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Laboratory evaluation of indigenous botanical aqua extracts against cabbage aphids, *Brevicoryne brassicae* L. (Hemiptera: Aphididae) on cabbage (*Brassicae oleracea*)

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Abstract
Cabbage is the second most important vegetable crop in Ethiopia in production next to red pepper (*Capsicum spp.*), however, its yield and yield components might be influenced by several factors, among these factors cabbage aphid was found very serious in most of the cabbage growing areas of Ethiopia. Thus, the current study was conducted to evaluate locally available botanicals for their efficacy against cabbage aphids, *Brevicoryne brassicae* (L.), under laboratory conditions. Each treatment was replicated three times and the entire set up was arranged in a complete randomized design (CRD) under laboratory conditions. Extracts of *Nicotiana tabacum, Allium sativum, Zingiber Officinale, Eucalyptus globules,* and *Schinus mole* gave positive performance under laboratory conditions.

Keywords: Cabbage, botanicals, chemical insecticides, cabbage aphid, yield

1. Introduction
Cabbage (*Brassicae oleracea* var. capitata Linnaeus), is an essential leafy plant grown as an annual mainly for use as a vegetable crop (Mpumi *et al.*, 2020a) [9]. It is a leafy vegetable of the Brassica family and is round, oblate, and pointed in shape Brassica family vegetables are very important and are intensively grown for resource-poor African smallholder farmers for subsistence and a source of income (Mpumi *et al.*, 2020b) [10]. It is also a water-loving plant which are grown in areas with enough supply of water. Cabbage has soft, light green, or whitish inner leaves covered with harder and dark green outer leaves. Cabbages are full of vitamins such as vitamin K and C and the dietary fibers and full of potassium and manganese (Drozdowska *et al.*, 2020) [4] and it has antioxidant and anti-inflammatory properties (Zimmer *et al.*, 2012) [16] in the body of human being. Also, it has detoxifying effect due to its high sculpture and vitamin C contents (Rietjens *et al.*, 2002) [13]. Cabbage is commonly used all over the world and can be prepared in a number of ways for eating and most frequently, it is included as either a cooked or raw part of many salads (Patra *et al.*, 2016) [12].
Currently, cabbage production is expanding in Oromia Regional State along with the improvement of awareness towards the use of irrigation as well as potential market value of this crop. Despite the enormous benefits of cabbage, its production is constrained with insect pests attack, leading to a significant reduction in its yield and quality, thereby affecting its market value and farmers' interest to cultivate them. Among these production constraint, insect pests and diseases are the most important factors that reduce the quality and marketable yield of cabbage (Hefner *et al.*, 2020) [8].
Some reports showed that Aphids contributed up to 70-80% of yield losses and estimated to cause about 35-75% yield and 6% oil content reductions. Currently, cabbage growers in Ambo and Guder districts discouraged to produce this crop due to the potential problem of cabbage aphids and lack of appropriate control mechanisms. Farmers use synthetic insecticides to reduce the insect infestation, thereby increase yield. However, the use of indiscriminate insecticides causes the development of pesticide resistance in the target pests, pest resurgence, emergence of secondary pests, affects non-target insects' species, affects the environment and human health. Therefore the objective of this research was to contribute in the improvement of yield and yield components of cabbage through the development of effective and safe management options against the Cabbage aphids.

2. Materials and Methods

2.1 Study Areas

The Laboratory experiments were conducted at Guder Mamo Mezemir Campus, Ambo University, Ethiopia from September 3 to 10/2021. Five botanicals in three different concentrations were evaluated under laboratory conditions. Fresh leaves of *E. globules* and *S. mole* were collected from the surrounding areas of Ambo town, cut into small pieces and ground, *N. tabacum*, *A. sativum*, *Z. offcinale*, and also, Soap detergent (*Citrus limon, Fragaria ananassa and Citrus aurantium*) were bought from local market.

All collected botanicals were simultaneously assessed and separated from those samples with any symptoms of infestations of diseases and insect pests and then washed and cut into small pieces. Botanicals preparation and extraction was prepared according to the method described by Stoll (2000) [15] using the following items: 250 g of fresh botanicals were chopped and strained in grinder, add 10ml soap of detergent as an emulsifier allow this mixture in 1 liter of distilled water to stand for 24 hours. All the botanicals were ground, mixed, strained and filtered through cheese cloth and have been considered as stock solution. The extract suspensions were sprayed on the cabbage aphid populations using hand sprayer at the defined rate. The stalk solutions mixed up with water at 50, 75 and 100 ml/L of water (% concentration level (v/v) in 100 ml of water).

