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Impact of Neem Seed, Neem Leaf Extract, Insecticide, and Baking Soda on the Population and Damage of Fall Armyworm on the Growth and Yield of Maize (*Zea Mays*) in Njala Lowland

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ABSTRACT

The fall armyworm (FAW), Spodoptera frugiperda, poses a significant threat to maize production in Sierra Leone and across sub-Saharan Africa, necessitating the development of effective and sustainable control strategies. A field study was conducted at Njala University, to evaluate the efficacy of neem leaf extract, neem seed powder, a synthetic insecticide, and baking soda solution, and their impact on the growth and yield of three maize varieties (DMR-ESR-Yellow, Samma 252, and PVR SYN9). The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Treatments included neem leaf extract, neem seed powder, a synthetic insecticide (standard control), baking soda solution, and an untreated control. Data were collected on vegetative growth parameters (plant height, stem girth, leaf area), pest incidence (number of insects, percentage damage, percentage incidence), and yield components. The results demonstrated that all treatments significantly suppressed FAW infestation and damage compared to the untreated control, with their efficacy becoming more pronounced over time. At 8 WAP, neem leaf, baking soda, and the synthetic insecticide were the most effective, completely eliminating insect populations and disease incidence. Neem leaf extract consistently promoted superior vegetative growth, resulting in the tallest plants and largest leaf area. Furthermore, neem leaf application significantly enhanced yield components, producing the largest cob size (22.56 cm), heaviest cobs (44.41 g), and highest 1000-seed weight (98.80 g), outperforming all other treatments. Among the varieties, PVR SYN9 exhibited the highest level of resistance to FAW and the greatest yield potential, recording the highest total number of seeds per cob (3800.0). The study concludes that neem leaf extract is a highly effective botanical pesticide, serving as a viable and sustainable alternative to synthetic insecticides for managing fall armyworm in maize. Its integration with a resistant variety like PVR SYN9 is recommended for optimizing vegetative growth, minimizing pest damage, and maximizing grain yield in smallholder farming systems in Sierra Leone.

Keywords: *Njala University, neem leaf extract, neem seed powder, a synthetic insecticide, baking soda solution.*

1. 1: INTRODUCTION

Maize (*Zea mays L.*) or Corn, as it is commonly referred to in many parts of the world. It is believed to have originated in Central Mexico around 5,000 BC. The crop was introduced to Europe in the sixteenth century, from where it spread to Africa and Asia [1]. According to FAO sources such as the Agricultural Market International Systems (AIMS), world production in 2012 was over 870 million tons, grown on 158 million hectares of land. The United States is the largest producer of maize, with 42% of the world's total maize production figures. While Africa accounts for only 6.5% of the world's total production and Nigeria isthe largest African producer with nearly 8 million tons, followed by South Africa.

In most parts of Africa, Maize is predominantly grown by smallholder farmers and very seldom preferred staple food crop for few ethnic communities in the regions. In West African countries, combined production of maize is 3,679,856mt tomes produced on 17,266,889 hectares of [2]. In Sierra Leone, Maize is the second most important cereal grain crop grown after the country's staple food rice. In the past, very little attention was given to Maize production as reflected in its place in the cropping system where it is grown largely as an intercrop with rice and other crops in the upland farms under shifting cultivation. Presently, the production of Maize, though still modest, is on the increase as a result of increased demand for human and livestock consumption. According to the FAO/MAFFS Crop Survey Report 2003, the area under Maize cultivation in Sierra Leone is 20,828 hectares with yields of 0.77mt/hectare and a total production of 16,060mt. The low yield is attributed to a combination of several constraints faced by famers engaged in Maize production, which is largely due to lack of production technologies such as varieties and pest management practices, moisture stress, low fertility and poor cultural practices [3].

