Insecticidal aactivities of the aqueous extracts of *Chromolaena odorata* leaves and *Anacardium occidentale* nutshell liquid against insect pests of cabbage and its effect on yield

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ABSTRACT

The current study investigated the insecticidal potential of *Anacardium occidentale* and *Chromolaena odorata* in managing the main insect pests of cabbage in field settings. The 2018 and 2019 major and minor rainy seasons were when the study was carried out. Four treatments were used: a normal insecticide (Emamectin benzoate, 3 mL/L), a water extract of *C. odorata* leaves, a water extract of *A. occidentale* nutshell liquid (50 g/L), and soapy water as a control. Four replicates were used in a Randomized Complete Block Design (RCBD) arrangement for these. The quantity and presence of insects, an evaluation of leaf damage, and an estimation of harvest yield were the data collected. Thirteen different species of insects were recorded, and classified as major, minor, and beneficial pests. *Plutella xylostella* and *Hellula undalis* infestations in the control group were generally much greater than those in the other treatments. The botanicals were more successful than the control at reducing the aphid population. In general, the botanicals outperformed the control in terms of *Phyllotreta* sp. and ant population; however, there was no discernible difference in the response for *Zonoceros variagatus* and cabbage white flies. The mean weights, head diameters, and mean head heights for each treatment showed a significant difference ($p < 0.05$). For both seasons, more than 60% of the leaves had damage ranging from 0% to 20% (Damage 1). The results of this study demonstrate the two botanicals insecticidal properties against the most common insect pests of cabbage, allowing them to be included in an integrated pest management (IPM) package.

Key word: *Plutella xylostella, Hellula. undalis*, Insecticidal activities, Cabbage, Pests

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INTRODUCTION

According to Ozobia *et al*. (2013), the primary reason vegetables are grown is as a source of sustainable micronutrients for diets. Cabbage (*Brassica oleracea* var. *capitata* L.) is a widely consumed vegetable. Grown as an annual crop for its densely leafy crowns, this biennial vegetable plant can be either green or purple depending on the variety. Due to rising consumer demand, cabbage is now grown year-round in Ghana, either in open fields or under greenhouse conditions. Cabbage cultivation has various obstacles, including attacks from a variety of pests and illnesses, which reduce yield and quality even with the rise in output (Timbila and Nyarko, 2006).

Three major cabbage pests have been identified in Ghana: the cabbage webworm, *Hellula undalis* Fab (Lepidoptera: Crambidae), the cabbage aphid, *Brevicoryne brassicae* Lin. (Hemiptera: Aphididae), and the diamondback moth (DBM), *Plutella xylostella* Lin. (Lepidoptera: Plutellidae) (Timbilla and Nyarko, 2004; Owusu-Boateng and Amuzu, 2013; Ezena *et al.*, 2016). According to Waiganjo *et al.* (2011), these insect pests can cause crop losses of up to 100%. According to Zalucki *et al.* (2012), the yearly cost of controlling DBM worldwide is projected to be between US$4 billion and US$5 billion.

Farmers have long used synthetic pesticides as a standard method of managing insect pests on cabbage (Owusu-Boateng and Amuzu, 2013; Ezena *et al.*, 2016). However, the excessive and careless use of synthetic pesticides to manage insect pests has resulted in negative effects on organisms that are not intended targets, the emergence of pest resistance in some of these pests, and pest resurgence (Avicor *et al.*, 2012).

It is necessary to create substitute pesticides with very low or no toxicity, a novel possible mode of action, and environmental friendliness. Because they offer novel modes of action that may effectively control pests that have already developed resistance to conventional insecticides, plant-based insecticides are garnering more and more attention from researchers (Owusu *et al.*, 2010; Owusu *et al.* 2007; Osabutey *et al.*, 2019; Eziah *et al.*, 2012). In general, using botanical insecticides is less harmful to the environment and more sustainable than using synthetic ones (Devanand and Rani, 2008). It has also been discovered that certain plant metabolites contain insecticidal qualities. These metabolites are employed by the plants to protect themselves against pests, and in recent years, there has been much research on using them as pesticides (War *et al.*, 2012).

