International Journal of Agriculture and Environmental Research

ISSN: 2455-6939

Volume: 08, Issue: 02 "March-April 2022"

COMPARATIVE STUDY OF BOTANICALS AND SYNTHETIC INSECTICIDE ON THE CONTROL OF INSECT PESTS AND DISEASES OF COWPEA

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DOI: https://doi.org/10.51193/IJAER.2022.8212

Received: 21 Apr. 2022 / Accepted: 02 May. 2022 / Published: 07 May. 2022

ABSTRACT

The quest to minimize synthetic insecticide use due to their adverse environmental effects and the need to improve yield has led to eco-friendly botanical pesticides use. This study was carried out to demonstrate the efficacy of garlic and lemon liquid botanical extracts in mitigating cowpea insect pests, diseases and increasing yield at Faculty of Agriculture and Veterinary Medicine, University of Buea, Cameroon. The design was a randomized complete block with four treatments, replicated four times. The treatments comprised synthetic insecticide, garlic liquid extract, lemon liquid extract, and control. Data collected were subjected to ANOVA(P<0.05). Cowpea vegetative parameters differed significantly (P<0.05), with garlic liquid extract dominating synthetic insecticide in the number of leaves having 32 highest leaves, but there was no significance between botanical pesticides and synthetic insecticide. Botanical pesticides effectively mitigated pest, significantly different from the control (P<0.05) but similar to the synthetic insecticide. Garlic liquid extract had 11 thrips per 10 flowers, three less than synthetic insecticide, and one pod borer/10 flowers less than synthetic insecticide. *Fusarium oxysporium*, *Curvularia lunata* and *Botryodiplodia theobromae* (BT) were identified to infect cowpea. Least disease incidence was 11.6 % from plants treated with garlic liquid extract. Cowpea treated with garlic liquid extract was least infected with the pathogens (23). The highest weight of pods yield was recorded in garlic liquid extract 10 kg/treatment with the lowest in control 5 kg/treatment and differed significantly (P<0.05) across treatments. Thus garlic and lemon liquid extracts improved cowpea yield while minimizing environmental hazards.

Keywords: Thrips, pod borer, aphid, yield, vegetative parameters, botanical pesticide

1. INTRODUCTION

The cowpea (*Vigna unguiculata*) is a dicotyledonous plant of the family Fabaceae. It is widely farmed in Africa's lowlands and mid-latitude regions, especially in the dry savanna, sometimes as a solitary crop but more commonly intercropped with cereals like maize, sorghum, or millet [1]. Africa produces 7.1 million metric tons of the world's 7.4 million metric tons of dried cowpea [2, 3]. Nigeria, Africa's highest producer and consumer, is responsible for 48 % of African production and 46 % of global production. Cameroon is Africa's fifth-largest producer, with 190,000 million metric tons produced annually [2, 4].All portions of the crop are used to provide protein, carbohydrates, fiber, lipids, and vitamins for people, as well as feed/fodder for animals [5, 6]. Despite its importance in food security and malnutrition, the crop's yield is rather modest [7, 8]. Insect pests and diseases account for more than 80% of the low productivity [9]. To address this issue, local farmers have turned to synthetic pesticides, which they frequently misuse owing to a lack of expertise or a desire to eliminate the problem at any costs [10, 11, 12, 13]. This, combined with the high cost of chemicals and short shelf life, has resulted in a slew of harmful environmental and human health repercussions [14, 15]. As a result, more cost-effective and healthy control measures for increasing cowpea output are needed. Plant extracts or botanicals have been proposed as alternatives to chemical insecticides in this quest [16, 17]. Garlic and lemon have been shown to be effective in the control of insect pests and diseases in the literature [18, 19, 20]. Due to no research being done on the use of garlic and lemon extracts on cowpea, it is vital to use these plant extracts in controlling cowpea insect pests, diseases and increasing productivity. This research aims to use the pesticide properties of garlic and lemon to manage cowpea insect pests and diseases as a sustainable alternative to synthetic insecticides.

2. MATERIALS AND METHODS

2.1. Experimental site

The research was carried out at the University of Buea's Faculty of Agriculture and Veterinary Medicine's Teaching and Research Farm. The site is at the foot of Mount Cameroon in the Southwest Region, between latitudes 3 27' and 4 27' N and longitudes 8 58' and 925' E, and is around 500 to 1000 m above sea level. Buea has a mono-modal rainfall pattern, with 86 % relative humidity and 900-12000 hours of sunlight each year. With a mean annual rainfall of

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2800mm, the dry season runs from October to March while the wet season runs from March to September. The average monthly air temperature is between 19°C and 30°C, and the temperature of the soil at 10cm depth drops from 25°C to 15°C. Weathered volcanic rocks dominate the soil, which is characterized by silt and clay [21, 22, 23, 24].