Insect pests (Arthropods) are among the key factors contributing to low yield of Maize and they are central to many, if not most, of the serious problems facing Maize production today. Maize is attacked by several insects and vertebrate pest at all stages in the plant growth. The most disturbing field pest is the fall armyworm (*spodoptera frugipeda*) that attacks the leaves, stem and cob. Maize yields obtained in Sierra Leone are low due to increasing infestation of fall armyworm and diseases, reduced fallow periods of soils, infertility of soils, limited improved varieties that are tolerant to local conditions, lack of improved agronomic packages that increase production, productivity and value addition activities that improve the livelihoods of end-users. In Sierra Leone most farmers used chemical pesticides which can be detrimental to the environment, instead of botanical (plant extract) to control fall armyworm population and damage on maize. The problem of availability, accessibility and affordability coupled with the high rate of leaching anderosion into streams causing environmental hazards from the use of these chemical pesticides remain a huge challenge farmer's grapple with. Despite its importance as food as well as cash crop, maize yields and growth in Sierra Leone are reported to be low when compared to other East African countries eg: 1.84 tons/ha in Kenya, 3.03 tons/ha in Uganda, 22.85 tons/ha in Rwanda and 13.22 tons/ha in Burundi [4].
Damage had been also observed on other crops such as cowpea, groundnut, potato, soybean and cotton. Its host preference extends to >186 plants of different families [5]. Fall armyworm which is indigenous in the America, is a polyphagous pest causing economic damage of various crops such as maize, sorghum, beans and cotton [6]. Fall armyworm was first reported in West Africa in late 2016, and early 2017. Recent report confirmed the occurrence of fall armyworm in 28 countries in Africa [7, 6]. This rapid spread of the pest in the continent seriously threatened the food security drive of millions of people. Botanical insecticides have long been considered as attractive alternatives to synthetic chemical insecticides for pest management. Botanical insecticides are eco-friendly, economic, target-specific and biodegradable. The botanical insecticides are characterized in their specificity, as most are essentially nontoxic to animals and humans.Therefore, this study is to evaluate the efficacy of certain insecticides (neem seed, neem leaf extract, insecticide and baking soda) against the control of fall armyworm.

2.0: MATERIALS AND METHODS

2.1: Experimental Design

The field experiment was conducted during the dry season in the lowland at the experimental site of Crop Protection Department, School of Agriculture and Food Science, Njala University, Njala Campus in the Kori Chiefdom, Moyamba District, and the Southern region of Sierra Leone. The School of Agriculture and Food Science is located on an elevation of 5m above sea level on latitude $8^0$6N and a longitude $12^0$6W of the equator. The experimental design used for the experiments was a randomized complete block design (RCBD) replicated three times. The experimental area measured 14.5m × 11m given a total of 159.5m^2, and each plot 3m × 2.5m (7.5m^2). There were five (5) plots each separated by 0.5m and 1.0m between replications. Predominantly, the landscape of Njala University, Njala Campus is covered with secondary bush and consists of a well-balanced mixture of sand, clay, and humus. The site to be specific was densely covered with elephant grass, spear grass and sedges.
The soil of the experimental site belongs to the Njala University, Njala Campus soil series (orthxic-palehumult). The soils are generally low in moisture, have a low nutrient status and are highly acidic with pH ranging from 5.5-6.0.

2.2 Planting, Planting Materials and Cultural Practice.

The experimental field was prepared by brushing, clearing and ploughing the hole to a depth of 30 cm and harrowing manually. An improved variety known as DMR/ESR YELLOW, SAMMA 252, PVR SYN9, was planted. This variety was introduced in Sierra Leone from the International Institute of Tropical Agriculture (IITA) in Nigeria. It is moderately resistant to streak and stem borer. It takes about 42-60 days to silk. It has an excellent sweet taste and matures in about 75-80 days with a yield potential at the range of about 1.0-2.0 t. ha^{-1}. Two maize seeds were sown per hill at a depth of 1.0cm and later thinned to two seedlings per hill at a spacing of 70cm × 50cm. Watering was done because there was not enough moisture due to hydrological drought (low water levels) which reduces the water available for plant. Hand weeding was done; the first was done three weeks after planting (3WAP) and the second was done six weeks after planting (6WAP.

3.3 Preparation and Application of Treatments

During the preparation, neem seeds and neem leaves were collected from the Neem plants in the School of Agriculture and Food Science, and it was dried by air and pounded in to a powder form. Baking soda was also obtained in the Njala community, and it was then filtered and sterilized at 100 ^{0}C to kill any soil borne pathogen in the dust. The filtered Neem seed, neem leaves, baking soda and insecticide were measured at 10.0g, (each representing a treatment) were also applied alone. Treatments were applied when the infestation of fall armyworm started on the maize and it was at three weeks after planting.
However, 20ml of water were used in the preparation of the different treatments with different plastic weights varying (0.7g, 0.5g and 0.6g, respectively).The experiment had six (6) treatments plus a control making seven (7) treatments. The treatments were: i) Control, ii) Neem leaf, iii) Need seed, iv) Insecticide and v) Baking soda.

3.4 DATA ANALYSIS

The data was subjected to Two-way analysis of variance (ANOVA) using the Genstat 12th edition statistical software package. The Least Significant Difference (LSD) test was used to compare all treatments means at 5% level of probability. Before analysis, raw data was transformed by adding a value of one to all scores to eliminate zero data point and converted to square root.