Among these are *Chormolaena odorata* and *Anacardium occidentale*, which are well-known for their insecticidal properties. Growing wild, *C. odorata* is regarded as a significant weed in agriculture. Most of the time, weedicide is sprayed on this plant because it has no useful purpose (Odugbemi, 2006). The cashew, or *A. occidentale*, is a crop of significant commercial value. The nuts of this crop are its most valuable component, and the shell is typically thrown away as a byproduct once the nuts have been extracted and the shell cracked. In field experiments carried out during the major and minor rainy seasons, we investigated the insecticidal activities of the aqueous extracts of the leaves of *C. odorata* and *A. occidentale* shell liquid against the major insect pests of cabbage and evaluated their effect on the yield of the cabbage.

MATERIALS AND METHODS

Study area

The study was carried out at the Forest and Horticultural Crops Research Center (FOHCREC) of the University of Ghana, located at Okumaning-Kade in the Denkyembour district in the Eastern Region of Ghana. The center is located (06º 09' and 6° 06N, 0º 55' and 0° 49W) in the semi-deciduous forest agro-ecological zone. It is characterized by a semi-equatorial climate with bimodal rainfall ranging between 1200-150 mm. The major rainy season starts from mid-March to July, with a peak in June. The minor rainy season runs from September to mid-December, with a peak in October. However, the region experiences a certain amount of rain every month of the year. The mean annual temperature range at this location is 24-38°C. The relative humidity is around 70–80% in most parts of the year. This work was done during the major raining season (February 2019 to May 2019) and the minor raining season (October 2018 to December 2018).

Collection and preparation of aqueous extracts

The *C. odorata* leaves were collected from the wild at FOHCREC, and the leaves were dried at room temperature. The dried leaves were pounded using a mortar and pestle to obtain a fine powder. The cashew nuts were also collected from a cashew plantation at the Research Center that has a history of no insecticide application over 10 years. The nuts were cracked, and the nutshell was removed and dried at room temperature. The partly dried shells were pounded using a mortar and pestle to obtain an oily paste.

The sample extraction was done using untreated tap water. One hundred grams of the grounded samples of the plant parts were mixed with 1L of water to obtain a mixture and left to stay for 48 hurs in darkness under room temperature in the laboratory. After 48 hurs, the mixture was sieved to obtain a uniform extract, and 1L of 10% soapy water using African black soap (*'alata samina')* was added to dilute the extract, making 50 g/L of the extract.

Nursing of Seedling and Transplanting

Cabbage seeds (variety: Oxylus) were nursed in a green house. The seeds were nursed in a seed tray filled with fungicide-treated, virgin soil obtained from the forest. All nursery practices were carried out for five weeks until seedlings were ready for transplanting at the stage of 4-5 leaves. The cabbage seedlings were transplanted with a spacing of 0.5 × 0.5 m. The treatment plots, measuring 1.5 × 2 m, comprised 20 plants/plot. A two-meter-wide unplanted alley was left between each plot to avoid spray drift, and a two-meter-wide unplanted alley was between blocks. Agronomic practices such as weed control, fertilizer application, watering, and earthing up of the soil to improve aeration were employed during the growing periods.

Field experimental design and treatments

The experimental design adopted for the field work was a randomized complete block design (RCBD). consisting of four treatments replicated four times. The treatments were: water extracts of *C. odorata* leaves; water extracts of *A. occidentale* nutshell liquid (@50 g/L); a standard insecticide (Emamectin Benzoate) applied at a rate of 3 mL/L; and soapy water used as a control. Treatment started one week after transplanting. The application was done on a weekly basis with a CP-15 Knapsack sprayer.

Population dynamics of insects

Data collection started a week after transplanting and was done twice every week. Data on insect population, that is, the presence and number of insects present, was counted and recorded on six randomly selected plants out of the 20 on each plot. These insects were grouped into major pests, minor pests, and beneficial insects.

Damage assessment

At harvest, five cabbage heads were randomly selected from each treatment plot to assess the yield. Leaf damage during the growing season was also estimated using the modified damage index adopted from Osabutey *et al.* (2019) as follows: Damage 1 (0–20% leaves damage); damage 2 (20–40% leaves damage); damage 3 (40–60% leaves damage); and damage 4 (<60% leaves damage).

