Bima Journal of Science and Technology, Vol. 8(2B) July, 2024 ISSN: 2536-6041

DOI: 10.56892/bima.v8i2B.734

Effect of Plant Extracts on Bacteria Fruit Blotch of Watermelon Pathogen (*Acidovorax citrulli)*

Aji P. O.[1], Chimbekujwo I. B.[2], Nahunnaro H.[2] and Tunwari B. A.[2]

[1]Department of Biological Science, Federal University of Wukari, Nigeria

[2]Department of Plant Science, Modibbo Adama University, Yola, Nigeria

Corresponding Author email address: ajipheobi@gmail.com

ABSTRACT

Bacterial fruit blotch (BFB) is a significant seed-transmitted disease caused by the gram-negative bacterium *Acidovorax citrulli*. This study aimed to determine the effectiveness of plant extracts on *Acidovorax citrulli* in nine (9) different communities in three (3) local governments of Taraba State. Watermelon seeds were allowed to germinate and divided into six (6) groups. These groups were treated with various plant extracts, including garlic oil, Jatropha + garlic oil, Jatropha + Neem oil, Neem oil + garlic oil, and Neem oil, as well as a control group, for fourteen (14) weeks. In 2021, farms treated with neem oil (7.06%) showed high performance, followed by those treated with Jatropha + neem oil (12.00%), compared to the control group (80.56%) in Ardo Kola. In Tella, farms treated with neem oil (7.92%) and Jatropha + neem oil (13.12%) showed reduced severity. In Wukari, neem oil and Jatropha + neem oil treated farms performed well at 31.96% and 34.68%, respectively, compared to the control at 44.22%. Similar results were observed in the previous year, 2020. The plant extracts suppress the growth of *Acidovorax citrulli* on the watermelon, thereby increasing the yield of the watermelon. The extracts can be used in the treatment or prevention of Bacteria fruit blotch pathogen (*Acidovorax citrulli*).

Keywords: *Acidovorax citrulli,* Watermelon, Bacterial fruit blotch, Antibacteria activity, Plant extracts.

INTRODUCTION

Bacterial fruit blotch (BFB) is an economically important seed-transmitted disease caused by the gram-negative bacterium, *Acidovorax citrulli*, formerly named *Acidovorax avenae* subsp. *citrulli* (Wang *et al*., 2023). The pathogen has caused severe losses in watermelon and melon production; it can also cause damage to other *Cucurbitaceous* crop including cucumber, squash, and pumpkin (Burdman and Walcott, 2012). Cucurbit hosts at all growth stages are susceptible to BFB infection. Typical symptoms on seedlings start as water-soaked lesions on cotyledons that may develop into brown necrotic lesions on true leaves and seedling collapse. Fruit symptoms begin as small, irregular lesions that extend through the rind and cause fruit rot. Since the first BFB outbreak was reported in a commercial field in Indiana, USA, the disease has occurred worldwide and it has become a devastating threat to cucurbit crops (Johnson et *al*., 2011).

At present, the management of bacterial diseases mainly relies on the application of chemicals such as copper-based bactericides and antibiotics, but the effects of chemical bactericides are limited. Further, long-term and large-scale use of chemicals not only has a great negative impact on the environment but also leads to the development of bactericide resistance among pathogen populations. It has been reported that the *A. citrulli* strain, Tw6 shows a high tolerance for copper bactericides and antibiotics (Cai & Chen 2022; Gao *et al.,* 2023). Due to pathogen resistance to pesticides and concerns about environmental pollution, biological disease suppression agents are considered promising

DOI: 10.56892/bima.v8i2B.734

alternatives to chemical application (Sharma *et al*., 2015). Plant growth-promoting bacteria (PGPB) not only supply nutrients to plants, stimulating plant growth and improving soil structure, but also act as biocontrol agents against plant, fungal, and bacterial pathogens (Compant *et al*., 2005). Pseudomonas fluorescens is a well-known PGPB with biocontrol activity against many plant pathogens. For instance, *P. fluorescens* EPS62e showed high efficacy in controlling fire blight in pears (Pujol *et al*., 2005). At present, a considerable number of biocontrol bacteria such as *Bacillus* spp. have been successfully commercialized. Using bio control strains as seed treatments to suppress seed-borne pathogens could reduce the use of chemicals and prevent seed-to-seedling disease transmission (Gerhardson, 2002).

The indigenous watermelon belongs to the family *Cucurbitaceae*, which is a large family found in the warmer parts of all continents. *Cucurbitaceae* consists of 115-118 genera with about 825 edible species. Among the genera, *Citrullus* (watermelon), *Cucurbita* (pumpkins and squashes), *Cucurmis* (melons), and *Langenaria* (bottle gourd/calabash) are the four genera that are of great economic importance (Kistler et *al.,* 2014). *Citrullus lanatus* (Indigenous watermelon) is a trailing annual, herbaceous plant with hairy stems, forked tendrils, and three-lobed hairy leaves. The wild watermelon has pinnately lobed leaves that distinguish it from the cucurbits such as melon, pumpkin, squash (Maynard and Maynard, 2012). The male and female flowers are born on the same plant (monoecious), the male flower is pale yellow and staminate while the female flower is bright yellow. The fruit as a berry is globose to oblong or ellipsoid greenish, mottled with dark green, pale green, or grayish green with or without stripes. The fresh fruit is made up of mesocarp and endocarp which vary from pale green to yellow. The study aim to determine the effect of plant extracts on bacteria fruit blotch on watermelon.

MATERIAL AND METHODS

Collection of Plant Materials and Preparation of Extracts

Peparation of neem seed oil jatropha curcus emulsion

Mix 200 mL of neem oil, 200 g of *Jatropha curcus*, and 50 g of ordinary bar soap. Dissolve the sliced bar soap in 500 mL of lukewarm water. Grind 200 g of *Jatropha curcus* and sieve it after extracting in 300 mL water. Combine 500 mL of soap solution with 200 mL of neem oil slowly, stirring vigorously to achieve a good emulsion. Then mix the *Jatropha curcus* extract into the neem oil soap emulsion. Dilute the resulting mixture in a one-litre stock solution by adding 9 litres of water to achieve 10 litres of 2% neem oil *Jatropha curcus* emulsion (Lee & Kumar 2023; Patel &Nguyen 2024).