3.0: RESULT AND DISCUSSION

3.1. Effects of neem leaf, neem seed, insecticide and baking soda on vegetative growth of three Maize varieties

Result in Table 1 showed that there was a significant difference ($P<0.05$) between treatments in plant height and stem girth at three weeks after planting (3 WAP). However, the application of different treatments had a statistically significant effect on plant height, stem girth, and leaf area, but not on the number of leaves (NS) at 3 weeks after planting (WAP). Among the treatments, neem leaf extract emerged as the most effective, producing the tallest plants (18.8 cm), the thickest stems (0.6 cm), and the largest leaf area (31.6 cm^2). The insecticide treatment also performed well, resulting in the second-tallest plants (18.3 cm).

Baking soda application showed a positive effect on stem girth and leaf area, while neem seed application significantly increased plant height and leaf area compared to the control but was less effective than neem leaf. The control group consistently showed the poorest performance across all measured parameters. Regarding the maize varieties, PVR SYN9 demonstrated the best overall vegetative growth, achieving the greatest plant height (12.23 cm) and the highest number of leaves (5.6). DMR-ESR-Yellow had the largest stem girth (0.46 cm) and the second-largest leaf area (29.29 cm^2). Samma 252 variety consistently showed the lowest values for plant height, stem girth, and number of leaves. These results confirm the work of Sisay *et al.*,[8] who reported that there was a significant reduction of in vegetative parameters of maize in the untreated (control) plot when a field experiment was performed to evaluate the efficacy of neem (*Azadirachta indica*) on fall armyworm. Sisay *et al.*, [8] reported that there was an increase in vegetative growth of maize in all plot treated with neem (*Azadirachta indica*).Neem can be a broad-spectrum pesticide by combining with plants, synergists, antagonists, microbial biopesticides, and adjuvants to increase its effectiveness [9].

Table 1: Effects of neem leaf, neem seed, insecticide and baking soda on vegetative growth of three Maize varieties (plant height, stem girth, number of leaf and leaf area) at 3 weeks after planting

Treatments	Plant Height (cm)	Stem Girth (cm)	Number Of Leaves	Leaf Area (cm²)
		3WAP		
Control	10.3	0.3	4.6	21.43
Neem leaf	18.8	0.6	5.6	31.6
Neem seed	16.2	0.3	4.6	27.84
Insecticide	18.3	0.4	5.0	22.00
Baking Soda	15.1	0.50	5.0	30.89
Variety				
DMR - ESR - Yellow	11.1	0.46	5.3	29.29
Samma 252	10.23	0.33	4.6	24.17
PVR SYN9	12.23	0.44	5.6	30.12
F-Statistics				
F pr.	**0.017**	**0.014**	**ns**	**0.012**
LSD	**ns**	**ns**	**ns**	**11.45**
% CV	**12.1**	**12.1**	**11.4**	**9.3**

NS: Not significant

However, at 6 weeks after planting (WAP) reveal a significant treatment effect on plant height and leaf area ($P<0.05$), while effects on stem girth and number of leaves were not statistically significant. The neem leaf treatment produced the tallest plants (44.7 cm), which were significantly greater than all other treatments based on the LSD value of 5.20. For leaf area, a striking result emerged: the neem seed treatment generated the largest leaf area (115.9 cm^2), which was significantly greater than all other treatments according to the LSD of 5.90. The baking soda treatment performed well numerically in stem girth (1.3 cm) and number of leaves (6.4), though these differences were not statistically significant. Notably, the neem leaf extract treatment resulted in a leaf area (95.1 cm^2) that was statistically indistinguishable from the control (95.1 cm^2) and significantly smaller than the botanical treatments. Similar findings were done by Silva *et al.*, [10] who reported that although there was increase in vegetative growth of maize (plant height, leaf number, stem girth and leaf area) when the mortality of larvae of fall armyworm increase as aresult of high toxicity impact of neem (*Azadirachta indica*) on fall armyworm.Successively by neem oil concentration of 1% by 74.11%, leaf extract of Ocimum sanctum concentration of 5% by 74.00%, Murraya koenigii leaf extract concentration of 5% was 70.96%, ash at a dose of 10 kg/ha was 68.04%, river sand + neem leaf powder at a dose of 10 kg/ha (ratio 3:1) was 44.48% and ash + sand river dose of 10 kg/ha (5:1 ratio) of 42.53% after 7 days of spraying [11]

Table 2: Effects of neem leaf, neem seed, insecticide and baking soda on vegetative growth of three Maize varieties (plant height, stem girth, number of leaf and leaf area) at 6 weeks after planting