Data analysis

Data involving counts were transformed before data analysis. Analysis of variance at 95% confidence was run on the data using GenStat Statistical Package 9.2 (9^{th} Edition), and mean separation was done by Tukey's LSD test at 5% level of significance. Means of untransformed data were presented in tables and graphs using Microsoft Excel.

RESULTS

Categorization of the collected insect pests

For every treatment, a total of thirteen distinct bug species were gathered during the major and minor seasons (Table 1). But 12 were gathered during the major season, which ran from February to May 2019, and another 12 during the minor season. As indicated in Table 1, these were recognized and categorized as major pests, minor pests, and beneficial insects.

During the sample time, *Lypaphis erisimy* and *Myzus persicae*, two distinct species of aphids, were observed. In the minor season, records for both *M. persicae* and *L. erisimy* were made; in the major season, records for only *L. erisimy* were made. While was seen in both the minor and major seasons, *Hellula undalis*, *Plutella xylostella*, also known as the diamond back moth, was only found during the major season and not at all during the minor. Other insect pests that were deemed minor pests since they were not as harmful to cabbage as the aforementioned ones include *Phyllotreta* sp., *Bemisia tabaci*, *Zonocerus variegatus*, and several ant species. All of these were present in both seasons.

Table 1. Classification of Insects collected on the field in both major and minor seasons.

Classification	Insect Collected	Season	
		Major season	Minor season
Major pests	*Plutella xylostella* *Hellula undalis,* *Lypaphis erisimy* *Myzus persicae*	+ + + -	- + + +
Minor pests	*Zonocerus variegatus* *Phyllotreta sp* *Bemisia tabaci*	+ + +	+ + +
Predators and parasitoids	*Cotesia plutellae* *Allograpta exotica* *Harmonis* spp, *Euborellia* sp Earwing, Ants	+ + + + + +	+ + + + + +

(+): Present; (-): absent

From Plutella xylostella larvae that were brought into the lab to be raised, the larval parasitoid Cotesia plutellae was discovered to be emerging. On the extremely aphid-infested plots, Allograpta exotica, hoverflies a natural opponent of aphids were also present. There were also general predatory insects discovered, such as ants, lady bird beetles, *Harmonis* spp., earwings, and *Euborellia* sp. The impact of plant extracts on the population dynamics of the most common insect pests that were collected *X. plutella.*

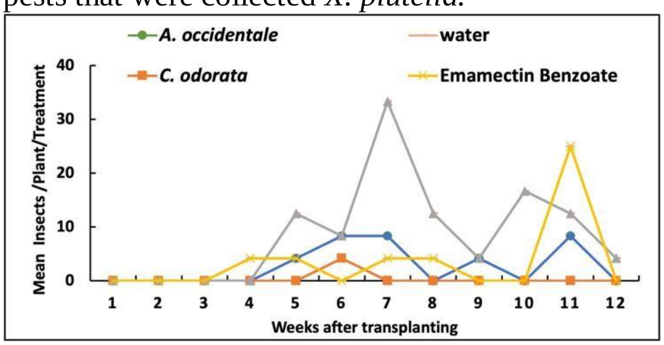

Fig. 1. Graph of weekly mean of *Plutella xylostella*. per cabbage plant per treatment during the major season

P. xylostella was found during the research, but only during the main rainy season. In contrast, no *P. xylostella* was found during the minor season in any of the treatments. The *P. xylostella* population dynamics that were observed during the minor season differed greatly depending on the treatments (Fig. 1). In general, compared to the other treatments, the infestation in the control treatment (soapy water) was noticeably higher. The control group had the most infestation, with 33.3 *P. xylostella* larvae recorded on the seventh week. The emamectin benzoate treatment group recorded 25.0 *P. xylostella* larvae on the eleventh week. The *C. odorata* treatment resulted in the least amount of *P. xylostella* infestation. With the exception of the sixth week, when it recorded 4.17 *P. xylostella* larvae, the *C. odorata* treatment consistently reported the lowest *P. xylostella* infestation of 0.0 larvae during the study period. During the first four weeks of treatment, the *A. occidentale* nutshell treatment had the lowest *P. xylostella* infestation, while on the sixth, seventh, and eleventh week, the maximum infestation.

