by contact (choice test)

The choice tests were used to evaluate the repellency effect of different insecticidal products towards insects by the preferential area method on Whatman paper (McDonald, 1970; Ndomo *et al.*, 2009).

The Whatman paper discs of 9 cm diameter were cut into two equal parts. One half of whatman paper were spread uniformly with 0.5 ml the botanical extracts or with the chemical pesticides and the second portion of whatman paper were treated with only 0.5 mL of distilled water (Control). After one hour, time required for complete evaporation of the diluting solvent, the two halves of the discs were re-sealed with an adhesive strip. The reconstituted whatman paper disk was placed in a 9 cm diameter Petri dish and a batch of 20 larvae of *Plutella xylostella* (L2) was placed in the center of each reconstituted whatman paper disk. Three replicates were performed for each concentrations of each product and for the control. Observations were made in each treatment every two hours for eight hours. At each observation, the number of larvae presents on the portion of whatman paper treated with the botanical extracts or with the chemical pesticides (Nt) and the number of larvae on the portion of whatman paper treated with distilled water (Nc) were recorded. The repellency rates (PR) was calculated using the following formula (Alzouma 1990; Diabaté *et al.*, 2014).

$$\text{PR} = \frac{(\text{Nc} - \text{Nt})\text{x } 100}{\text{Nc} + \text{Nt}} \quad (2)$$

Then, the repellency rates (PR) of different products tested were assigned to different repellent classes ranging from 0 to V (McDonald, 1970): class 0 (PR< 0.1%), class I (PR= 0.1-20%), class II (PR= 20.1-40%), class III (PR= 40.1- 60%), class IV (PR= 60.1-80%) and class V (PR= 80.1-100%).

Evaluation of the antiappetent effect of A. indica and J. curcas aqueous powder extracts by contact

Batches of 20 larvae of *P. xylostella* (L2) were uniformly applied with 250 µl of the botanical extracts based on *A. indica* and *J. curcas* or with the insecticides Decis 12 EC® and Cypercal 50 EC®, diluted in 1 mL of distilled water in Petri dish, during 10 seconds. Then, each batch of 20 larvae of *P. xylostella* (L2) treated was transferred to whatman paper to absorb the additional product. After 30 minutes of drying, the 20 larvae were placed in a new Petri dish (9 cm diameter) containing a disc of untreated cabbage leaf of 5 cm diameter on a 9 cm disc of whatman paper.

Observations were made every day for three days and the area of the consumed cabbage discs was recorded on graph paper. After feeding for 48 hours, the larvae were transferred into another Petri dish which cabbage leaf disc was also untreated. Three concentrations of *A. indica* seed powders (10.3, 25.9 and 41.5 g) and of *J. curcas* seed powders (14.7, 36.9 and 59.1g/L) and one concentration of the insecticides Decis 12EC® (0.042g/L) and Cypercal 50 EC® (0.13g/L) were used for the bioassays. Each treatment was replicated three times including the control. The antifeedant effects of the treatments against *P. xylostella* were calculated using the formula of Cui *et al.* (2013):

$$\text{Antifeedant rate} = \frac{(\text{Cc}-\text{Ct})*100}{\text{Cc}} \quad (3)$$

With:
Cc= Cabbage leaf disc consumed in the control;
Ct= Cabbage leaf disc consumed by *Plutella xylostella* larvae (L2) treated with the aqueous extract or with the insecticides (Synthetic pyrethroids).

Statistical analysis

Data of the antifeedent rates and the repellency effects of the biopesticides and of the insecticides on *P. xylostella* were analyzing using STATISTICA, version 7.1 (2005) and XLSTAT 2013. The antifeedent rates and the repellency effects of the biopesticides and of the insecticides on *P. xylostella* were subjected to an analysis of variance (ANOVA main effect) at the 5% threshold and the means discriminated with the Newman-Keuls test.

Results

Yield of A. indica and J. curcas grain powders and the appearance of their aqueous extracts

The yields of the powders obtained with *A. indica* and *J. curcas* seeds were 51.9% and 73.8% respectively. Indeed, 200g, 500g and 800g of neem seeds yielded 103.8g; 259.6 and 415.5g of *A. indica* seed (kernel) powders, respectively. On the other hand, 200g, 500g and 800g of *J. curcas* seeds yielded 147.7g; 369.3g and 591g of *J. curcas* kernel powders, respectively (Table 2).

Table 2. Yield of neem (*Azadirachta indica*) and Jatropha (*Jatropha curcas*) seed powders.

Mass of seeds (g)	Mass of seeds powders (g)	
	Neem	Jatropha
200	103.8	147.7
500	259.6	369.3
800	415.5	591
Yield (%)	51.9	73.8

The aqueous extracts of *A. indica* and *J. curcas* seed powders, obtained after 24 hours of maceration, showed variable aspects (Fig. 1).