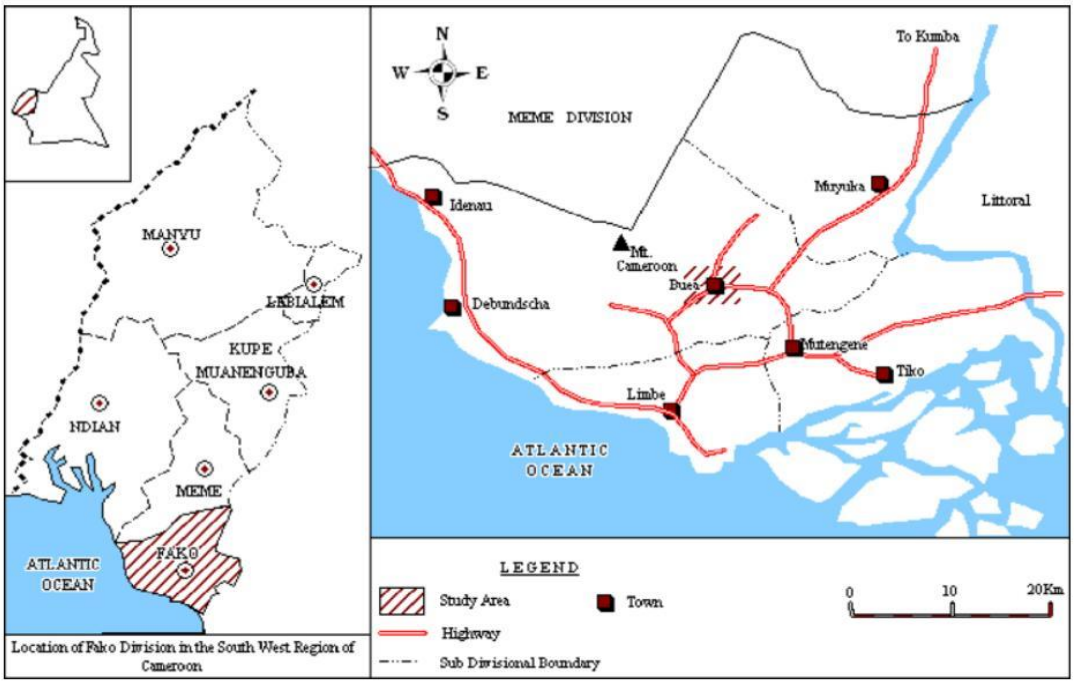

Figure 1: Location of Buea in Fako Division, Southwest Region, Cameroon.

2.2. Preparation of botanical extracts and pest management.

Insecticidal properties of garlic and lemon extracts are utilized to combat insect pests on cowpea. The botanicals of garlic (*Allium sativum*) and lemon (*Citrus lemon*) were extracted from the plants as follows: 250 g of garlic was weighed on an electronic balance and processed into a fine paste in a kitchen blender. After cooling for 24 hours, the paste was put into 1 l of boiling water, agitated thoroughly for five minutes, and filtered through a 250 µ screen. To maximize surface area for extraction. 250g of fresh lemon peels were weighed and macerated with a mortar and pestle. After transferring the macerated peelings to a glass jar, 1 l of boiling water was added to the jar, which was then filtered after 24 hours of chilling. Before applying to the plants, 25 g of detergent (SANET soap) was dissolved in 5 l of water and placed into plant extracts to create a 4.17 % emulsion of plant extracts. With a knapsack sprayer, these botanicals were applied once per week.

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2.3. Experimental design.

The experimental field was measured using meter tape at 346.75 m^2. The area was manually cleared and treated with GLYCOT (Glyphosate 42 % SL), a systemic herbicide. A randomized complete block design was used in the study, with four treatments reproduced four times. Sixteen experimental plots, each measuring 3 m x 3 m, were marked and hoed to a height of 25 cm. Plots within a replication were separated by 0.75 m, and one replicate was separated from the other by 1 m. Planting locations were marked with pegs at a planting distance of 60 cm x 50 cm, resulting in 5inter and 6intra rows with 30 stands per plot.