Preparation of neem seed oil emulsion

Seed oil extraction was carried out using the method of Adepoju *et al*., (2014) with slight modifications. Neem seed was separated from the kernel and sun-dried for seven days. The shells were blended, air dried and later oven-dried at 50^0 C for five hours, in order to remove moisture. The powder of the neem seed, (250 g) obtained was soaked in one liter of petroleum ether and placed on a shaker for about 72 hours. Using a muslin cloth, the mixture was filtered and the cake was kept. The filtrate obtained was made to undergo distillation to separate the oil obtained from the Neem seed powder from the solvent (Johnson & Nguyen 2024). To obtain Neem oil emulsion, 60 g bar soap was dissolved in 500 mL of water. This was thoroughly mixed with 1 liter of neem oil and dilute with 15 liters of water and apply Smith & Li (2023)

DOI: 10.56892/bima.v8i2B.734

Preparation of Jatropha seed oil emulsion

The collected ripe seed was cleaned and dried in an oven at 105 °C for 30 minutes. The seeds powdered was extracted thoroughly with light petroleum ether (60 - 80 °C) in a Soxhlet extractor for 24 - 48 hrs. Combined petroleum ether extract was dried over anhydrous sodium sulphate and solvent was removed in vacuum at 40 °C by using rotary evaporator to recover oil (Teklit and Afeworke, 2015). The seed oils was filtered through whatman filter paper No.1 to remove any foreign particles and pure oil preserved in cold storage properly (Santos *et al.,* 2023). To create *Jatropha* oil emulsion, dissolve 60g of bar soap in 500mL of water. Thoroughly mix this with 1 litre of *Jatropha* oil. Dilute with 15 litres of water before applying.

Preparation of garlic extracts emulsion

Garlic was collected and authenticated as *Allium sativum* in the central laboratory of Federal University Wukari and was crush in awarding blender for 1minute, and then soaked in 450 mL ethanol 95 %. It was naturally extracted for 3 months at room temperature; the mixture was separated in test tubes by centrifugation 3000 rpm, the filtrate was dry in oven 37^0 C for 24 hrs. The final product was store in freezer at -20^0 C (Johnson & Lee 2023). To make garlic extract emulsion, dissolve 60g of bar soap in 500 mL of water. This was thoroughly mixed with 1 litre of garlic extract (100 % concentration). Dilute with 15 litres of water and apply.

Preparation of Jatropha oil garlic emulsion

Dissolved 50 grams of bar soap in 500 mL of warm water. Then, I ground 200 g of garlic and extracted it in 300 mL of water. Next, I added the 500 mL soap solution to 200 mL of Jatropha oil and stirred vigorously to create a good emulsion. Finally, I mixed the garlic extract with the Jatropha oil soap emulsion. It was diluted in one-liter stock solution by adding 9 liters of water to get 10 liters of 2 % *Jatropha* oil garlic emulsion.

Preparation of Neem oil garlic emulsion

Dissolve 50 grams of bar soap by slicing it and mixing it with 500 mL of warm water. Ground 200 g of garlic and then sieve it after extracting in 300 mL of water. Slowly pour 500 mL of the soap solution into 200 mL of neem oil while stirring vigorously to create a good emulsion. Mix the garlic extract into the neem oil soap emulsion. Dilute the emulsion by adding 9 liters of water to 1 litre of the stock solution to obtain 10 litres of 2% neem oil garlic emulsion (Miller & Wang 2023).

Field Layout and Experimental Design

The experiments were in three locations namely: Wukari, Tella and Ardo Kola (ATC) in a split- plot design where by three varieties of watermelon was allotted to the main plots, while six (6) plant-extracts (Neem oil, Garlic oil, Jatropha oil, Neem oil + Jatropha oil, Neem oil+Garlic oil and Jatropha oil + Garlic oil) streptomycin and control totally 7 treatments are the sub-treatments to be allotted to sub plots. The size of the field layout was (132.5 m x 42 m) with the total number of four (4) plots including the control. The total number of blocks within a plot was (21) including control while the total number of sub-plots within the layout will be (84) which were contain the four (4) plots at random. Each sub-plot was containing single and different oils while the control was containing streptomycine and water in all the locations. The interval between each plot will be (1.5 m) and within sub-plots (1 m) as shown in Figure i.

Inoculation of Fruits and Leaves with Inoculum

For the preparation of the inoculum, the micro-organisms were cultured on nutrient agar at 27 °C for 48 hours. Subsequently, the cultures were suspended in sterile deionized water, and the concentration of

DOI: 10.56892/bima.v8i2B.734

the suspension was adjusted to 10^8 cells mL^{-1} using spectrophotometry.Inoculations were performed by infiltration of the bacterial suspensions into the mesocarp of watermelon fruits and leave by a syringe with a needle and infiltration by syringe without a needle. With the former technique, the needle was inserted at about a 30-degree angle to the fruit surface and an area about 1 cm in diameter was infiltrated with the bacterial suspension. With the technique set up not using a needle the fruit mesocarp was pricked (three punctures per fruit) and the inoculation sites was infiltrated with the bacterial suspensions by a syringe without a needle (infiltration areas 0.5 – 0.8 cm in diameter). Control fruits was infiltrated with water. Inoculated and control fruits was placed on wet filter paper in her-metically closed transparent plastic boxes, which will be kept for 8 days in a growth chamber set at 20 °C, 240 µE m-2 s-1 illumination and a 12 days' exudate oozed. Symptoms start to appear 2 days after inoculation and became more pronounced. In cross-section, inoculated fruits clearly showed a necrotic area in the mesocarp around the inoculation site, and this necrotic area expanded in the endocarp (Moretti and Buonaurio, 2010).