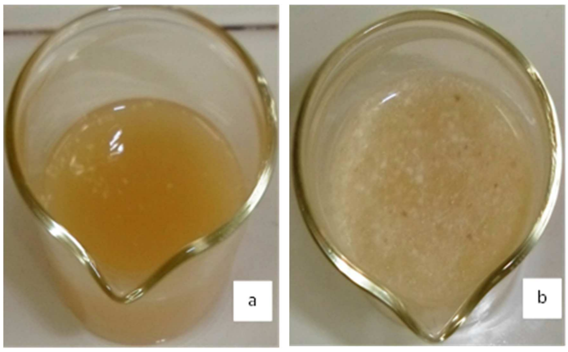

Fig. 1. Aqueous extracts of *Azadirachta indica* (a) and *Jatropha curcas* (b) seed powders.

Repellency effects of aqueous extracts of A. indica and J. curcas, and the insecticides Decis and Cypercal

The aqueous extracts of *A. indica* seeds and *J. curcas* seeds powders as well as the insecticides Decis® and Cypercal® exerted repulsive effects on *P. xylostella* larvae (L2) (Table 3).

Repellency effects of insecticides, and of the aqueous extracts of A. indica and J. curcas seeds powders diluted

During 4 hours of *P. xylostella* larvae (L2) exposure, the repellency rates induced by the aqueous extracts of *A. indica* 10.3g/L and *J. curcas* 14.7g/L seed powders and the insecticides Decis12 EC® and Cypercal 50 EC® were low and were between 3 and 12%. They were on repellent class I. From sixth hour to eighth hour of *P. xylostella* larvae (L2) exposure, Cypercal 50 EC® and the aqueous extract of *A. indica* seed powders 10.3g/L were on repellent class I, while Decis 12EC® was on repellent class II (PR= 20.1-40%). On the other hand, the repellent class of the aqueous extract of *Jatropha* seed powders 14.7g/L was repellent class II (PR= 20.1- 40%) at the sixth hour and repellent class I at the eighth hour (Table 3).

Table 3. Repellency effects of the pesticides and the aqueous extracts of *Azadirachta indica* and *Jatropha curcas* seed powders on *Plutella xylostella* larvae (L2).

Treatment	Nc (2h)	Nt (2h)	PR (%) (2h)	Nc (4h)	Nt (4h)	PR (%) (4h)	Nc (6h)	Nt (6h)	PR (%) (6h)	Nc (8h)	Nt (8h)	PR (%) (8h)
T1	12	8	20	14.333	5.667	43.333	13	7	30	15.333	4.667	53.333
T2	12.667	7.333	26.667	12.667	7.333	26.667	11.333	8.667	13.333	13	7	10.67
T4	11	9	10	11	9	10	13	7	30	12.333	7.667	23.333
T5	12.667	7.333	26.667	14	6	40	13.667	6.333	36.667	14.333	5.667	43.333
T6	13	7	30	14.333	5.667	43.333	13.667	6.333	36.667	13.667	6.333	36.667
T7	10.667	9.333	6.667	10.667	9.33	6.667	10.333	9.667	3.333	11	9	10
T"1	10.667	9.333	6.667	10.333	9.667	3.333	10.667	9.333	6.667	10.667	9.333	6.667
T"2	11	9	10	11	9	10	12.333	7.667	23.333	11.333	8.667	13.333
p	0.170			0.208			0.065			0.112		

PR= Reppellency rate, Nt= Average of the number of *Plutella xylostella* larvae (L2) on the whatman paper treated with the pesticides or biopesticides, (Nc)= Average of the number of *Plutella xylostella* larvae (L2) on the portion of whatman paper treated with distilled water.

T1= Neem grain powders 41.5g/L; T5= Neem grain powders 25.9g/L; T1=Neem grain powders 10.3g/L; T2= *Jatropha* grain powders 59.1g/L; T6= *Jatropha* grain powders 36.9g/L; T2= Jatropha grain powders 14.7g/L, T4= Decis (0.042g/L deltamethrin), T7= Cypercal (0.13g/L cypermethrin).

Repellent effects of insecticides and aqueous extracts of neem and jatropha grain powders at highest concentrations

After 2 hours, the repellency rates (PR) of the insecticides and those of the aqueous extracts of *A. indica* (25.9 and 41.5g/L) and *J. curcas* (36.9 and 59.1g/L) seeds powders ranged from 6 to 30%. The repellency rate of the aqueous extracts of powders, of *A. indica* seeds 25.9g/L and of *J. curcas* 36.9g/L and 59.1g/L were between 26 and 30% and were on repellent class II (PR= 20.1- 40%). They were more repellent than the insecticides Decis 12EC® and Cypercal 50EC® which were on repellent class I (PR= 0.1-20%), respectively. Their repellency rate was between 6 and 20% (Table 3).