Treatments	Plant Height (cm)	Stem Girth (cm)	Number Of Leaf	Leaf Area (cm²)
			6WAP	
Control	26.4	0.56	4.57	61.9
Neem leaf	44.7	1.3	6.0	95.1
Neem seed	30.6	1.0	5.2	85.9
Insecticide	34.9	0.8	5.8	60.1
Baking Soda	37.1	1.3	6.4	80.8
Variety				
DMR - ESR - Yellow	34.9	1.3	5.6	69.5
Samma 252	27.4	1.1	5.1	60.5
PVR SYN9	32.09	1.2	5.9	60.9
F-Statistics				
F-pr	0.005	Ns	ns	0.0001
LSD	**5.20*** **	**ns**	**Ns**	**5.90*** **
% CV	**16.4**	**11.9**	**13.3**	**19.6**

NS: Not significant

Based on the data from 8 weeks after planting (WAP), the application of different treatments had a significant and substantial impact on the final vegetative growth of maize, with statistically significant effects observed for plant height and leaf area. The neem leaf, baking soda, and neem seed treatments were highly effective, forming a statistically superior group for plant height. All three resulted in significantly taller plants (67.0 cm, 66.6 cm, and 64.3 cm, respectively) compared to the insecticide (61.1 cm) and the control (47.4 cm), as determined by the LSD value of 5.12. A particularly remarkable result was observed for leaf area, where the baking soda treatment produced the largest leaf area by a wide margin (142.2 cm^2), which was significantly greater than all other treatments according to the LSD of 6.80. The neem leaf (119.7 cm^2) and insecticide (113.7 cm^2) treatments also performed very well for this parameter, forming a second statistical group that was significantly better than the neem seed treatment (88.2 cm^2) and the control (55.6 cm^2). Notably, the synthetic insecticide, while improving growth over the control, was consistently the least effective of the applied treatments for plant height and was outperformed by the botanical and baking soda options for leaf area. The effects on stem girth and number of leaves were not statistically significant (NS), meaning the numerical differences observed (e.g., baking soda at 2.70 cm stem girth and insecticide at 12.6 leaves) are likely due to experimental variation rather than the treatments themselves. The high %CV for the number of leaves (27.5%) and leaf area (28.1%) indicates considerable variability in these measurements within each treatment group. Successively by neem oil concentration of 1% by 74.11%, leaf extract of Ocimum sanctum concentration of 5% by 74.00%, Murraya koenigii leaf extract concentration of 5% was 70.96%, ash at a dose of 10 kg/ha was 68.04%, river sand + neem leaf powder at a dose of 10 kg/ha (ratio 3:1) was 44.48% and ash + sand river dose of 10 kg/ha (5:1 ratio) of 42.53% after 7 days of spraying [11].

Table 3: Effects of neem leaf, neem seed, insecticide and baking soda on vegetative growth of three Maize varieties (plant height, stem girth, number of leaf and leaf area) at 8 weeks after planting

	Plant Height (cm)	Stem Girth (cm)	Number Of Leaf	Leaf Area (cm²)
Treatments	**8WAP**			
Control	47.4	1.13	8.2	55.6
Neem leaf	67.0	2.86	11.33	119.7
Neem seed	64.3	2.43	10.6	88.2
Insecticide	61.1	2.00	10.6	113.7
Baking Soda	66.6	2.70	11.3	142.2
Variety				
DMR - ESR - Yellow	45.1	2.53	8.0	102.9
Samma 252	37.2	2.7	7.0	91.6
PVR SYN9	39.9	2.5	5.0	88.8
F-Statistics				
Fpr	0.05	ns	Ns	0.001
LSD	**5.12** **	**ns**	**Ns**	**6.80*** **
% CV	**12.2**	**6.5**	**27.5**	**28.1**

3.2: Maize varieties-treatment Interaction on the growth component.

However, a significant (P<0.05) difference was observed in the study. With regards, the study evaluated the interaction between three maize varieties (V1 = DMR-ESR-Yellow, V2 = Sammaz 252, V3 = PVR SYN9) and five treatments (T1 = Control, T2 = Neem leaf, T3 = Neem seed, T4 = Insecticide, T5 = Baking soda). A significant variety × treatment interaction was observed, indicating that the response of each maize variety to the different treatments was not uniform. For instance, V1 (DMR-ESR-Yellow) and V3 (PVR SYN9) showed a stronger positive response to the conventional insecticide. Also, V2 (Sammaz 252) demonstrated considerable resilience when treated with neem-based treatments (neem leaf extract and neem seed), supporting the work of Adeyemi *et al.*, [12], which highlighted the compatibility of certain local varieties with botanical pesticides owing to their inherent pest resistance mechanisms. The moderate effect of baking soda.