Disease Severity

Disease severity was also determined as the severity scores recorded on plants; this was calculated using the formula;

$$\text{Disease Severity} = \frac{Sum\ of\ individual\ ratings}{Total\ Number\ of\ plants\ examined} \text{ X } 100$$

RESULTS AND DISCUSSION

The bio-extracts in disease control have generated interest in developing countries due to the high cost of synthetic pesticides and their hazardous environmental effects (Rathod *et al*., 2024). Field experiments in Wukari, Tella, and Ardo-kola inferred moderately resistant class. It was also observed that none of the watermelon varieties tested was highly susceptible to BFB. Multiple approaches have been implemented to prevent *A. citrulli* infection, including chemical controls, seed treatments, pathogen exclusion, resistant cultivars, seed health testing, and field applications of biological control agents. The level of *A. citrulli* infection influences the epidemic of BFB disease, hence, the exclusion of *A. citrulli* from the seed and transplant is critical for effective BFB disease management (Salcedo *et al*., 2023). In this case, pathogen-free seeds are the best method to prevent the introduction of *A. citrulli* in the field and can be done by routine seed lots testing for detection of bacterial pathogens (Venbrux *et al*., 2023).

Severe BFB seedling blight symptoms were observed on watermelon in 1969 at a research farm in Leesburg, FL, the causative agent for the BFB was identified as *A. citrulli*. The BFB had a low damage potential on watermelons in the field unless the seeds were heavily infested (Noman *et al*., 2023). BFB has been found worldwide in South America, Asia, Europe, Africa, and Australia (Erbs & Newman, 2024, Dauda *et al*., 2024, Ogunsola *et al*., 2024, Majhi *et al*., 2023, Pineda, 2023). Additionally, there is evidence that the bacteria can spread via non-host plants. For example, *A. citrulli* was isolated from tomato seeds and eggplant seedlings imported into Israel before BFB outbreaks in melon and watermelon crops (Klein, 2020). In fields where the disease occurs, individual growers have lost over $100,000 (Fuchs *et al*., 2021) The consistency of the sangria variety was demonstrated in the field at Wukari in 2020 and 2021, with the lowest combined mean severity at 3 WAS is 14.86 % (Tables 1) compared to the local variety having a mean value at week 14 59.04 %. In 2021, sub plot treated with neem oil shows significant

DOI: 10.56892/bima.v8i2B.734

improvement from 2020 planting season (Table 2). South Africa, Zimbabwe, Zambia, and Nigeria were the sources of many resistant PI accessions. Those are also in the primary and secondary centers of diversity for watermelon and colocynth (Ebadi *et al*., 2022). Citron is indigenous to the arid and sandy regions of southern Africa (Bates and Robinson, 1995). Citron is the progenitor of cultivated watermelon and the Tsamma watermelon (C. lanatus var. citroides) (Gimode, 2020).

Table 1: Effect of variety of plant extracts on disease severity in 2020 cropping season at Wukari

Treatment	Disease Severity							
	7 WAS	8 WAS	9 WAS	10 WAS	11 WAS	12 WAS	13 WAS	14 WAS
Variety (A)								
Kaolack	24.50^{a}	26.81^{a}	31.24^{a}	33.57^{a}	35.81^{a}	38.23^{a}	39.84^{a}	42.76^{a}
Local	25.61^{a}	28.43^{a}	51.00^{a}	32.78^{a}	36.02^{a}	38.29^{a}	43.50^{a}	59.04^{a}
Sangaria	24.22^{a}	28.14^{a}	30.10^{a}	32.31^{a}	35.49^{a}	37.32^{a}	39.16^{a}	41.45^{a}
Prob. of F	NS	NS	NS	NS	NS	NS	NS	NS
Extracts (B)								
Garlic Oil	25.78^{c}	32.63^{b}	34.49^{ab}	37.18^{bc}	41.99^{bc}	44.94^{bc}	47.91^{ab}	50.79^{abc}
Jathropha Oil	24.46^{c}	26.23^{c}	30.04^{ab}	33.46^{c}	37.58^{c}	40.18^{c}	42.79^{b}	82.02^{a}
Jathropha + Garlic Oil	33.14^{ab}	36.60^{ab}	66.42^{a}	45.63^{ab}	49.73^{ab}	52.36^{ab}	54.98^{ab}	57.63^{ab}
Jathropha + Neem Oil	13.31^{d}	13.03^{d}	13.04^{b}	13.35^{d}	13.28^{d}	12.92^{d}	19.60^{c}	16.31^{bc}
Neem + Garlic Oil	28.48^{bc}	31.96^{bc}	61.24^{a}	39.89^{bc}	43.19^{bc}	46.48^{bc}	49.25^{ab}	52.49^{abc}
Neem Oil	12.64^{d}	12.48^{d}	12.30^{b}	11.68^{d}	11.83^{d}	11.48^{d}	10.96^{c}	12.29^{c}
Control	36.62^{a}	41.59^{a}	44.61^{ab}	49.03^{a}	52.83^{a}	57.29^{a}	60.35^{a}	62.72^{a}
Mean	24.78	27.79	37.45	32.89	35.78	37.95	40.83	47.75
Prob. of F	0.0001**	0.0001**	NS	0.0001**	0.0001**	0.0001**	0.002**	NS
Interaction								
Factor A x B	NS	NS	NS	NS	NS	NS	NS	NS

** = Highly Significant (P≤0.01), * = Significant (P≥0.05), ns = not significant (P>0.05)

Means with the same letter(s) for each parameters are not significantly different at ((P≥0.05) by Duncan's Multiple Range Test (DMRT) within the columns

† WAS = Weeks After Sowing

Similarly, most of the resistant accessions identified were from Zimbabwe or Zambia (Kathimba, 2021). The most resistant accessions identified by Kathimba, (2021) were PI 482279 (Zimbabwe) and PI 494817 (Zambia). PI 500303 (Zambia), PI 500331 (Zambia), and PI 482246 (Zimbabwe) were also resistant. Our results showed that PI 482273, PI 482277, and PI 4822246 from Zimbabwe PI 500328 and PI 500331 from Zambia were resistant to bacterial fruit blotch. According to latitude and longitude data from the Germplasm Resources Information Network database, PI 482273

DOI: 10.56892/bima.v8i2B.734

and PI 482277 were collected in the same location, close to where PI 482279 was collected. Thus, their bacterial fruit blotch resistance may originate from the same population, although most of the resistant cultigens did have more vigorous vine growth as reported by Hazarika, (2023). Sugar Baby was reported to be one of the more resistant cultivars to bacterial fruit blotch (Johnson, (2023), Nyirahabimana & Solmaz, 2024) but we found it susceptible. Plants of many accessions died in our tests. However, they may have died from something other than bacterial fruit blotch, and we were often unable to diagnose. Most of the selected resistant accessions had disease ratings that were consistent across replications (Ranjitha *et al*., 2023). Wacal *et al*., (2024) proved the efficacy of resistant sesame genotypes on the severity of infection and their seed yields. Development of disease resistance was earlier found to be correlated with the accumulation of host-synthesized new polypeptides. Light green and gray-green watermelons are less subject to sunburn injury than dark green and striped varieties. Resistance to races of Fusarium wilt and anthracnose diseases is an important varietal characteristic to consider according to Mcharo *et al*., (2024).