After 4 hours of exposure, the aqueous extracts of *A. indica* seed powders 41.5g/L and *J. curcas* seed powders 36.9g/L were in repellent class III (PR= 40.1- 60%). Their repellency rates were between 42 to 44%. They were more repellent than *A. indica* aqueous extracts of powders 25.9g/L and of *J. curcas* seed powders 59.1g/L which were in repellent class II (PR= 20.1- 40%). Their repellency rates were 28 and 40%, respectively. The repellency rate of the insecticides Decis12 EC® and Cypercal 50 EC ® were on repellent class I (PR= 0.1-20%) (Table 3).

At the sixth hour of exposure, the repellency rates induced by the aqueous extracts of *A. indica* seed powders 25.9 and 41.5g/L and of *J. curcas* 36.9g/L and the insecticide Decis 12EC® were between 20 to 40% and were in repellent class II (PR= 20.1- 40%). The aqueous extract of *J. curcas* seed powders 59.1g/L and the insecticide Cypercal 50EC® were in repellent class I (PR= 0.1-20%) (Table 3).

At the eighth hour of exposure, the repellency rates induced by the aqueous extracts of *A. indica* seed powders 25.9 and 41.5g/L were between 41 to 55%. They were on repellent class III (PR= 40.1- 60%) and were more repellent than the aqueous extracts of jatropha seed powders 36.9 and 59.1g/L and the insecticide Decis 12EC® which were in repellent class II (PR= 20.1- 40%). The insecticide Cypercal 50EC® have the lowest repellency rate at eighth hour of exposure and was on repellent class I (PR= 0.1-20%) (Table 3).

Repellency effect of A. indica and J. curcas aqueous extracts seed powders, and of the insecticides

The average of the repellency rate of each product tested during eight hours of experimentation was used to determine their repellency effect. Thus, these choice tests showed that the aqueous extracts of *A. indica* seed powders 25.9g/L and 41.5g/L, and the aqueous extract of *J. curcas* seed powders 36.9g/L have the highest repellency effect with a rate of 36.67%. They were followed by the aqueous extract of *J. curcas* seed powders 59.1g/L (24.17%).

They were therefore in repellent class II (PR= 20.1-40%). However, the insecticides Decis 12EC® and Cypercal 50EC®, and the aqueous extracts of *A. indica* seed powders 10.3g/L and *J. curcas* seed powders 14.7g/L were on repellent class I (PR= 0.1-20%) (Table 4).

Table 4. Antifeedent, repellency effects of the treatments on *Plutella xylostella* larvae (L2).

Treatment Anti-appetence rate ± SE	Antifeedent rate ± SE	PR (%)	Class
Neem seed powders 41.5g/L (T1)	98.19 a ±1,26	36.67	II
Neem seed powders 25.9g/L (T5)	97.53 a ±1,14	36.67	II
Neem seed powders 10.3g/L (T''1)	39.65 e ±10,91	5.83	I
Jatropha seed powders 59.1g/L (T2)	97.53 a ±1,46	24.17	II
Jatropha grain powders 36.9g/L (T6)	86.00 bc ±2,74	36.67	II
Jatropha grain powders 14.7g/L (T''2)	54.43 d ±12,03	14.17	I
Decis® 12 EC (T4)	78.00 c ±1,15	18.33	I
Cypercal® 50 EC (T7)	91.30 ab ±3,02	6.67	I
P	0.001	-	-

SE= Standard Error, PR= Repellency effect

Means with the same letter within the same column are not statistically different from each other (Newman-Keuls test, $p<0.05$).

Antifeedant effect of A. indica and J. curcas aqueous extracts, and of the insecticides

The feeding behavior of *P. xylostella* larvae towards treatments at different rates was demonstrated by choice tests and measurements of the ingestion rate of cabbage leaves during contact toxicity tests. The antifeedant rates of aqueous extracts of *A. indica* and of *J. curcas* seed powders were decreased progressively as their concentrations decreased. Aqueous extract of *A. indica* seed powders 41.5g/L strongly inhibits cabbage leaves consumption by *P. xylostella* larvae. Their antifeedant rates of 99.65% were decreased to 53.38% when the larvae were treated with the aqueous extract of *A. indica* seed powders 10.3g/L.. The antifeedant rate of the aqueous extracts of *J. curcas* seed powders 59.1g/L was 88.91% and was decreased to 88.91% at 68.11% for the *J. curcas* seed powders 14.7g/L. The antifeedant rates of the aqueous extracts of *A. indica* seed powders (10.3 and 25.9g/L) and of *J. curcas* (14.7 and 36.9g/L) were low and were similar to those of the insecticides Decis12EC® and Cypercal50EC® (Table 4)

The aqueous extracts of neem seed powders 25.9 and 41.5g/L and of *Jatropha* seed powders 59.1g/L have highest antifeedant rates than the insecticides Decis12 EC® and Cypercal 50 EC® by contact. The aqueous extract of *A. indica* seed powders 41.5g/L was more effective than the aqueous extract of *J. curcas* seed powders 59.1g/L by contact.