Helula undalis

For every season, there were notable differences in the *H. undalis* population according to treatments (Fig. 2 and 3). The control group saw the highest *H. undalis* infestation of 12.5 larvae during the minor season on week 12, as seen by Fig. 2. With the exception of week 4, when the emamectin benzoate treatment recorded 1.9 larvae per plant each treatment, the other treatments, on the other hand, recorded the fewest throughout the majority of the week.

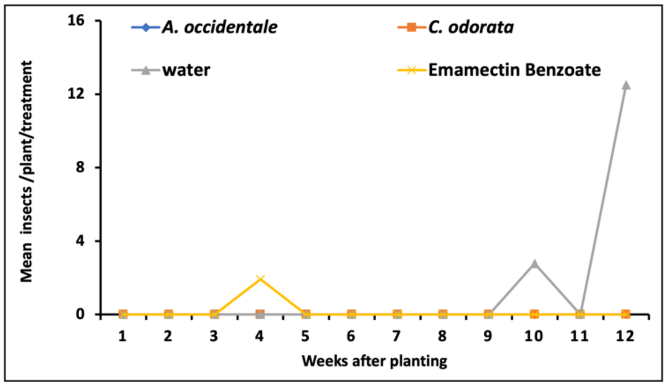

Fig. 2. Graph of weekly mean of *Hellula undalis* per cabbage plant per treatment during the minor season

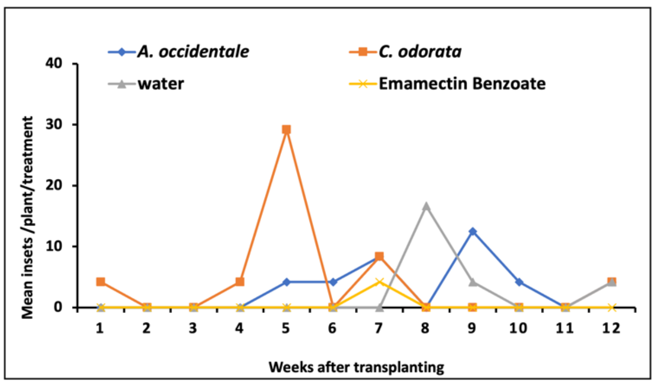

Fig. 3. Graph of weekly mean of *Hellula undalis* per cabbage plant per treatment during the major season.

Conversely, during the main growing season, more *H. undalis* was gathered on the plots treated with *C. odorata* and *A. occidentale* than on the treatments with emamectin benzoate and the control (Fig. 3). The *C. odorata* treatment had the highest infestation (29.17) on the fifth week, and the cotrol treatment (16.67) on the eighth week. On the other hand, for the course of the study and for both the minor and major seasons, the plot treated with emamectin benzoate showed the lowest number of *H. undalis.*

Myzus persicae* and *Lypaphis erisimy

The plots treated with *C. odorata* and emamectin benzoate did not have any aphids in either of the two seasons (Fig. 4 and 5). On the other hand, the *A. occidentale* treatment recorded 10.0 *L. erisimy* on the 10th week and reduced to 0.0 *L. erisimy* on the 12th week for the minor season (Fig. 4). In the 11th week, 2.9 *L. erisimy* were documented for the control group; by the 12th week, that number had dropped to 1.5 per plant. *L. erisimy* was only detected on the control treatment during the main season (Fig. 5), not on any of the other treatments. On the tenth week following transplanting, the maximum infestation (374.41 aphid per plant per treatment) was noted.

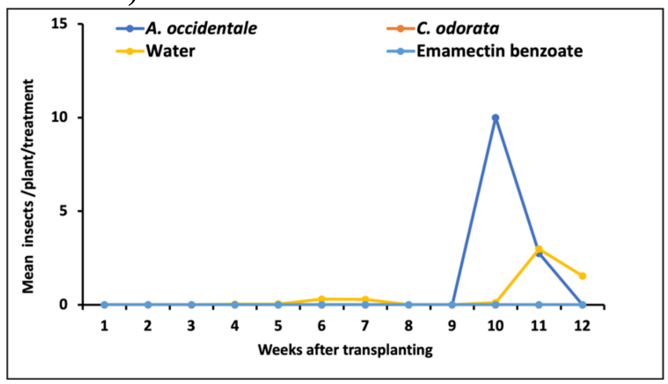

Fig. 4. Graph of weekly mean of *Lypaphis erisimy* per cabbage plant per treatment during the minor season