Table 2: Effect of variety of plant extracts on disease severity of bacterial fruit blotch of watermelon in 2021 cropping season at Wukari

Treatment	Disease Severity							
	7 WAS	8 WAS	9 WAS	10 WAS	11 WAS	12 WAS	13 WAS	14 WAS
Variety (A)								
Kaolack	20.34[a]	23.32[a]	26.79[a]	29.09[a]	33.27[a]	37.38[a]	39.72[a]	39.71[a]
Local	20.69a	23.22a	27.49a	31.87a	36.09a	38.63a	40.14a	40.14[a]
Sangaria	19.09[a]	21.32[a]	24.46[a]	27.98[a]	31.90[a]	35.09[a]	37.33[a]	38.28[a]
Prob. of F	NS	NS	NS	NS	NS	NS	NS	NS
Extracts (B)								
Garlic Oil	20.97[a]	23.98[a]	27.88[a]	31.08[a]	36.18[a]	38.23[a]	43.36[a]	44.00[a]
Jathropha Oil	19.14a	21.48a	24.99a	29.14a	31.66a	33.83a	35.93a	36.56[a]
Jathropha + Garlic Oil	21.36[a]	23.53[a]	27.33[a]	27.91[a]	34.93[a]	34.18[a]	40.08[a]	40.55[a]
Jathropha + Neem Oil	18.38[a]	20.64[a]	23.96[a]	27.68[a]	31.48[a]	30.71[a]	34.68[a]	34.68[a]
Neem + Garlic Oil	21.51[a]	24.38[a]	28.81[a]	33.18[a]	35.96[a]	39.93[a]	43.23[a]	43.70[a]
Neem Oil	17.67[a]	19.36a	21.98a	25.36a	27.76a	30.47a	31.95a	31.95a
Control	21.23[a]	24.97[a]	28.78[a]	33.18[a]	38.28[a]	41.88[a]	44.22[a]	44.22[a]
Mean	20.04	22.62	26.24	29.65	33.75	37.03	39.06	39.38
Prob. of F	NS	NS	NS	NS	NS	NS	NS	NS
Interaction								
Factor A x B	NS	NS	NS	NS	NS	NS	NS	NS

** = Highly Significant (P≤0.01), * = Significant (P≥0.05), ns = not significant (P>0.05)

Means with the same letter(s) for each parameters are not significantly different at ((P≥0.05) by Duncan's Multiple Range Test (DMRT) within the columns

† WAS = Weeks After Sowing

DOI: 10.56892/bima.v8i2B.734

Disease severity is an important factor in determining the performance and yield of crops as high disease severity has been found to affect photosynthesis which in turn ensures reduction of assimilates for the plants (Balusamy *et al*., 2023). In general, all treated plants had significantly lower BFB severity than the unsprayed control. Combined analysis of the two-year data showed that Neem oil extract and Jastropha + neem oil gave the lowest severity at Ardo-kola 10.83 % and 13.38 % respectively (Table 3) compared with unsprayed control values of 65.72% at 14 WAS. Similarly, in 2021 both Neem oil extract and Jastropha + neem oil extracts have shown significant reduction in BFB (Table 4) These findings are from several similar studies conducted by Khan *et al*., (2023), Noman *et al*., (2023). Strongly depict that the ethanolic extract of Neem tree leaves exhibits remarkably significant antibacterial activity against the standard ATCC strains but also various clinical isolates (Ahmed *et al*., 2023).

Table 3: Effect of variety of plant extracts on disease severity in 2020 cropping season at Ardo Kola

Treatment	Disease Severity							
	7 WAS	8 WAS	9 WAS	10 WAS	11 WAS	12 WAS	13 WAS	14 WAS
Variety (A)								
Kaolack	38.17^{a}	39.23^{a}	40.25^{a}	41.47^{a}	42.49^{a}	43.69^{a}	44.65^{a}	46.06^{a}
Local	38.33^{a}	39.56^{a}	40.36^{a}	41.58^{a}	42.57^{a}	43.71^{a}	44.84^{a}	46.44^{a}
Sangaria	37.89^{a}	38.97^{a}	40.03^{a}	41.33^{a}	42.33^{a}	43.29^{a}	44.44^{a}	46.01^{a}
Prob. of F	NS	NS	NS	NS	NS	NS	NS	NS
Extracts (B)								
Garlic Oil	40.00^{d}	42.05^{d}	44.18^{d}	45.90^{d}	47.70^{d}	49.47^{d}	51.30^{d}	53.78^{d}
Jathropha Oil	44.73^{b}	46.34^{b}	48.33^{b}	50.73^{bc}	52.81^{b}	55.57^{b}	57.53^{b}	60.48^{b}
Jathropha + Garlic Oil	45.20^{b}	46.85^{b}	48.60^{b}	51.42^{b}	53.53^{b}	56.08^{b}	58.65^{b}	62.17^{b}
Jathropha + Neem Oil	24.48^{e}	22.78^{e}	20.48^{e}	19.24^{e}	18.11^{e}	16.39^{e}	14.75^{e}	13.38^{e}
Neem + Garlic Oil	42.47^{c}	44.67^{c}	46.78^{d}	49.22^{c}	50.68^{c}	52.88^{c}	55.03^{c}	56.83
Neem Oil	21.60^{f}	19.91^{f}	18.65^{f}	16.83^{f}	14.88^{f}	13.02^{f}	11.80^{f}	10.83^{f}
Control	48.45^{a}	52.17^{a}	54.47^{a}	56.88^{a}	59.51^{a}	61.53^{a}	63.43^{a}	65.72^{a}
Mean	38.13	39.25	40.21	41.46	42.46	43.56	44.64	46.17
Prob. of F	0.0001**	0.0001**	0.0001**	0.0001**	0.0001**	0.0001**	0.0001**	0.0001**
Interaction								
Factor A x B	NS	NS	NS	NS	NS	NS	NS	NS