Table 1: Treatments

Codes	Treatment
T1	Synthetic insecticide (LAMIDAGOLD with active ingredients, lambda-cyhalothrin, and imidacloprid
T2	Garlic liquid extract
T3	Lemon liquid extract
T4	Control

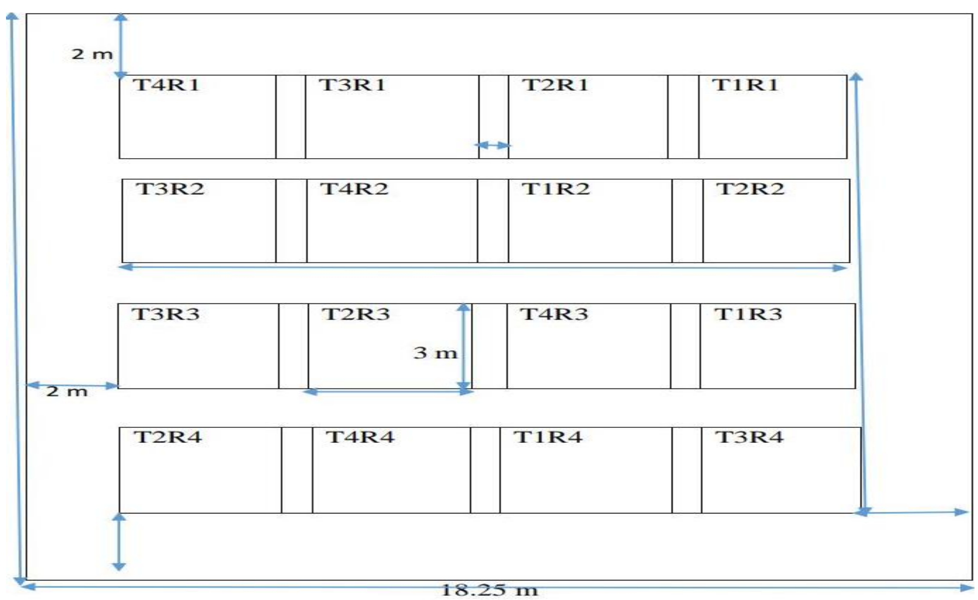

Figure 2: Randomize complete block design with four treatments and four replicates

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2.3.1. Seeding

On the raised beds, seeding was done at 60 cm x 50 cm spacing according to the stands indicated with pegs in the design above. With direct seeding of three seeds each stand into the soil at a depth of 3 cm, this pattern yielded a total of 30 stands per plot. Two weeks following germination, the seedlings were thinned by removing one plant per stand, leaving two.

2.3.2. Maintenance cowpea

Weeding was done by hand using a hoe and a cutlass to eliminate grass that competed with the crop for space and nutrients, as well as being a breeding ground for pests and diseases. Thinning was done to reduce plant competition by lowering the number of plants per stand to two. After each weeding operation, earthing up plants was done by covering the rhizosphere of plants with soil to avoid exposing plant roots, which could have negative impacts on crops. Insect pests and disease on cowpea were controlled with synthetic insecticide and botanical liquid extracts. Once a week, a knapsack sprayer was used to apply insecticide at a concentration of 25 ml/15 l of water. Before applying to the plants, 25 g of detergent (SANET soap) was dissolved in 5 l of water and placed into plant extracts to create a 4.17 % emulsion of plant extracts. A knapsack sprayer was used to apply these botanicals once a week.

2.4. Data collection.

2.4.1. Vegetative and insect pests' data collection

Plant height, stem girth, and the number of leaves were among the vegetative data metrics obtained. The number and types of insects per plant, the number of leaves attacked and the severity of the attack, the number of thrips per 10 flowers, the number of borers per 10 flowers, and the percentage of pods damaged were the criteria for insect pests. The fresh weight of pods per plot was the yield data metric gathered.

2.4.2. Disease data collection

Field inspection and collection of samples for identification

Plots were inspected weekly for fungal disease symptoms two weeks after planting until flowering. In each plot, root, stem and leaf samples showing typical disease symptoms were collected, put on labeled polythene zip-lock bags (symptom type, treatment and plot number) and transported to the Faculty of Science laboratory of the University of Buea following quarantine regulations. At the laboratory, samples were kept in a cold room until when needed for isolation

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and identification of fungal pathogens infecting them, using diagnostic keys of Rayner [25], Kirk et al. [26].

Method

Detergents were used to wash glassware for this experiment and inoculation needles, cork borers and scalpels were dipped into 70 % ethanol and flamed to red hot using a Bunsen burner to effect sterilization. Glassware like beakers, pipettes, agar plates were sterilized by heating at 120 ℃ for an hour in a hot air oven and allowed to cool before plating. Laminar flow hood was powered on for 2 hours before plating samples on semi-solid Potato dextrose agar (PDA). PDA before use was suspended in a 1 l conical flask containing distilled water in a water bath and heated for 20 minutes at 50 ℃. This was later autoclaved at 121 ℃ for 20 minutes to effect sterilization before it was cooled and stored at 4 ℃ in a refrigerator until when needed