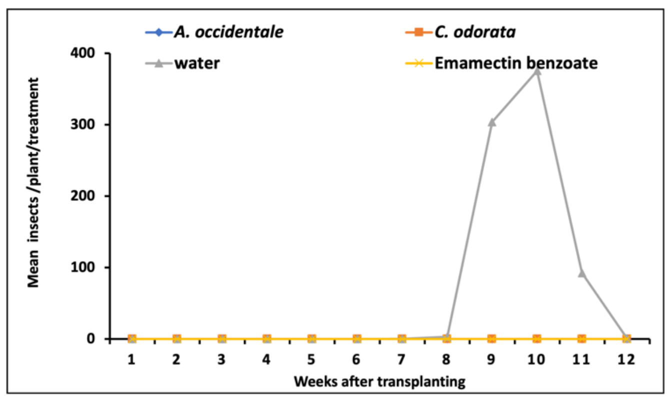

Fig. 5. Graph of weekly mean of *Lypaphis erisimy* per cabbage plant per treatment during the major season.

In all of the plots, *M. persicae* was absent throughout the minor season (Fig 6). In contrast, *M. persicae* was recorded in the main season (Fig. 7) after the ninth week. Its peak infestation of 6.25 aphids per plant per treatment was noted on the *A. occidentale* plot, and 4.54 aphids on the *C. odorata* treated plot. Nonetheless, the control plot showed the lowest *Myzus persicae* population.

Plant Extracts on population of other Insects

Tables 2 and 3 display the impact of the treatments on the total number of other insects collected.

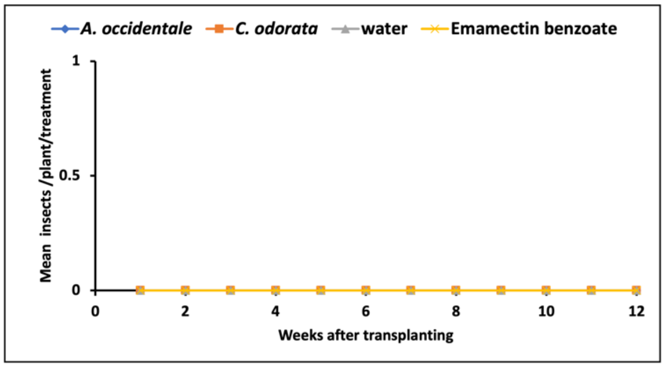

Fig. 6. Graph of weekly mean of *Myzus persicae*. per cabbage plant per treatment during the minor season during the minor season

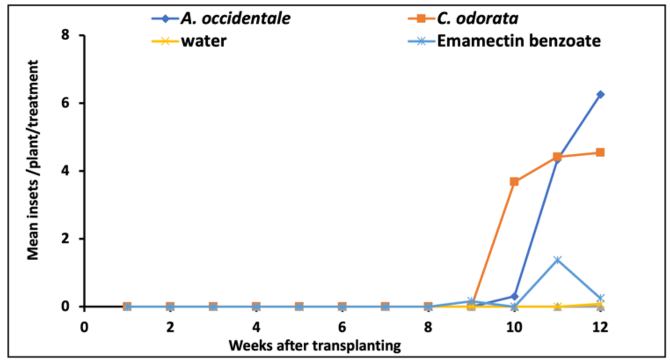

Fig. 7. Graph of weekly mean of *Myzus persicae*. per cabbage plant per treatment during the major season.