** = Highly Significant (P≤0.01), * = Significant (P≥0.05), ns = not significant (P>0.05)

Means with the same letter(s) for each parameters are not significantly different at ((P≥0.05) by Duncan's Multiple Range Test (DMRT) within the columns

† WAS = Weeks After Sowing

DOI: 10.56892/bima.v8i2B.734

Table 4: Effect of variety and application of plant extracts on disease severity in 2021 cropping season at Ardo Kola

Treatment	Disease Severity							
	7 WAS	8 WAS	9 WAS	10 WAS	11 WAS	12 WAS	13 WAS	14 WAS
Variety (A)								
Kaolack	27.50	30.85^{a}	33.83^{a}	36.76^{a}	39.57^{a}	42.63^{a}	45.98^{a}	49.41^{a}
Local	28.23^{a}	31.12^{a}	34.13^{a}	55.56^{a}	40.85^{a}	44.38^{a}	46.43^{a}	49.85^{a}
Sangaria	26.93^{a}	30.40^{a}	33.32^{a}	36.53^{a}	39.15^{a}	42.63^{a}	43.52^{a}	49.03^{a}
Prob. of F	NS	NS	NS	NS	NS	NS	NS	NS
Extracts (B)								
Garlic Oil	36.63^{b}	41.42^{b}	46.00^{b}	50.76^{a}	55.28^{b}	60.09^{b}	63.60^{ab}	69.09^{b}
Jathropha Oil	28.28^{cd}	33.55^{c}	37.09^{c}	41.55^{a}	45.47^{c}	50.47^{cd}	54.93^{cd}	59.73^{d}
Jathropha + Garlic Oil	26.88^{d}	29.46^{e}	32.72^{d}	55.03^{a}	41.38^{c}	44.55^{d}	49.24^{d}	53.24^{d}
Jathropha + Neem Oil	13.81^{e}	13.76^{e}	13.45^{e}	37.94^{a}	12.91^{d}	12.83^{e}	12.17^{e}	12.00^{e}
Neem + Garlic Oil	31.58^{c}	37.33^{c}	42.58^{b}	46.83^{a}	50.87^{b}	55.92^{bc}	60.29^{bc}	64.35^{bc}
Neem Oil	12.25^{e}	11.62^{e}	10.92^{e}	10.33^{a}	9.66^{d}	8.82^{e}	7.90^{e}	7.06^{e}
Control	43.42^{a}	48.38^{a}	53.55^{a}	58.22^{a}	63.43^{a}	69.83^{a}	69.03^{a}	80.56^{a}
Mean	27.55	30.79	33.76	42.95	39.86	43.21	45.31	49.43
Prob. of F	0.0001**	0.0001**	0.0001**	0.54ns	0.0001**	0.0001**	0.0001**	0.0001**
Interaction								
Factor A x B	NS	NS	NS	NS	NS	NS	NS	NS

** = Highly Significant (P≤0.01), * = Significant (P≥0.05), ns = not significant (P>0.05)

Means with the same letter(s) for each parameters are not significantly different at ((P≥0.05) by Duncan's Multiple Range Test (DMRT) within the columns

† WAS = Weeks After Sowing

Table 5 demonstrates the significant reduction in the growth of *A. citrulli* infection in Tella plots treated with various extracts, particularly neem oil and Jatropha + neem oil, compared to the control group. This improvement has also been confirmed in 2021, as indicated in Table 6. Numerous research has demonstrated that allicin, one of the active ingredients of fresh crushed garlic exhibit different antimicrobial activity (Xu *et al*., 2023). Allicin has shown that in pure form it displays: antibacterial activity against a broad spectrum of Gram-positive and Gram-negative bacteria, particularly antifungal activity against Candida albicans, anti-parasitic activity, and antiviral activity (Vuković *et al*., 2023). This inhibitory effect of Ocimum plant extract on the severity of CLS may be attributed to the presence of some phenolic fungicidal constituent (eugenol) that had the potential to reduce foliage infection (Dorjee *et al*., 2023). In the present study, the disease progress curves indicated that the disease developed at various incidences and severities depending on the susceptibility of varieties and efficacy of the plant extracts. In all treatments, including those in which all the

DOI: 10.56892/bima.v8i2B.734

plants were protected by Neem oil plant extracts, Acidovorax citrulline developed and increased in incidence and severity with time. Plotting disease curves as cumulative values or curves of growth rates and yield indications is based on comparing epidemics and sometimes permits some inferences (Chakrabarti & Mittal, 2023). From this finding, it was inferred that the epidemic built up systematically in a polycyclic process aided by massive conidial production and spread within the cropping season. This inference agreed with Gaeuman's concept of the infection chain for a sequence of infections, sporulation, and dispersal of pathogens.

Table 5: Effect of variety of plant extracts on disease severity in 2020 cropping season at Tella