Fungal isolation and identification

Equipment used was sterilized and growth media prepared as described in bacterial isolation. Same plant portions were used for bacterial and fungal isolation. About 2 mm^2 of plant part was cut using a sterile scalpel from the leading edge of the symptomatic area, where it is known that fungal growth is most active. After washing with tap water, it was surface sterilized in 1 % sodium hypochloride solution for 5 minutes and rinsed in distilled water 4 times at 1 minute per wash in 9-diameter Petri dishes containing distilled water and thereafter, 4 pieces of plant material was plated separately on Potato dextrose agar. Fusarium isolates were identified by streaking sample portions on Peptone-pentachloronitrobenzene (PPA) a selective medium for isolation of Fusarium sp. and the others fungi, sub-cultured in potato dextrose agar (PDA). Single spores were plated and incubated on water agar for a day; in complete medium for 7 days and on carnation leaf agar for 2 weeks. Pure fungal cultures raised were identified based on colony morphology and microscopic examination of their spores [27].

All microscopic examination of fungal isolates was done by teasing a small portion of the material with a sterilized needle on a slide using lactophenol and covering with a cover slip before mounting on a microscope. Sub-culturing was done by cutting a 2 mm^2 portion of growing mycelium using a sterile needle and placing it centrally on a fresh plate containing PDA. All magnifications were done on X100 and or X400 depending on clarity of the micrographs. Colony morphology, growth rates and presence of pigments was identified on PDA alongside microconidia (shape, size, number of septa, shape of basal and apical cells, presence of chlamydiospores, conodiogenous cells (monophylides and polyphylides) and spore type. Description of microconidia was done aided by the use of the mycological dictionary of Kirk et al. [26], while Rayners morphological chart [25] and Hawsksworth et al. [28] terminologies were

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used in describing colony colours and nature of their edges, zonation and texture of aerial mycelium.

Disease Incidence (%) = $\frac{\text{Number of infected plants}}{\text{Total no of sampled plants}} x\ 100$Anjorin et al. [29].

Abundance = Number of each pathogen isolated per total samples collected per treatment

2.5. Data analysis

The data was entered into a Microsoft Excel worksheet 2016 and then uploaded to IBM SPSS Statistics (SPSS v26). To examine the influence of treatments (n4) as categorical predictors, variables were subjected to univariate analysis of variance (ANOVA, $P<0.05$). Duncan Multiple Range Test (DMRT) $P<0.05$ was used to differentiate significant data means.

3. RESULTS

3.1. Effect of treatments on growth parameters of cowpea.

At five weeks after seeding (WAS), Synthetic insecticide recorded the highest plant height (13.5cm), which was not significantly different from the organic treatments but different ($F_{3, 8}$ = 7.3, P= 0.003) from control, the lowest 10.4cm. At 7 WAS, Synthetic insecticide recorded the highest plant height (57.4 cm), which was not significantly different from the organic treatments but different ($F_{3, 8}$ = 5.3, P= 0.014) from control, the lowest 44.8 cm. At 5 WAS, Synthetic insecticiderecorded the highest stem girth (2.2 cm), which was not significantly different from the organic treatments but different ($F_{3, 8}$ = 8.3, P= 0.003) from control, the lowest 1.2 cm. For stem girth at 7 WAS, synthetic insecticide had the highest (3.0 cm), which was not significantly different from the organic treatments, but was significantly different ($F_{3, 8}$ = 4.3, P= 0.027) from control, the lowest 1.9 cm. For the number of leaves at 5 WAS, Garlic liquid extract had the highest (10), which significantly differed ($F_{3, 8}$ = 3.9, P= 0.038) from control, the lowest 8. At 7 WAS, garlic liquid extract recorded the highest number of leaves (32), which significantly differed ($F_{3, 8}$ = 5.3, P= 0.015) from control, the lowest 27 as shown in Table 2.

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Table 2: Effect of treatments on cowpea growth parameters

Treatment	Plant height (cm)		Stem girth (cm)		Number of leaves	
	5WAS	7WAS	5WAS	7WAS	5WAS	7WAS
Synthetic insecticide	13.5±0.8[a]	57.4±4.3[a]	2.2±0.4[a]	3.0±0.2[a]	9±0.7[ab]	31±2.3[a]
Garlic liquid extract	12.9±0.8[a]	56.7±4.9[a]	2.1±0.3[a]	2.8±0.1[a]	10±1.2[a]	32±2.4[a]
Lemon liquid extract	12.7±1.0[a]	54.1±6.1[a]	1.9±0.3[a]	2.7±0.8[a]	9±0.7[ab]	30±0.8[a]
Control	10.4±1.0[b]	44.8±4.5[b]	1.2±0.2[b]	1.9±0.2[b]	8±0.7[b]	27±0.4[b]

Values within the column with the same letters are not significantly different according to Duncan Multiple Range Test, $P<0.05$.