Table 2. Average number of other insects found during the major season

Treatments	Mean number of Insects		
	Ant	*Phyllotreta sp.*	*Zonocerus variegatus*
A. occidentale	4.16 ± 1.79 a	11.80 ± 7.92 a	5.57 ± 1.50 b
Chromolaena odorata	5.208 ± 1.31 a	9.07 ± 20.6 a	20.47 ± 0.67 a
Control	10.16 ± 7.33 a	20.37 ± 30.9 a	6.94 ± 2.04 ab
Emamectin benzoate	3.47 ± 1.65 a	13.23 ± 9.01 a	5.90 ± 0.04 b
F and *P* Values	F= 0.20; P= 0.891	F= 2.61; P= 0.115	F= 5.67; P=0.018

Mean value with the same letters means no significant difference (P> 0.05); Mean value with different letters means there is a significant difference (P < 0.05)

Table 3. Average number of other insects found during the minor season

Treatments	Mean (± SE) number of Insects		
	Ants	*Phyllotreta sp.*	*Zonocerus variegatus*
A. occidentale	8.14 ± 4.10 a	69.60 ± 19.2 a	0.0±0.0a
Chromolaena odorata	11.55 ± 6.70 a	40.15 ± 8.02 a	0.43 ± 0.25 a
Control	3.82 ± 1.90 a	57.80 ± 10.8 a	0.27 ± 0.28 a
Emamectin benzoate	4.86 ± 2.30 a	94.22 ± 21.5 a	0.60 ± 0.46 a
F and *P* Values	; F= 0.35; P=0.791	F= 1.29; P=0.337	F= 0.80; P=0.525

With the exception of the quantity of *Zonocerus variegatus* observed in the main season, there were generally no significant (p > 0.05) variations in the mean number of the various insect species detected in the various treatments for both seasons. Mean value with the same letters means no significant difference (P> 0.05); Mean value with different letters means there is a significant difference (P < 0.05)

The *Z. variegatus* per plant throughout the main season was highest in the *C. odorata* treatment, then in the control (Table 2). The number of *Z. variegatus* recorded for the emamectin benzoate and *A. occidentale* treatments, however, did not differ significantly (p > 0.05). The study found that while the number of *Phyllotreta* sp. (flea beetles) recorded for each treatment did not differ significantly, the control group recorded the maximum number (20.37 ± 30.9), while the *C. odorata* treatment group recorded the lowest number per plant. Similarly, the control group recorded the greatest number of ants, while the group treated with emamectin benzoate reported the lowest number). The most common bug detected in all treatments throughout the minor season was the cabbage white fly (Table 3). The emamectin benzoate treatment had the greatest, although not differing significantly from the other treatments. On the other hand, there were fewer ants and *Z. variegatus t*han there were whiteflies.

Impact of plant extracts on beneficial insects

There were only a few natural enemies of the main insect pests of cabbage that could be found. From larvae brought in for laboratory rearing, *Cotesia plutella*, the larval parasitoid of the DBM (*P. xylostella*), was discovered emerging. On the plots where aphid infestation was severe, hoverflies, *Allograpta exotica*, the natural adversary of aphids, were also present in comparatively smaller numbers. General predators such as earwings, *Euborellia* sp., ladybirds *Harmonis* spp., and ants were also discovered. However, it's unclear if the plant's aqueous extracts have any effect on these natural enemies given their numbers seen in the field and degree of parasitism.

Yield, diameter, and height of harvested heads

Table 4 displays the average weight of cabbage heads based on five heads taken for each treatment during the two seasons. Throughout the minor season, there was a significant difference ($p < 0.05$) in the mean weights for each treatment. The mean weights of the cabbage heads for each treatment do not, however, differ significantly ($p < 0.05$) during the main season. During the major season and the minor season, the emamectin benzoate treatment had the highest mean weight. During the minor season, the treatments with *C. odorata* and *A. occidentale* produced more cabbage heads, than the control group.

For the minor season, there was a significant difference between the treatments for both the mean head height and the mean head diameter; however, for the major season, there was no significant difference between the treatments (Table 4). The emamectin benzoate treatment had the maximum head diameter (33.87 cm) and matching head height (17.19 cm) during the minor season, while the *A. occidentale* treatment had the lowest head diameter (26.38 ± 0.56 cm) and height (14.87 ± 0.77 cm) as shown in Table 5.