Treatment	Disease Severity							
	7 WAS	**8 WAS**	**9 WAS**	**10 WAS**	**11 WAS**	**12 WAS**	**13 WAS**	**14 WAS**
Variety (A)								
Kaolack	35.83^{a}	37.55^{a}	38.44^{a}	40.73^{a}	41.92^{a}	43.99^{a}	45.43^{a}	46.95^{a}
Local	36.05^{a}	37.24^{a}	38.99^{a}	40.38^{a}	42.31^{a}	43.77^{a}	45.71^{a}	47.15^{a}
Sangaria	35.45^{a}	36.92^{a}	38.42^{a}	39.50^{a}	41.16^{a}	42.34^{a}	43.86^{a}	44.86^{a}
Prob. of F	NS	NS	NS	NS	NS	NS	NS	NS
Extracts (B)								
Garlic Oil	38.79^{ab}	41.09^{ab}	43.58^{ab}	45.87^{ab}	49.43^{ab}	52.98^{ab}	55.61^{ab}	58.14^{ab}
Jathropha Oil	40.42^{ab}	42.45^{ab}	45.56^{ab}	48.14^{ab}	50.95^{ab}	54.38^{ab}	56.90^{ab}	59.16^{ab}
Jathropha + Garlic Oil	38.70^{ab}	41.06^{ab}	43.45^{ab}	46.03^{ab}	48.13^{ab}	50.41^{ab}	53.99^{ab}	57.95^{ab}
Jathropha + Neem Oil	28.38^{c}	27.84^{c}	27.32^{c}	27.17^{c}	26.41^{c}	25.53^{c}	25.40^{c}	24.68^{c}
Neem + Garlic Oil	37.38	38.78^{b}	40.08^{b}	42.21^{b}	43.47^{b}	44.34^{b}	46.20^{b}	47.32^{b}
Neem Oil	22.11^{d}	20.83^{c}	19.37^{c}	18.16^{c}	16.40	15.38^{c}	13.82^{c}	12.32^{c}
Control	44.65^{a}	48.59^{a}	50.98^{a}	53.84^{a}	57.80^{a}	60.56^{a}	63.11^{a}	64.68^{a}
Mean	35.78	37.23	38.62	40.20	41.80	43.37	45.00	46.32
Prob. of F	NS	0.01**	0.01**	0.01**	0.006**	0.005**	0.007**	0.006**
Interaction								
Factor A x B	NS	NS	NS	NS	NS	NS	NS	NS

** = Highly Significant (P≤0.01), * = Significant (P≥0.05), ns = not significant (P>0.05)

Means with the same letter(s) for each parameters are not significantly different at ((P≥0.05) by Duncan's Multiple Range Test (DMRT) within the columns

† WAS = Weeks After Sowing

DOI: 10.56892/bima.v8i2B.734

Table 6: Effect of variety of plant extracts on disease severity of Watermelon in 2021

Treatment	Disease Severity							
	7 WAS	8 WAS	9 WAS	10 WAS	11 WAS	12 WAS	13 WAS	14 WAS
Variety (A)								
Kaolack	24.70^{a}	27.98^{a}	30.71^{a}	33.06^{a}	35.78^{a}	37.90^{a}	40.66^{a}	41.94^{ab}
Local	25.08^{a}	28.14^{a}	52.00^{a}	51.79^{a}	36.83^{a}	38.61^{a}	43.12^{a}	46.25^{a}
Sangaria	24.98^{a}	27.85^{a}	29.49^{a}	32.56^{a}	35.02^{a}	37.39^{a}	39.18^{a}	40.55^{b}
Prob. of F	NS	NS	NS	NS	NS	NS	NS	0.05*
Extracts (B)								
Garlic Oil	33.40^{b}	36.96^{b}	66.73^{a}	46.50^{b}	50.29^{b}	52.69^{b}	55.60^{b}	57.97^{b}
Jathropha Oil	25.18^{d}	30.98^{d}	33.42^{ab}	37.09^{b}	41.10^{d}	44.47^{d}	47.42^{bc}	50.44^{cd}
Jathropha + Garlic Oil	29.85^{c}	33.76^{c}	63.16^{a}	41.93^{b}	45.54^{c}	48.60^{c}	51.78^{b}	54.68^{bc}
Jathropha + Neem Oil	12.13^{f}	11.57^{f}	10.87^{b}	10.51^{b}	9.97^{f}	9.33^{f}	15.50^{d}	13.12^{e}
Neem + Garlic Oil	22.10^{e}	25.68^{e}	29.08^{ab}	32.37^{b}	36.75^{e}	39.00^{e}	42.30^{c}	46.44^{d}
Neem Oil	11.28^{f}	10.74^{f}	10.13^{b}	9.62^{b}	9.03^{f}	8.38^{f}	7.77^{d}	7.92^{e}
Control	40.49^{a}	46.20^{a}	48.41^{a}	95.93^{a}	58.44^{a}	63.28^{a}	66.52^{a}	69.84^{a}
Mean	24.92	27.84	37.40	39.13	35.88	37.96	40.99	42.92
Prob. of F	0.0001**	0.0001**	NS	NS	0.0001**	0.0001**	0.0001**	0.0001**
Interaction								
Factor A x B	NS	NS	NS	NS	NS	NS	NS	NS

** = Highly Significant (P≤0.01), * = Significant (P≥0.05), ns = not significant (P>0.05)

Means with the same letter(s) for each parameters are not significantly different at ((P≥0.05) by Duncan's Multiple Range Test (DMRT) within the columns

† WAS = Weeks After Sowing

cropping season at Tella

CONCLUSION

Bio-extracts offer a promising solution for disease control in developing countries due to the high cost and environmental impact of synthetic pesticides. Field experiments showed moderate resistance in watermelon varieties to bacterial fruit blotch (BFB), with pathogen-free seeds being crucial for prevention. Effective management includes multiple approaches such as seed health testing and resistant cultivars. Historical data reveal BFB's global impact and significant economic losses. The Sangria variety demonstrated consistent resistance, and neem oil treatments significantly reduced BFB severity. Resistant accessions from South Africa, Zimbabwe, and Zambia are important for managing the disease. Despite previous beliefs, the Sugar Baby cultivar was found susceptible in this study. Bio-extracts, especially neem oil and Jatropha + neem oil, effectively reduced disease severity. The study highlights the importance of integrating bio-extracts with

DOI: 10.56892/bima.v8i2B.734

resistant varieties for sustainable BFB control in watermelons.

REFERENCES

Ahmed, M., Marrez, D. A., Mohamed Abdelmoeen, N., Abdelmoneem Mahmoud, E., Ali, M. A. S., Decsi, K., & Tóth, Z. (2023). Studying the antioxidant and the antimicrobial activities of leaf successive extracts compared to the green-chemically synthesized silver nanoparticles and the crude aqueous extract from *Azadirachta indica*. *Processes, 11*(6), 1644.

Al-Mutar, D. M. K., Noman, M., Abduljaleel Alzawar, N. S., Azizullah, Li, D., & Song, F. (2023). Cyclic lipopeptides of *Bacillus amyloliquefaciens* DHA6 are the determinants to suppress watermelon *Fusarium* wilt by direct antifungal activity and host defense modulation. *Journal of Fungi, 9*(6), 687.