3.2. Effect of treatments on the damage of leaves and pest population of cowpea.

The number of leaves damaged on cowpea at 5 WAS ranged from 0 to 4 and differed significantly ($F_{3,\,8}$ = 16.4, P = 0.000) across treatments with the highest in control 4(Table 3). The number of leaves damaged on cowpea at 7 WAS ranged from 5 to 8 and differed significantly ($F_{3,\,8}$ = 17.5, P = 0.000) across treatments with the highest in control 8(Table 3). The number of aphids observed on cowpeaat 5 WAS differed significantly ($F_{3,\,8}$ = 59.4, P = 0.000) across treatments with the highest in control 69(Table 3). The number of aphids observed on cowpeaat 7 WAS differed significantly ($F_{3,\,8}$ = 108.5, P = 0.000) across treatments with the highest in control 12(Table 3).The number of thrips/10 flowers observed on cowpeaat 2 weeks after flowering (WAF)differed significantly ($F_{3,\,8}$ = 23.9, P = 0.000) across treatments with the highest in control 21(Table 4). The number of thrips/10 flowers observed on cowpeaat 4 WAF differed significantly ($F_{3,\,8}$ = 31.0, P = 0.000) across treatments with the highest in control 25(Table 4). The number of pod borers/10 flowers observed on cowpeaat 2 WAF differed significantly ($F_{3,\,8}$ = 27.9, P = 0.000) across treatments with the highest in control 9(Table 4). The number of pod borers/10 flowers observed on cowpeaat 4 WAF differed significantly ($F_{3,\,8}$ = 14.4, P = 0.000) across treatments with the highest in control 8 (Table 4).

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Table 3: Effect of treatments on the damage of leaves and number of aphids

Treatment	Number of leaves damaged		Number of aphids	
	5WAS	7WAS	5WAS	7WAS
Synthetic insecticide	2 ± 0.5^{b}	5 ± 0.6^{c}	18 ± 2.2^{c}	3 ± 0.6^{d}
Garlic liquid extract	2 ± 0.3^{b}	5 ± 0.7^{bc}	25 ± 3.5^{bc}	8 ± 0.5^{c}
Lemon liquid extract	2 ± 0.3^{b}	6 ± 1.0^{b}	33 ± 2.8^{b}	9 ± 0.8^{b}
Control	4 ± 0.1^{a}	8 ± 0.8^{a}	69 ± 10.6^{a}	12 ± 0.8^{a}

Values within the column with the same letters are not significantly different according to Duncan Multiple Range Test, $P<0.05$.

Table 4: Effect of treatments on the number of thrips and pod borers

Treatment	Number of thrips/10 flowers		Number of pod borers/10 flowers	
	2WAF	4WAF	2WAF	4WAF
Synthetic insecticide	9 ± 1.0^{c}	14 ± 3.3^{bc}	5 ± 0.6^{d}	4 ± 1.3^{b}
Garlic liquid extract	9 ± 1.3^{c}	11 ± 1.0^{c}	3 ± 1.0^{c}	3 ± 1.7^{b}
Lemon liquid extract	14 ± 1.3^{b}	17 ± 1.8^{b}	7 ± 1.3^{b}	7 ± 1.7^{a}
Control	21 ± 4.4^{a}	25 ± 1.8^{a}	9 ± 2.5^{a}	8 ± 1.0^{a}

Values within the column with the same letters are not significantly different according to Duncan Multiple Range Test, $P<0.05$.

3.3. Effect of treatments on cowpea yield

The weight of cowpea pods collected differed significantly ($F_{3,8}$ = 32.4, P = 0.000) across treatments with the highest in garlic liquid extract treatment10.5 kg per treatment and the lowest in control 5.4 kg per treatment (Fig. 3).