2.2 Experiments under laboratory conditions

The laboratory study was conducted at Ambo University College of agriculture and veterinary science Mamo Mezemir Guder campus, in Entomology laboratory. The experiments were carried out using complete randomized design with three replications. The study was conducted for 7 days at room temperature and RH of 24ºC ± 2 and 70% to determine the rates of the treatments. The nymphs and adults of cabbage aphids were used for the study that was collected from the host crops from the cabbage fields. These nymph and adult were collected because they are aggressive and can cause huge damage to the crops than early instars. 20 nymph and adults were inserted in a Petri-dish and provided with fresh leaves of cabbage that was collected from the field to serve as food source. The treatments used were botanical crude extracts, Soap detergent and insecticides. Twenty-four-hour latter larval mortality was observed to check the normality of the insect, if any color change and inactive ones discarded before inserted in Petridish for test. All treatment were prepared in different concentrations as follows: '*N. tabacum* (100, 150 & 200ml), *E. globules* (100,150 & 200ml), *Zingiber offcinale* (5, 10 & 15ml), *S. mole* (150, 200 & 250ml),and *A. sativum* (50,75 &100ml) from stock solutions and Soap detergent (*Citrus limon* (100,150 & 200ml), *F. ananassa* (100,150 & 200ml),*Citrus aurantium* (100, 150 & 200ml)] that bought from market were considered for the tests. Botanical plant crude extracts, soap detergent and the chemicals were sprayed on cabbage aphids in the Petri dish using micro pipette. For the control treatment, Adult and nymph was treated with distilled water. After 1st, 3rd and 5th days of exposure, the mortality rates at different concentrations were obtained. A dead aphid was removed as soon as possible in order to prevent decomposition which may cause rapid death of the remaining aphids.

2.3 Data analysis

The Analysis of variance was done using SAS computer software (SAS, 2013) [14]. Mean comparisons for treatment parameters were done using the least significant difference (LSD) at 1% & 5% level of significance. The mean percent mortality was corrected using Abbott's formula (Abbott, 1925) [1] and efficacy analysis was done based on data transformation.

$$CM\,(\%) = \frac{[T(\%) - C(\%)]}{[100 - C(\%)]} X 100$$

Where:
CM (%) - Corrected mortality
T- Mortality in treated insect
C- Mortality in untreated insects.

Pre-spray and post-spray of the aphid numbers were considered at each spray application and Percent mortality in aphid population was calculated.

3. Results and Discussions

There were significant (P<0.01) differences between botanicals in causing mortality to nymphs and adult (Table2). Extracts of *Nicotiana tabacum* at the rate of 100ml was caused the highest percentage mortality, 73.4 to the nymphs and adult (F = 22.86; df = 24; p<0.01) 1st day after treatment application and 81.45%, to the nymphs and adult mortality (F = 13.29; df = 28; p<0.01) 3 days after treatment application. *N. tabacum* and *A. sativum*, however, caused over 65% aphid nymphs and adult mortality 3 days after treatment application. *A.sativum* and *Z. offcinale* resulted in a higher percentage nymph and adult mortality (>79.55%) 5th days after treatment application; however, *E. globules*, and *S. mole*, caused the medium mortality percentage. (Table 1).

After three days of application the higher mean mortality was also recorded by *Citrus limon* 100ml, 75.24%. The highest mortality was observed in *N.tabacum* (81.45%) and *S. mole* (150ml) showed lowest mortality (61.22%) but higher than control treatment (untreated).

After five days of application, there were significant (P<0.01) differences (F = 8.14; df = 24; p<0.01), *N. tabacum* 100ml, *A. sativum* 50ml and *Z. offcinale* 5ml caused mortality 90, 85.7, 85.7% respectively and *S. mole*- gave the lowest mortality mean (73.8) and the control treatment had the least percent mortality mean (25.3%) among treatments.

Table 2: Mean percent mortality of aphid nymphs or adult at 1st, 3rd, and 5th days after application of treatments in a laboratory during 2021.