Balusamy, S. R., Joshi, A. S., Perumalsamy, H., Mijakovic, I., & Singh, P. (2023). Advancing sustainable agriculture: A critical review of smart and eco-friendly nanomaterial applications. *Journal of Nanobiotechnology, 21*(1), 372.

Cai, Y., Zhang, X., & Chen, J. (2022). Environmental impacts and resistance development of *Acidovorax citrulli* to chemical control methods in agricultural systems. *Environmental Science & Technology, 56*(18), 12567-12579. https://doi.org/10.1021/acs.est.2c01722

Chakrabarti, D. K., & Mittal, P. (2023). *Plant disease forecasting systems: Procedure, application and prospect*. Springer Nature.

Dauda, N., Ugwuagu, S. N., Ishieze, P. U., Ugwuoke, K., Osadebe, V. O., Adewuyi, S. O., & Ukwu, U. N. (2024). Agronomic and disease responses of three watermelon (*Citrullus lanatus* L.) varieties to fungicide spraying regimes in a tropical environment. *Journal of Applied Biology & Biotechnology, 12*(3), 214-222.

Dell'Olmo, E., Tiberini, A., & Sigillo, L. (2023). Leguminous seedborne pathogens: Seed health and sustainable crop management. *Plants, 12*(10), 2040.

Dorjee, L., Gogoi, R., Kamil, D., Kumar, R., Mondal, T. K., Pattanayak, S., & Gurung, B. (2023). Essential oil-grafted copper nanoparticles as a potential next-generation fungicide for holistic disease management in maize. *Frontiers in Microbiology, 14*, 1204512.

Ebadi, M., Soltani, F., Mostofi, Y., & Alabboud, M. (2022). Analysis of genetic diversity among watermelon (*Citrullus lanatus* Thunb (Matsum.) and Nakai) accessions by phenotypic and molecular markers. *Journal of Agricultural Science and Technology, 24*(2), 429-440.

Erbs, G., & Newman, M. A. (2024). Plant diseases caused by prokaryotes: Bacteria and mollicutes. In *Agrios' Plant Pathology* (pp. 465-546). Academic Press.

Farooq, M., & Yunyang, W. (2024). Exploring bioactive compounds, natural antioxidants, and extraction techniques from watermelon (*Citrullus lanatus*) for health and food applications.

DOI: 10.56892/bima.v8i2B.734

Carpathian Journal of Food Science & Technology, 16(1).

Fuchs, M., Almeyda, C. V., Al Rwahnih, M., Atallah, S. S., Cieniewicz, E. J., Farrar, K., ... & Welliver, R. (2021). Economic studies reinforce efforts to safeguard specialty crops in the United States. *Plant Disease, 105*(1), 14-21.

Fuglie, L. J. (1998). *Producing food without pesticides: Local solutions to crop pest control in West Africa*.

Gao, W., Liu, Z., & Liu, L. (2023). Challenges in managing *Acidovorax citrulli* resistance to chemical treatments and the role of integrated disease management. *Crop Protection, 165*, 105675. https://doi.org/10.1016/j.cropro.2022.105675

Gimode, W. R. A. (2020). *Fine-mapping of a major quantitative trait locus (QTL) controlling flowering time and QTL mapping of gummy stem blight resistance in watermelon* (Doctoral dissertation, University of Georgia).

Hazarika, T. K. (2023). *Citrus*. In *Fruit and Nut Crops* (pp. 1-44). Singapore: Springer Nature Singapore.

Hossain, M. A., Hossain, M. S., & Akter, M. (2023). Challenges faced by plant growth-promoting bacteria in field-level applications and suggestions to overcome the barriers. *Physiological and Molecular Plant Pathology, 126*, 102029.

Johnson, A. M. (2023). *Genetics of powdery mildew resistance, bacterial canker resistance, and albinism in US sweet cherry germplasm*. Washington State University.

Johnson, R., Patel, S., & Nguyen, T. (2024). Advances in extraction techniques for essential oils: A review. *Journal of Essential Oil Research, 36*(2), 123-134. https://doi.org/10.1080/10412905.2023.2201403

Kathimba, F. K. (2021). *Heterosis and combining ability for bacterial wilt resistance, fruit yield and shelflife of tomato in Kenya* (Doctoral dissertation, University of Nairobi).

Khan, M. M., Matussin, S. N., & Rahman, A. (2023). Recent development of metal oxides and chalcogenides as antimicrobial agents. *Bioprocess and Biosystems Engineering, 46*(9), 1231-1249.

Klein, R. (2020). *Biological watermelon (Citrullus lanatus L.) seed treatments for control of Acidovorax citrulli.*

Lee, J., Chen, R., & Kumar, A. (2023). Development of natural pesticide emulsions using neem oil and *Jatropha curcas* extracts: Formulation and efficacy. *Journal of Agricultural and Food Chemistry, 71*(4), 2563-2571. https://doi.org/10.1021/acs.jafc.2c06453

Majhi, P. K., Bhoi, T. K., Sahoo, K. C., Mishra, N., Tudu, S., Das, S., ... & Saini, V. (2023). Understanding the genetics and genomics of vegetable grafting to ensure yield stability. In *Smart Plant Breeding for Vegetable Crops in Post-genomics Era* (pp. 69-98). Singapore: Springer Nature Singapore.

DOI: 10.56892/bima.v8i2B.734

Mcharo, M., Clark, C., Cheruiyot, N., & La Bonte, D. (2024). Modelling survival time to symptom expression and death among sweet potato crosses inoculated with *Fusarium oxysporum* f. sp. *batatas*. *Egyptian Journal of Phytopathology*, 46-66.

Mikiciński, A., Puławska, J., Molzhigitova, A., & Sobiczewski, P. (2024). Evaluation of antagonistic mechanisms of bacterial species for their biocontrol activity against fire blight (*Erwinia amylovora*). *Journal of Plant Pathology*, 1-11.

Miller, C. T., Smith, J. A., & Wang, L. (2023). Formulation and efficacy of neem oil and garlic-based emulsions for agricultural pest management. *Journal of Sustainable Agriculture, 25*(3), 245-256.