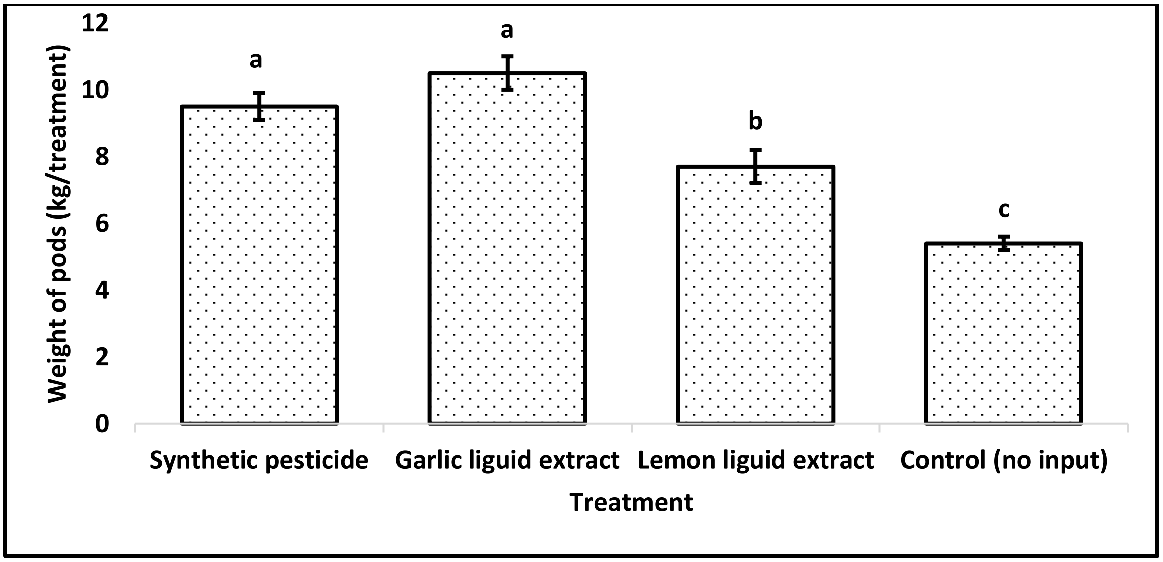

Figure 3: Effect of treatments on the yield of cucumber. Different letter columns are significantly different (p<0.05), Duncan Multiple Range Test.

3.4. Symptoms of fungal diseases on cowpea plants

Foliar symptoms observed on leaves were yellowish spots with central brownish points that enlarge to dark brown spots; browning of the leaflets spreading from the leaf tip with sharply defined boundaries between healthy and diseased tissues. The yellowish and brownish discoloration of leaf in the middle of crown spreads to neighbouring leaves. For the stem symptoms, the presence of rot on the base of the stem near the ground was apparent.

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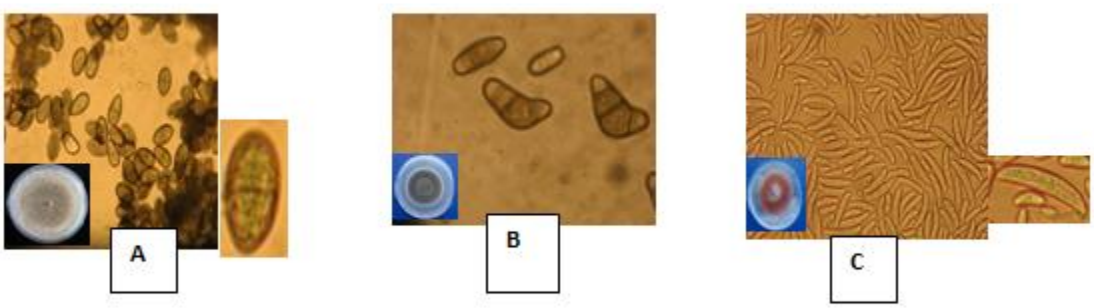
Plat 1: Mosaic disease symptoms on cowpea

Plat 2: Puckering and yellowing

Morphological features of fungal pathogens after culture and isolation

Isolates of BT showed greyish to black colour on PDA with abundant mycelia which were fast growing with zonations. The conidia had thick cell walls that were hyaline, unicellular and oblong in shape and when mature, they looked dark brown, pigmented and uniseptate. The colony of *Curvularialunata* (CL) on PDA was generally black with three distinct zones. The mycelia were abundant and septate and the conidia four celled with pale end walls). Banana shaped *Fusarium oxysporium* (FO) had the microconidia with mainly three septa and foot shaped at the basal end. The microconidia were uniformed and their microconidia were elongated and two celled.



3.5. Effect of treatments on disease incidence and fungi pathogen abundance in cowpea

Cowpea disease incidence differed significantly ($F_{3, 12}$ = 38.3, P = 0.000) across treatments with the lowest disease incidence in garlic liquid extract treatment 11.6 % and the highest in control 36 % (Fig. 4).

From table 5 below, *Fusarium oxysporium* (FO) pathogen differed significantly ($F_{3, 12}$ = 28.5, P = 0.000) across treatments with the highest in control 19 and lowest in garlic liquid extract 11. *Curvularia lunata* (CL) differed significantly ($F_{3, 12}$ = 76.3, P = 0.000) across treatments with the highest in control 15and lowest in garlic liquid extract 5. *Botryodiplodia theobromae* (BT) differed significantly ($F_{3, 12}$ = 76.4, P = 0.000) across treatments with the highest in control 25 and lowest in garlic liquid extract 8. Overall, more fungal pathogens were recorded in control 59, which differed significantly ($F_{3, 12}$ = 79.8, P = 0.000) across treatments (Table 5).