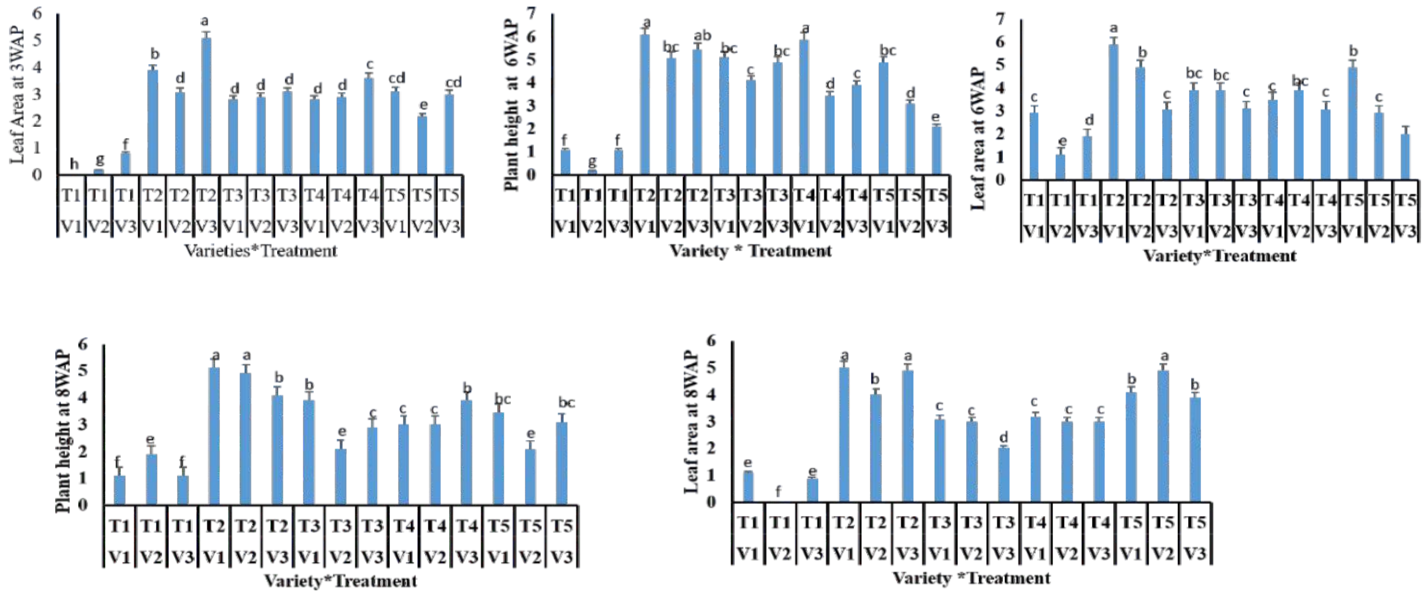

Figure 1: Maize varieties-treatment Interaction on the growth component.

3.3 Effects of neem leaf, neem seed, insecticide, and baking soda on number of insects, percentage damage, and percentage incidence at 3,6 and 8 weeks after planting

Table 4 showed that there was no significant difference (P>0.05) between the control plot and treated plots in incidence, % damage, and % incidence at three weeks after planting. The analysis reveals that the percentage damage was the only parameter significantly affected (P<0.05) by the treatments. All applied treatments neem leaf (3.2%), neem seed (4.0%), insecticide (4.3%), and baking soda (4.5%) resulted in statistically lower damage compared to the untreated control (10.2%). Among the treatments, neem leaf was the most effective, causing the greatest reduction in damage and performing on par with the synthetic insecticide. While the number of insects and percentage incidence showed numerical reductions in treated plots compared to the control, these differences were not statistically significant (NS), meaning they could be due to random chance within the experiment. The high %CV for these parameters (18.2% and 20.1%, respectively) indicates a considerable degree of variability in the data, which may have contributed to the lack of statistical significance. Regarding the maize varieties, numerical differences are observable. Samma 252 hosted the fewest insects (1.5) while DMR-ESR-Yellow showed the least damage (3.1%). However, without provided F-statistics or LSD values for the variety factor, these differences cannot be deemed statistically significant and may simply represent natural variation. In conclusion, at this early growth stage, all treatments were effective at significantly reducing pest-induced plant damage compared to the control. The neem leaf extract emerged as a particularly effective botanical alternative, matching the performance of the synthetic insecticide.