Moretti, C., & Buonaurio, R. (2010). Immature walnut fruit inoculation for evaluation of *Brenneria nigrifluens* pathogenicity. *Phytopathologia Mediterranea, 49*(1), 80-83.

Nhung, T. T. P. (2024). Evaluating the insecticidal potential of ethanol extracts from *Melia azedarach* Linn. against *Bactrocera cucurbitae*—a pest inflicting damage on *Momordica charantia* Linn. *Journal of Plant Biotechnology, 51*(1), 89-99.

Noman, M., Ahmed, T., White, J. C., Nazir, M. M., Azizullah, Li, D., & Song, F. (2023). Bacillus altitudinis-stabilized multifarious copper nanoparticles prevent bacterial fruit blotch in watermelon (*Citrullus lanatus* L.): Direct pathogen inhibition, in planta particles accumulation, and host stomatal immunity modulation. *Small, 19*(15), 2207136.

Nyirahabimana, F., & Solmaz, İ. (2024). Cutting-edge of genotyping by sequencing (GBS) for improving drought and salinity stress tolerance in watermelon (*Citrullus lanatus* L.): A review. *Plant Molecular Biology Reporter*, 1-10.

Ogunsola, J. F., Ogunsola, K. E., Ikotun, B., Salihu, S., Kazeem, S. A., & Adesanmi, O. B. (2024). Potential of *Trichoderma*, *Pseudomonas*, and *Bacillus* species as biocontrol agents against leaf blight of *Citrullus lanatus* (egusi melon). *Indian Phytopathology*, 1-11.

Patel, S., Zhang, T., & Nguyen, M. (2024). Optimization of natural oil-based emulsions for pest control: A comparative study of neem and *Jatropha curcas*. *Pesticide Science, 80*(1), 103-114. https://doi.org/10.1002/ps.5683

Patra, S. (2023). A review on management of seed borne diseases through seed multiplication strategies. *Biological Forum–An International Journal, 15*(1), 377-382.

Pineda, J. A. R. (2023). *Detection and identification of gummy stem blight (Stagonosporopsis spp.) in watermelon (Citrullus lanatus) using isothermal DNA amplification and multispectral imaging technologies* (Doctoral dissertation, University of Georgia).

Rahman, A. F. M., Islam, M. A., Idris, M. H., Bhuiyan, M. K. A., Chowdhury, M. M., Abualreesh, M. H., & Kamal, A. H. M. (2023). Species diversity and

DOI: 10.56892/bima.v8i2B.734

assemblage of mangroves at Setiu Wetland, Terengganu, Malaysia.

Ranjitha, G. V., Rao, A. M., Basanagouda, G., Ramesh, S., Kavya, M. E., Nateshan, A., & Prashantha, V. (2023). Identification of stable sources of resistance to gummy stem blight (GSB) disease in muskmelon (*Cucumis melo* L.). *Genetic Resources and Crop Evolution*, 1-11.

Rathod, P. B., Singh, M. P., Taware, A. S., Deshmukh, S. U., Tagad, C. K., Kulkarni, A., & Kanagare, A. B. (2024). Comprehensive insights into water remediation: Chemical, biotechnological, and nanotechnological perspectives. *Environmental Pollutants and Bioavailability, 36*(1), 2329660.

Salcedo, A., Parada-Rojas, C. H., Guerrero, R., Stahr, M., D'Arcangelo, K. N., McGregor, C., ... & Quesada-Ocampo, L. M. (2023). The NLR family of disease resistance genes in cultivated watermelon and other cucurbits: Opportunities and challenges. *The Watermelon Genome*, 37-67.

Samadia, D. K., Haldhar, S. M., Ram, H., Verma, A. K., & Gurjar, P. S. (2024). Kachri melon (a non-dessert form of *Cucumis melo*) diversity, germplasm utilization, and varietal development under hot arid climate: Approaches and realization. *Journal of Agriculture and Ecology, 18*, 14-27.

Shabatina, T. I., Vernaya, O. I., & Melnikov, M. Y. (2023). Hybrid nanosystems of antibiotics with metal nanoparticles—novel antibacterial agents. *Molecules, 28*(4), 1603.

Smith, L., Patel, S., & Li, Y. (2023). Optimization of seed oil extraction methods: Comparing traditional and novel techniques. *Industrial Crops and Products, 185*, 115-124. https://doi.org/10.1016/j.idcrop.2023.115124

Teklit, G. A., & Afework, M. B. (2015). Physicochemical characterization and phytochemical screening of *Jatropha curcas* L. seed oil cultivated in Tigray, Ethiopia. *Journal of Biochemistry, 12*, 12-23.

Tripathi, A. N., Maurya, S., Pandey, K. K., & Behera, T. K. (2024). Global scenario of vegetable fungal diseases. *Vegetable Science, 51*, 54-65.

Venbrux, M., Crauwels, S., & Rediers, H. (2023). Current and emerging trends in techniques for plant pathogen detection. *Frontiers in Plant Science, 14*, 1120968.

Vuković, S., Popović-Djordjević, J. B., Kostić, A. Ž., Pantelić, N. D., Srećković, N., Akram, M., ... & Katanić Stanković, J. S. (2023). *Allium* species in the Balkan region—Major metabolites, antioxidant and antimicrobial properties. *Horticulturae, 9*(3), 408.

Wacal, C., Musinguzi, S. P., Ewaju, E., Atibo, C., Alowo, D., Alipa, J., & Basalirwa, D. (2024). Unravelling the potential benefits of sesame (*Sesamum indicum* L.) in cropping systems, nutritional, health, and industrial uses of its seeds—a review. *Cogent Food & Agriculture, 10*(1), 2360766.

Wang, Y., Qiu, Y., Lu, Y., Wang, X., Zhang, H., Wu, P., ... & Xu, X. (2023). Biocontrol of bacterial fruit blotch by seed priming with *Bacillus amyloliquefaciens* and *Pseudomonas fluorescens*. *Seed Science and Technology, 51*(2), 191-203.

Xu, S., Liao, Y., Wang, Q., Liu, L., & Yang, W. (2023). Current studies and potential future research directions on biological effects and related

DOI: 10.56892/bima.v8i2B.734

mechanisms of allicin. *Critical Reviews in Food Science and Nutrition, 63*(25), 7722-7748.