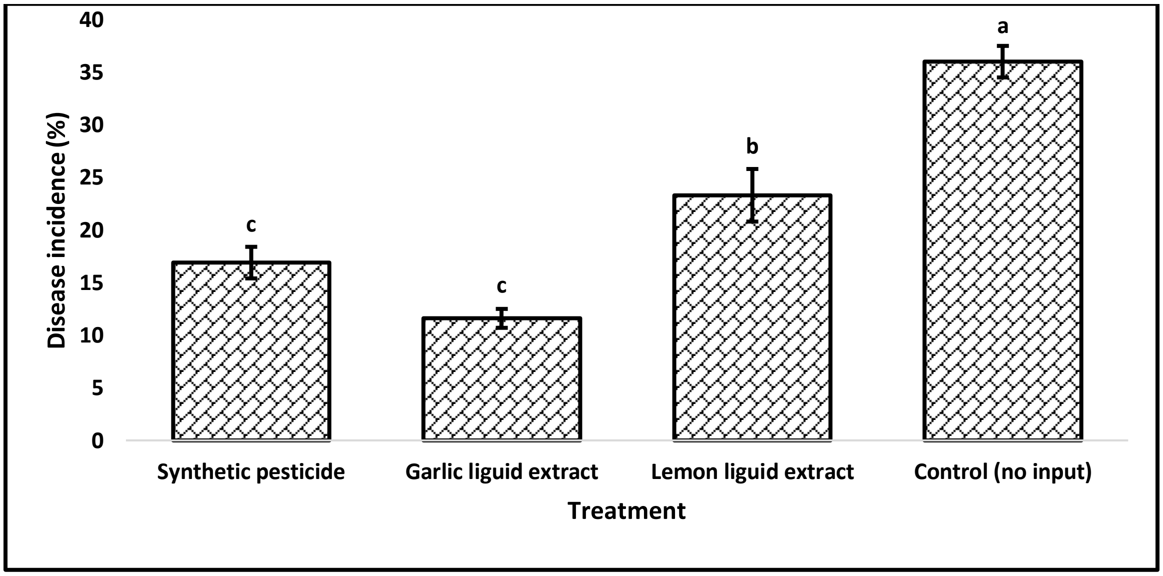


Figure 4: Effect of treatments on cowpea disease incidence. Different letter columns are significantly different (p<0.05), Duncan Multiple Range Test.

Table 5: Effect of treatments on the abudance of cowpea fungi pathogens

Treatment	*Fusarium oxysporium* (FO)	*Curvularia lunata*(CL)	*Botryodiplodia theobromae* (BT)	Total pathogens
Synthetic insecticide	13 ± 1.3^{c}	9 ± 1.3^{b}	11 ± 0.8^{c}	32 ± 2.2^{c}
Garlic liquid extract	11 ± 1.3^{bc}	5 ± 1.3^{c}	8 ± 0.8^{d}	23 ± 1.8^{d}
Lemon liquid extract	14 ± 1.3^{b}	11 ± 1.3^{b}	17 ± 2.4^{b}	41 ± 2.9^{b}
Control	19 ± 1.7^{a}	15 ± 1.8^{a}	25 ± 2.2^{a}	59 ± 5.6^{a}

Values within the column with the same letters are not significantly different according to Duncan Multiple Range Test, P< 0.05.

4. DISCUSSION

4.1. Effect of treatments on cowpea vegetative performance

The efficiency of garlic and lemon liquid extract in reducing cowpea insect pests is demonstrated by the high growth of vegetative parameters produced by the botanical garlic and lemon liquid extract treatments. This allows the photosynthesis produced assimilate to be used for the vigor and reproductive development of the cowpea [18, 30]. The lack of defense for the cowpea plants, which are easily devoured by aphids, thrips, and pod borers [31, 32], could explain the low growth of vegetative parameters in control treatments compared to synthetic insecticide and botanical garlic and lemon liquid extract treatments. The varied methods excluding control might lessen the influence of insect pests on cowpea, supporting healthy vegetative development, by managing cowpea insect pest infestation [19, 20]. Cowpea performance is correlated with the rate of insect pest infestation, indicating that an increase in insect pest population reduces vegetative growth in the control treatment [16, 33], whereas a decrease in insect pest infestation increases vegetative growth in the synthetic insecticide and botanical garlic and lemon liquid extract treatments [33, 34]. As a result, cowpea enhanced vegetative growth, which is consistent with the study's hypothesis.