Discussion

Repellent effect of aqueous extracts of A. indica and J. curcas seed powders

Aqueous extracts of *A. indica* and *J. curcas* seed powders showed repulsive effects on *P. xylostella*. Aqueous extracts of *A. indica* seed powders 25.9 and 41.5g/L and of *J. curcas* seed powders 36.9 and 59.1g/L have highest repellency effects than the insecticides Decis 12 EC® and Cypercal 50 EC® after 8 hours. These highest repellency effects of these aqueous extracts of neem and jatropha seed powders would be due to the highest concentrations of the primary or secondary metabolites. These primary or secondary metabolites were induced very quickly a highest toxicity and phagorepulsive effects on *P. xylostella* larvae. These active compounds were azadirachtin for *A. indica* (Senthil-Nathan, 2013) and the curcin for *J. curcas* (Boateng and Kusi 2008). However, when these aqueous extracts were diluted, the concentration of their active substances decreases as well as the repellency effects. According to Devappa *et al.* (2010) and Senthil-Nathan (2013), the azadirachtin of *A. indica* and the curcin of *J. curcas* grains have comparable efficacies to the pyrethroids commonly used to protect cabbage crops.

Antifeedent effect of aqueous extracts of A. indica and J. curcas seed powders

Aqueous extracts of *A. indica* seed powders and of *J. curcas* were showed antifeedant effects on *P. xylostella* larvae (L2). The feeding on cabbage leaves by *P. xylostella* larvae (L2) treated with the aqueous extracts of *A. indica* grains and of *J. curcas* was smaller than those that have been treated with the insecticides Decis 12EC® and Cypercal 50EC®.

Aqueous extracts of *A. indica* seed powders 25.9 and 41.5g/L and of J. curcas 59.1g/L have highest antifeedant effect by contact than the insecticides Decis 12EC® and Cypercal 50EC®. However, when these biopesticides were diluted, their antifeedant effects were decreased and induced a highest consumption of cabbage leaves. According to Isman (2007), aqueous extracts of *A. indica* contain triterpenoids such as azadirachtin, azadirone, nimbine and salanin which induced highest antifeedant effects. In addition, Senthil-Nathan (2013) showed that azadirachtin acts on chemoreceptors of the insects and inhibits food intake.

The antifeedant effects of *J. curcas* on *P. xylostella* were led to several compounds that have toxic and repellent effects. A wide range of chemical compounds such as, Protease inhibitors, Saponins and phenolic compounds have been isolated from *J. curcas* aqueous extract (Bouchelta *et al*., 2005; Nesseim *et al*., 2012; Treboux, 2013). The Protease inhibitors reduced the consumption of cabbage leaves by affecting the production of digestive enzymes such as amylase, glucosidases, lipases and proteases (Nesseim *et al*., 2012). Saponins have repellent and toxic effects on insects (Bouchelta *et al*., 2005). The phenolic compounds are antinutritional factors, especially for monogastrics (Nesseim *et al*., 2012; Treboux, 2013). Their ingestion causes growth retardation and reduced energy value of the ration (Boateng and Kusi, 2008; Nesseim *et al*., 2012). Thus, foliar applications of aqueous extracts of *A. indica* seed powders 25.9g/L and 41.5g/L, and those of *J. curcas* seed powders 59.1g/L can offer compatible control efficiency plus the benefit to environment.

Conclusion

The results of the bioassays showed that the aqueous extracts of *A. indica* seed powders 25.9 and 41.5g/L and those of *J. curcas* seed 59.1g/L induced highest repellency and antifeedant effects than the insecticides Decis 12EC® and Cypercal 50EC® commonly used against *P. xylostella*. These aqueous extracts were on repellent class II and the insecticides Decis 12EC® and Cypercal 50EC® were on repellent class I. These aqueous extracts of *A. indica* and of *J. curcas* have insecticidal activities on *P. xylostella* larvae by contact. Their large-scale production by agrochemical industries will allow to effectively control *P. xylostella* and to increase the yields of Brassica crops in tropical and subtropical regions.

Competing interests

The authors declare that they have no competing interests.

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