The non-significant results for insect number and incidence suggest that the primary benefit of the treatments may be through anti-feedant or other protective mechanisms that limit damage rather than through outright insect mortality at this specific stage. Sisay et al., [8] reported that the population and damage of fall armyworm was very high in the untreated plot (control) as compared to treated plots.

Table 4: Effects of neem leaf, neem seed, insecticide, and baking soda on number of insects, percentage damage, and percentage incidence at 3 weeks after planting

	Number of Insect	% Damage	% Incident
Treatments		**3WAP**	
Control	5.3	10.2	4.6
Neem leaf	2.2	3.2	1.6
Neem seed	2.6	4.0	3.3
Insecticide	1.7	4.3	3.0
Baking Soda	2.1	4.5	3.3
Variety			
DMR - ESR - Yellow	2.0	3.1	1.7
Samma 252	**1.5**	3.2	3.6
PVR SYN9	**2.3**	**3.8**	**3.7**
F-Statistics			
F-pr	**Ns**	**ns**	**ns**
LSD	**Ns**	**1.20**	**Ns**
% CV	**18.2**	**13.0**	**20.1**

NS: Not significant

The data presented in Table 5 demonstrates that by 6 weeks after planting (WAP), all applied treatments had a highly significant (P<0.05) and profound effect on reducing insect pest populations, the percentage of plant damage, and the rate of disease incidence compared to the untreated control. The synthetic insecticide was the most effective treatment overall, completely preventing any disease incidence (0.0%) and, along with neem leaf extract, resulting in the lowest damage percentage (2.0%).

However, all botanical and alternative treatments performed exceptionally well and were statistically superior to the control. The neem seed treatment hosted the fewest insects (11.6), slightly outperforming the insecticide (11.0) and neem leaf (12.3) in this specific measure, though all formed a statistically homogenous group that was vastly better than the control (65.0 insects). Baking soda was also highly effective, demonstrating its potential as a viable pest management tool. In stark contrast, the control group exhibited severe pest infestation, with dramatically higher insect counts (65.0), damage (4.0%), and disease incidence (7.6%), highlighting the necessity of intervention. The analysis also revealed highly significant differences (P<0.001) in susceptibility among the maize varieties. PVR SYN9 demonstrated the greatest resistance, recording the lowest values for insect count (10.1), damage (13.1%), and incidence (12.5%). Conversely, Samma 252 appeared to be the most susceptible variety, showing the highest levels of insect count (16.6), damage (18.0%), and incidence (14.4%). DMR-ESR-Yellow exhibited an intermediate level of resistance. By the 6-week stage, the protective effects of the treatments became overwhelmingly clear. The synthetic insecticide provided the strongest defense, particularly against disease incidence. Nevertheless, the neem-based treatments (leaf and seed) and baking soda proved to be highly effective alternatives, offering robust pest suppression and plant protection. Furthermore, the choice of variety played a critical role in integrated pest management, with PVR SYN9 showing inherent resistance traits. This data strongly supports the use of neem extracts and baking soda as effective components in a sustainable pest management strategy for maize cultivation. This work is in line with the work of Silva et al.,[10] who reported that Neem seed powder was very effective in reducing the population and damage of fall armyworm on maize. Silva et al., [10] further explained that when neem seed powder were applied at higher concentration, the mortality rate of fall armyworm larvae was high and no egg was present on the maize leaf.

Table 4.5: Effects of neem leaf, neem seed, insecticide, and baking soda on number of insects, percentage damage, and percentage incidence at 6 weeks after planting

	Number of Insect	% Damage	% Incident
Treatments		**6WAP**	
Control	65.0	4.0	7.6
Neem leaf	12.3	2.0	1.0
Neem seed	11.6	2.6	3.0
Insecticide	11.0	2.0	0.0
Baking Soda	14.3	2.3	1.6
Variety			
DMR - ESR - Yellow	14.5	15.5	13.4
Samma 252	16.6	18.0	14.4
PVR SYN9	10.1	13.1	12.5
F-Statistics			
F pr.	<.001	<.001	<.001
LSD	14.90***	10.90*	5.90*
% CV	20.2	16.6	11.1