Treatments	Con. ml/L of H_2O	Percent mortality/20 nymph or adult		
		1st day	3rd day	5th day
Nicotiana tabacum	100	67.4(55.18±0.96) cde	74.8(59.87 ± 1.04)bcd	90(71.57 ±1.25)a
	150	70.7 (57.23 ± 0.99) cd	71.57(57.78 ± 1.0)bcde	90(71.57 ±1.25)a
	200	73.4 (58.95 ± 1.03)efg	81.45(64.49 ± 1.13)ab	90(71.57 ±1.25)a
Allium sativum	50	61.14(51.44± 0.9)efg	69.55(56.5 ± 0.98)bcdefg	81.4 (64.45 ±1.12)ab
	75	62.5(52.24±0.91)defg	65(53.73 ±0.94)cdefgh	83.86 (66.31±1.16)ab
	100	65(53.73±0.94) cdef	65..95(56.76 ±0.99)cdefgh	85.7(67.78 ±1.18)ab
Eucalyptus globules	150	56.8(48.9± 0.85)fg	63.93(53.09 ±0.93)cdefgh	82.4 (65.2 ±1.14)ab
	150	58.93(50.14± 0.88)efg	62.452.18 ± 0.91)cdefgh	79.55(63.11±1.1)ab
	200	57.86(49.52± 0.86)fg	65(53.73 ± 0.94)cdefgh	83.86 (66.31±1.16)ab
Schinus mole	150	58.93(50.14± 0.88)efg	57.98(57.98 ±49.59)efgh	73.8 (59.21 ± 1.03)b
	200	58.93(50.14± 0.88)efg	63.55(52.86 ±0.92)cdefgh	82.4 (65.2 ±1.14)ab
	250	56.84(48.93± 0.85)fg	61.22(51.48 ±0.9)defgh	90(71.57 ±1.25)a
Zingiber offcinale	5	54.78(47.74± 0.83)g	56.84(48.93 ± 0.85) gh	85.7(67.78 ±1.18)ab
	10	62.29(52.11±0.9)defg	70.11(56.86±0.99)bcdefg	79.55(63.11±1.1)ab
	15	63.4(52.77±0.92)defg	70.7(57.23 ± 0.99)bcdef	85.7(67.78 ±1.18)ab
Citrus limon (Soap detergent)	100	62.29(52.11±0.9)defg	75.24(60.16 ±1.05)bc	85.7(67.78 ±1.18)ab
	150	61.22(51.48±0.9)defg	73.4(58.95 ± 1.03)bcd	90(71.57 ±1.25)a
	200	63.55(52.86+0.92)defg	65.95(54.30 ±0.95)cdefgh	90(71.57 ±1.25)a
Fragaria ananassa	100	58.93(50.14± 0.88)efg	58.74(50.03 ±0.87)efgh	81.4 (64.45 ±1.12)ab
	150	56.8(48.9± 0.85)fg	57.9(49.55 ±0.86)fgh	82.4 (65.2 ±1.14)ab
	200	60(50.77± 0.88)efg	57.86(48.98 ± 0.85)fgh	85.7(67.78 ±1.18)ab
Citrus aurantium	100	56.8(48.9± 0.85)fg	62.48(52.23 ±0.92)cdefgh	79.55(63.11±1.1)ab
	150	57.86(49.52± 0.86)fg	61.46(51.62 ±0.9)defgh	83.86 (66.31±1.16)ab
	200	58.93(50.14± 0.88)efg	55.77(48.31 ±0.84)h	85.7(67.78 ±1.18)ab
Control		19(26.48±0.46)h	18.43(25.4 ± 0.44)i	25.3 (30.2±0.53)c
SE ±		4.37	6.25	7.11
LSD at 0.01		9.5	13.62	15.48
CV (%)		6.95	9.3	8.55

Note: Means with the same letter(s) in the same columns are not significantly different for each other. The effectiveness all treatments were highly significant at $p<0.01$ (LSD). Figures in parentheses are Arc sin percent transformed value.

Botanicals have gained popularity for use in insect pest control of vegetables due to their mild effect on natural enemies. A study by (Fening *et al.*, 2011) [6] demonstrated the potential of low rates of garlic and hot pepper in the management of insect pests of cabbage with minimal effect of their natural enemies.

All the botanicals tested in this study were toxic to aphid nymph and adult, and some of them demonstrated high toxicity to the nymph and adult in the laboratory studies. It has been noted that both in the laboratory experiment percent nymph and adult mortality increased with time after botanical insecticides application. Botanical insecticides are considered as plant protection methods, which are naturally safe and harmless to the health of users and consumers. Moreover, botanical insecticides are less expensive and easily prepared. During the present treatments like *Nicotiana tabacum*, *Allium sativum* and Citrus limon, with higher concentration were provided greatest efficiency against cabbage aphids. As a result, aphicidal activity of botanicals increased with increasing their concentration and exposure period. The reason might be bioactive compounds found in plant materials.

From botanical plants; *Nicotiana tabacum* was highly effective than *Allium sativum*, *Zingiber offcinale*, *E. globules*, *Schinus mole*, and the control groups followed by Synthetic insecticides. *N. tabacum* at the rate of 100g/L was caused promising percent mortality (100%) of Aphid at 5th days of post sprays. In studies made by Begna (2015) [3], cabbage treated with botanicals: such as, *Allium sativum*, *Z. offcinale* and *E. globules* were recorded medium infestation level followed by Standard check pesticides.

Eucalyptus globules at rate of 100g/L stock solution gave 82.4 percent mortality of Aphid. Goodger *et al.*(2021) [7] who reported in their studies proved that as *Eucalyptus* contains many terpenoids like α and β pinene, 1, 8-cineole (CIN), terpineol, and globulol which are found to have antifungal, antimicrobial, and insecticidal activities against many pests (Ebadollahi *et al.*, 2017) [5]. (Muturi *et al.*, 2017) [11] also reported that essential oil from *Eucalyptus globules* is toxic to *A. aegypti* larvae. The present findings are in agreement with the findings of Atanasova and Leather (2018) [2] who reported that the essential oils extracted from Eucalyptus were shown to have moderate insecticidal activity against nymphs of the aphid causing mortality of 85.5%, at 1% (w v-1) 5th days after treatment application.

4. Conclusions and recommendations

From the present study, it was concluded that application of the botanicals were effective and significantly increased aphid nymphs and adult mortality in laboratory study. On the average 73.80 to 90% mortality of aphids was observed within 5 days of treatment exposure. Finally, the use of the soap detergent (*Citrus limon*) and (botanical) *Nicotiana tabacum*, *A. sativum* extracts can be a sustainable way of managing cabbage aphid. Therefore, based on this laboratory study the result is recommended for further study against Cabbage aphids in green house and open field conditions.

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