Table 4. Mean cabbage head weight (Mean (± SE) for cabbages harvested for minor and major seasons

	Minor season	Major season
Anarcadium occidentale	238.4± 30.60 bc	206.3± 31.50 a
Chromolaena odorata	382.8 ± 20.26 ab	183.0± 20.88 a
Control	227.1± 17.97 c	214.9± 57.15 a
Emamectin benzoate	407.3± 74.16 a	320.1± 101.3 a
F and *P* Values	$F= 7.77; P=0.007$	$F= 1.07; P=0.409$

Mean value with the same letters means no significant difference ($P> 0.05$); Mean value with different letters means there is a significant difference ($P < 0.05$)

Assessment of Leaves

Since over 60% of the leaves were damaged between 0 and 20% (Damage 1) for both seasons, the harvested leaves were generally not badly damaged (Fig. 8 and 9). But in the main growing season, the control group saw the greatest percentage of leaves damaged between 40% and 60%. During the main season, no treatment recorded damage greater than 60%. On the other hand, during the minor season, all damage levels were noted in all treatments, with the majority of the control group's leaves exhibiting the most damage.

DISCUSSION

Seasonal fluctuation was seen in the principal insect pests of cabbage, with a larger population presence during the minor rainy season compared to the major rainy season. The research area's high rainfall may have had a major effect on the pest numbers that were noted for each season. Ezena *et al.* (2016) found that *P. xylostella* was only present during the main season in a study that was identical to this one. The area of investigation had high rainfall, which might have had a major effect on P. xylostella numbers. According to Eziah *et al.* (2010), variations in climatic circumstances have an impact on the *P. xylostella* population. Additionally, this study demonstrated the insecticidal properties of the aqueous extracts of *A. occidentale* and *C. odorata* against *P. xylostella, H. undalis, L. erisimy,* and *M. persicae*, the main insect pests of cabbage.

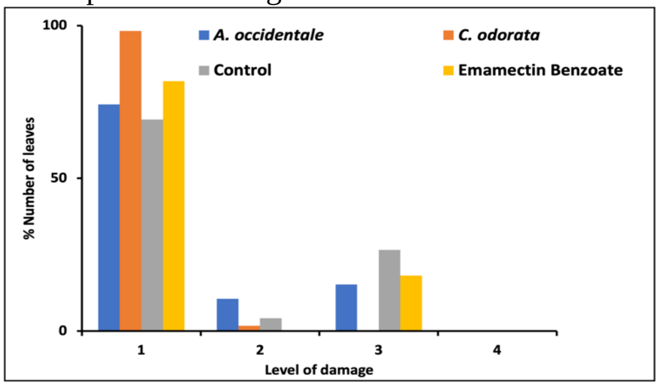

Fig. 8. Cumulative percentage leaf damage of the cabbage head for Major Season. Damage 1 = 0-20% damage to leaves, damage 2 = 20 - 40% damage to leaves, damage 3 = 40-60% damage to leaves and damage 4 = greater than 60%

Ezena *et al*. (2016) and Osabutey *et al.* (2018) revealed that the aqueous extract of *C. odorata* and *A. occidentale* had very strong insecticidal efficacy against the *P. xylostella* and cabbage aphids. The control treatment, which included a solution of African black soap (also known as "alata samina"), had the least amount of aphid infestation throughout the minor season. The results of Forchibe *et al.* (2017), who discovered that "alata samina" solution may lower population of several insect pests including aphids, imply that soapy water prepared with "alata samina" is efficient in Nonetheless, the notably low insecticidal activity of the chosen botanicals may be explained by the behavior of *H. undalis*. When the larvae attach themselves to the cabbage, they typically weave a web around themselves (Tran and Nguyễn, 2019), which can provide some protection from any insecticide that is sprayed.

controlling of aphids.

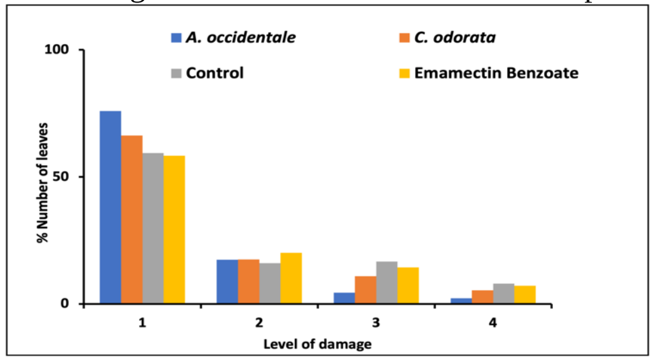

Fig. 9. Cumulative percentage leaf damage of the cabbage head for Minor Season. Damage 1 = 0-20% damage to leaves, damage 2 = 20 - 40% damage to leaves, damage 3 = 40-60% damage to leaves and damage 4 = greater than 60%