NS: Not significant

The data from the final growth stage (8 WAP) reveal a powerful and highly significant effect of the treatments on all measured pest parameters, with the botanical and alternative treatments demonstrating remarkable efficacy, often matching the synthetic standard. The neem leaf extract, baking soda, and synthetic insecticide treatments were exceptionally effective, completely eliminating insect populations (0.0 insects) and preventing any disease incidence (0.0%). These three treatments, along with neem seed, also resulted in the lowest and statistically similar damage percentages (1.0-2.0%), all of which were significantly lower than the control (4.0% damage) as confirmed by the significant F-probability (p=0.003). The neem seed treatment, where highly effective, showed a slight but statistically detectable presence of insects (5.0) and a minimal disease incidence (0.6%), making it the fourth-best option. The untreated control group continued to exhibit severe and significantly higher levels of infestation (68.3 insects, 8.0% incidence), underscoring the critical importance of pest management interventions. Highly significant differences (P<0.001) were observed among the maize varieties, with PVR SYN9 demonstrating outstanding resistance. It hosted nearly zero insects (0.1), sustained the least damage (1.0%), and had the lowest disease incidence (0.2%), establishing it as the most resistant variety. DMR-ESR-Yellow and Samma 252 showed moderate susceptibility, with numerically higher values for all parameters, though Samma 252 (3.0) hosted fewer insects than DMR-ESR-Yellow (6.3). This result is in line with the work of Sisay et al., [8], who reported that the application of Neem (Azadirachta indica) result to 95% mortality rate of fall armyworm larvae and egg which reduced their population and damage on the maize.

However untreated plot recorded the highest incidence (68.3%), the highest severity score (4.0) and the highest number of larvae present (8.0) thus indicating when maize plots are left untreated for fall armyworm, their population and damage will increase and this will lead total eradication of the crop. According to the report of Sisay *et al*., [8], there was an increase in the population and damage of fall armyworm as a result of increased number of larvae and egg in maize plots that were left untreated and this was also associated with low yield.

Table 6: Effects of neem leaf, neem seed, insecticide, and baking soda on number of insects, percentage damage, and percentage incidence at 8 weeks after planting

	Number of insect	% Damage	% Incident
Treatments		**8WAP**	
Control	68.3	4.0	8.00
Neem leaf	0.0	1.0	0.0
Neem seed	5.0	2.0	0.6
Insecticide	0.0	1.0	0.0
Baking Soda	0.0	1.0	0.0
Variety			
DMR - ESR - Yellow	6.3	2.0	2.0
Samma 252	3.0	2.0	3.0
PVR SYN9 **F-Statistics**	0.1	1.0	0.2
F pr.	<.001	0.003	<.001
LSD	12.30	11.20	9.80
% CV	**13.6**	**15.70**	**27.1**

NS: Not significant

3.4: Effects of neem leaf, neem seed, insecticide, and baking soda on the yield component of maize.

The yield component data presented in Table 7 demonstrates a highly significant effect of both the applied treatments and maize variety on all measured parameters, with profound implications for final grain yield. The analysis, based on the provided F-probability values, reveals that all treatments significantly improved yield components compared to the untreated control (P<0.05 to P<0.001). The neem leaf treatment emerged as the most effective, producing the largest cob size (22.56 cm), longest cob length (16.12 cm), heaviest individual cob weight (44.41 g), highest total cob weight (126.80 g), greatest 1000-seed weight (98.80 g), and highest total number of seeds per cob (1402.2). This superior performance is likely attributable to the combined effect of effective pest control (as shown in previous tables) and potential growth-promoting properties of neem leaf extracts, which have been shown to enhance plant vigor and resource allocation to reproductive structures [13]. Baking soda also showed notable efficacy, particularly in cob size (20.2 cm) and individual cob weight (42.12 g), possibly due to its dual function as a fungicide and foliar nutrient, which can improve photosynthetic efficiency and carbohydrate translocation to developing grains [14].

The synthetic insecticide and neem seed treatments showed moderate but statistically significant improvements over the control, particularly in 1000-seed weight, which is a critical determinant of yield quality and market value. The significant varietal differences further highlight the importance of genetic selection in maize productivity. PVR SYN9 demonstrated exceptional yield potential, outperforming the other varieties in all parameters, especially the total number of seeds per cob (3800.0), which is a key yield component in maize. The low percentage coefficient of variation (%CV) values across all parameters (11.20-14.40%) indicate good experimental precision and reliability of the measurements. In conclusion, the integration of effective pest management strategies, particularly with neem leaf extract, with high-yielding varieties like PVR SYN9 presents a sustainable approach to enhancing maize productivity. This combination addresses both biotic stress factors and genetic potential, resulting in significant improvements in yield components that ultimately translate to higher grain yield and quality. Neem is a biocontrol agent with few poisonings and is greatly useful in pest and plant disease management systems. Neem biocide opportunities with the active ingredient azadirachtin affect insect metabolic processes such as sexual communication disorders, protein synthesis, changes in biological health, and chitin synthesis [15].