4.2. Effect of treatments on cowpea pests

The fact that the management approaches controlled more bug infestations than the other treatments (synthetic insecticide, garlic liquid extract, and lemon liquid extract) implies that they were successful [35, 36]. Active components in garlic are allicin and other sulfur derivatives, secondary plant metabolites (polyphenols, flavonoids, considerable amounts of sulfur-containing derivatives), and secondary plant metabolites (polyphenols, flavonoids, significant amounts of sulfur-containing derivatives). Interestingly, biotic stress caused by herbivorous pests, diseases, and mammals promotes allicin production [36, 37]. Lemon contains active chemicals such as geranial, neral, myrcene, and many others. These components may have worked as neurotoxins, inhibiting acetylcholinesterase and octopamine, causing insect paralysis and death [38, 39, 40], resulting in reduced pest infestation in botanical liquid extract treatments. Botanical garlic and lemon-derived extracts have proved to offer a lot of pest-control potential [18, 41]. As can be observed from this study results, the botanical liquid extract had equivalent performance in suppressing cowpea insect pests and damage with synthetic insecticide but significantly different from the control, which is consistent with previous findings [42, 43, 44, 45]. Garlic and lemon liquid-derived extracts have shown high promise for insect pest management, with efficacy against insects reported [46, 47, 48]. The superior efficiency of synthetic insecticide in pod formation over garlic and lemon liquid extracts is attributed to their broad spectrum of action and the fact that they are systemic [16].

4.3. Effect of treatments on cowpea yield

The yield of cowpea was considerably higher in the botanical garlic and lemon liquid extract treatments than in the control, showing that the botanical garlic and lemon liquid extract treatments were effective in reducing insect pest problems and increasing productivity. Similar findings have been reported, in which botanical extract significantly increased agricultural output when compared to untreated crops [16, 33]. Low cowpea yield in control is due to insect pest infestation, and the resulting high leaf damage and insect numbers are expected to impair photosynthates production and, as a result, yield [17].This is in line with reports of severe insect pests entering cowpea and causing reduced yields, such as aphids, thrips, and pod borer [3, 8]. Cowpea yields are also harmed by whiteflies grasshoppers, which reduce yields [49, 50]. As a result of the qualities of garlic and lemon liquid extracts, they were able to increase cowpea output and even match the efficiency of synthetic insecticide [49, 50]. Indeed, garlic has a higher efficiency than lemon, which could be attributed to the latter's higher volatility, underscoring the role of adhesion in insecticide efficiency. These findings are comparable to Barry et al. [34]. Garlic and lemon have insecticidal properties due to terpenoids, flavonoids, steroids, saponins, and other chemical components [39, 51]. As a result, garlic and lemon were just as efficient as synthetic pesticides in combating the insect pests that cause cowpea output losses [50]. The outcome is in line with the study's hypothesis.

4.4. Effect of treatments on cowpea disease incidence and fungal pathogens

The identification of fungal pathogens (*Fusarium oxysporium*, *Curvularia lunata*, and *Botryodiplodia theobromae*) as causal agents of anthracnose, cercospora leaf spot, fusarium wilt, brown rust, and rot disease of cowpea in this study should be a cause for concern for cowpea production [52]. From this study, signs, and symptoms of the disease, including root rot, sclerotia formation on the plant, necrotic spots, yellowing, browning of leaves, vascular discoloration, and wilting of plants, were consistent with descriptions of disease on Bean (*Phaseolus vulgaris*) as described by Schwartz et al. [53]. Further laboratory analysis of the fungal isolates collected, including cultural characteristics observed on PDA such as mycelial structures, the embedded, irregular globose-shaped sclerotia, and hyphae pigmentation, confirmed the pathogen *Fusarium oxysporium*, *Curvularia lunata* and *Botryodiplodia theobromae*[26, 27, 28, 54]. Similar cases have been observed in India's two-year (2013 and 2014) disease survey [29, 55].The high rate of disease incidence in the control portrays lack of a disease check and balance strategy thus encouraging diseases to proliferate freely whereas the contrary was seen in the other treatments with the least incidence in the garlic liquid extract affirming its pesticidal properties[47, 48]. Infested leaves analysis reveals three fungal pathogens devouring the smooth growth of cowpea which translates to diseases thus reducing yield. It can be seen that garlic liquid extract

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minimizes the damage caused by these pathogens significantly[51]. This result is consistent with the hypothesis of this study.

5. CONCLUSION

Garlic and lemon liquid extracts has demonstrated efficacy in controlling cowpea insect pests, fungi pathogens, diseases and improve yield thus achieving the objective of this study. Also the pesticidal effects of garlic and lemon liquid extracts were comparable to synthetic insecticides, making them better sustainable eco-friendly alternatives to adopt. Thus farmers can use garlic and lemon liquid extracts to mitigate insect pest and disease challenges of cowpea, lowering their cost of production since they are cheaper alternatives and improve yield as seen in this study.

ACKNOWLEDGMENTS

We extend gratitude to the Ministry of Higher Education of Cameroon, and the Faculty of Agriculture and Veterinary Medicine (FAVM) of the University of Buea, Cameroon.

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