Cabbage and other green plants are reported to be defoliated by the variegated grasshopper, *Z. variegatus*, and the flea beetle, *Phyllotreta* sp (Timbilla and Lawson, 2004). Their eating may cause the cabbage to grow more slowly, slowing down the rate of photosynthesis and resulting in smaller cabbage heads. As a result, the cabbage yield is adversely affected by their feeding. Nevertheless, *Z. variegatus* was not effectively controlled by the *C. odorata* extract. The pharmacophagus link between the plant and the insect provides an explanation for this (Timbilla and Braimah, 1996). On the plots, natural enemies that prey on aphids, including hoverflies, ladybeetles, and *Cotesia plutellae*, a parasitoid larva of *P. xylostella*, were present, though in relatively small numbers. Since the primary parasitoids and predators were not as prevalent in big numbers in the control plots, their small populations may not have anything to do with the treatments' effects. The area's reduced concentration of cabbage plants may be the cause of their declining population (Mills, 2009). The parasitoid load increases with the number of hosts. Other predator populations, such ant populations, were higher on the control and botanically treated plots than on the positive control plot, indicating that the botanicals may not have had much of an adverse effect on the natural enemies.

Damage and yield of cabbage

The comparatively low level of *P. xylostella* infestations noted in the minor season as well as its abundance in the major season may be the reason why there were no appreciable variations in the mean cabbage weights among the treatments during the major season. The *C. odorata* plot had the highest infestation of *Z. variegatus* and one of the highest infestations of *H. undalis*, while having the fewest *P. xylostella*. The combined effect of these two insects is responsible for the reduced yield observed on this plot. The bulk of the leaves on the cabbage heads that were taken during the minor season from the negative control plot had significant level damage, and they had the lowest mean weight. Despite the absence of *P. xylostella* collection this season, the increased abundance of *H. undalis* and *Z. variegatus* both of which are notoriously ravenous defoliators—can be blamed for the yield loss. The high damage rate observed in the control plots suggests that cabbage cannot be grown without trying to manage insect pests because, like other crucifers, they contain glucosides and mustard oil (Gupta and Thorteinson, 1960), which increases their susceptibility to insect pest attack, particularly from aphids and *P. xylostella*, *Hellula undalis*, and *Zonocerus variegatus*, as demonstrated by this study. The most effective therapy for managing populations of *P. xylostella*, *H. undalis*, aphids, and other cabbage pests was an aqueous extract of *Chromolaena odorata* leaves and *Anacardium occidentale* nutshell liquid, which both shown insecticidal activity.

Table 5. Mean (± SE) of cabbage diameter and height per plant and per treatment

Treatments	Minor Season		Major Season	
	Head diameter (cm)	Head height (cm)	Head diameter (cm)	Head height (cm)
Control	28.66 ± 0.26 bc	14.96 ± 0.69 bc	28.86 ± 3.94 a	14.35 ± 1.70 a
A. occidentale	26.38 ± 0.56c	14.87 ± 0.77 c	25.82 ± 1.38 a	13.33 ± 0.63 a
C. odorata	32.49 ± 0.39 ab	17.03 ± 0.03 ab	24.16 ± 1.32 a	12.58 ± 0.74 a
Emamectin benzoate	33.87 ± 2.42 a	17.19 ± 0.75 a	28.10 ± 4.89 a	13.80 ± 1.89 a
F and *P* Values	F=8.65; P=0.005	F=7.05; P=0.010	F=0.59; P=0.635	F=0.63; P= 0.616

Mean value with the same letters means no significant difference (P> 0.05); Mean value with different letters means there is a significant difference (P < 0.05)

Whether the plant aqueous extracts have any effect on the natural enemies identified in this study is unclear, though. Additionally, the number of damaged cabbage heads decreased while the yield increased across the board for all treatments. Programs for integrated pest management can make use of these botanicals, particularly when it comes to controlling cabbage pests in the field.

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