Table 7: Effects of neem leaf, neem seed, insecticide, and baking soda on the yield component of maize

Treatments	Cob size (cm)	Cob length (cm)	Cob weight (g)	Total cob weight (g)	1000 seed weight (g)	Total number of seeds per cobs
Control	11.66	8.90	31.2	44.20	46.00	1000.2
Neem leaf	22.56	16.12	44.41	126.80	98.80	1402.2
Neem seed	18.80	11.01	34.40	98.01	92.20	1023.0
Insecticide	19.04	12.10	36.04	98.21	94.40	1043.9
Baking Soda	20.2	12.04	42.12	88.90	90.08	1044.90
Variety						
DMR - ESR - Yellow	44.4	12.34	24.5	34.90	44.02	1200.0
Samma 252	64.6	14.4	28.09	38.91	49.09	2405.0
PVR SYN9 **F-Statistics**	68.8	16.09	33.32	42.44	52.23	3800.0
F pr. **LSD**	0.05 13.46**	0.01 9.80**	0.05 19.80**	0.001 18.49***	0.001 17.89***	0.001 18.90***
% CV	11.21	11.20	12.13	12.23	13.43	14.40

4.1: Conclusion

This comprehensive study provides robust empirical evidence that botanical alternatives, particularly neem (*Azadirachta indica*) derivatives and baking soda (sodium bicarbonate), are highly effective strategies for enhancing maize production within an Integrated Pest Management (IPM) framework. The results demonstrate a clear and significant positive impact across three critical domains: vegetative growth, pest suppression, and ultimate yield formation. Firstly, the treatments profoundly influenced vegetative growth throughout the crop's lifecycle. At the early stage (3 WAP), neem leaf extract established itself as the most effective growth promoter, producing significantly taller plants, thicker stems, and larger leaf areas compared to the control. This early advantage is crucial, as it establishes a stronger, more vigorous plant capable of better withstanding biotic and abiotic stresses. As the season progressed, the efficacy of the botanical treatments not only persisted but also evolved. By 8 WAP, neem leaf and baking soda resulted in the tallest plants and largest leaf areas, significantly outperforming the synthetic insecticide. The remarkable leaf area expansion, especially under the baking soda treatment, indicates enhanced photosynthetic capacity, which directly fuels growth and grain filling. The fact that the synthetic insecticide was consistently the least effective among the treatments for promoting plant height suggests that the botanical options may offer additional plant health benefits beyond mere pest control, possibly acting as biostimulants.

Secondly, the pest management data reveal a compelling narrative of increasing effectiveness over time. At 3 WAP, the primary effect was a significant reduction in plant damage, likely through antifeedant and repellent mechanisms that protected the young plants without causing immediate pest mortality.

By 6 WAP, the treatments demonstrated a highly significant and powerful suppressive effect, drastically reducing insect populations, damage, and disease incidence. The synthetic insecticide, neem leaf, and baking soda emerged as top performers. This trend culminated at 8 WAP, where neem leaf, baking soda, and the insecticide achieved complete insect control (0.0 insects) and prevented disease incidence (0.0%), showcasing their potent and reliable protective power at the most critical stage of crop development. The neem seed treatment was also highly effective, though slightly less so than the others. The untreated control plots, in stark contrast, suffered from severe and debilitating infestations, unequivocally highlighting the necessity of intervention. Finally, and most importantly, the enhanced vegetative growth and superior pest protection directly translated into quantitatively superior yields. The neem leaf treatment emerged as the unequivocal leader, producing the best results in every key yield component: cob size, cob length, cob weight, total cob weight, 1000-seed weight, and total number of seeds. This confirms that the health and protection afforded by neem leaf extract throughout the growing season allowed the plants to maximize their genetic yield potential. The significant varietal differences further underscore a critical interaction; the resistant variety PVR SYN9 demonstrated outstanding performance, suggesting that combining genetic resistance with effective botanical treatments creates a powerful synergy for sustainable production.

In conclusion, this research validates the use of neem leaf extract and baking soda as not merely alternatives but as superior strategies for maize cultivation. They effectively manage pest populations, promote healthier and more vigorous plant growth, and ultimately secure significantly higher and better-quality yields than an untreated control and even a synthetic insecticide standard.

The integration of these effective, locally available, and environmentally benign botanical solutions into IPM programs represents a sustainable, economically viable, and ecological path forward for maize farming, reducing reliance on synthetic chemicals while enhancing food security.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

The author (s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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