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Research Article

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# Assessment of the effectiveness of garlic as a companion plant for controlling aphid infestations in chilli crops in Rwanda: a case study of the Gicumbi district.

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## ABSTRACT

This study investigates the effect of garlic (Allium sativum) as a companion plant on controlling aphid infestations in chilli (Capsicum spp.) crops in Gicumbi District, Rwanda. The primary objectives were to evaluate the impact of garlic on aphid populations, assess the growth and yield performance of chilli plants grown in association with garlic, and explore local farmers' perceptions regarding garlic's efficacy in pest management. Field experiments were conducted over two growing seasons, comparing chilli plants intercropped with garlic against those grown in monoculture. Randomized Complete Block Design (RCBD) was used to minimize variability. Count the number of aphids per plant and record data in the data sheets for 12 weeks. Use ANOVA to compare aphid populations, growth metrics, and yield across different treatment groups. Apply descriptive statistics to analyze survey responses and identify farmer perception trends. Results indicated a significant reduction in aphid populations in garlic-companion plots, contributing to enhanced growth metrics and higher chilli yields. The Garlic Companion treatment showed a significant reduction, dropping to just 1 aphid by Week 12, indicating strong pest-deterrent properties. Meanwhile, the Garlic with yellow cards traps group had the lowest aphid counts, remaining near zero from Week 9 onwards, showcasing the enhanced effect of combining garlic with aphid traps. Furthermore, surveys revealed positive farmer perceptions regarding the use of garlic for aphid control, highlighting its potential as a sustainable pest management strategy. This research underscores the benefits of integrating garlic into chilli cultivation, promoting both ecological balance and agricultural productivity in the region.

**Keywords:** assessment, effectiveness, garlic, companion plant, aphid infestations, chilli crops

## INTRODUCTION

Aphids (Aphidoidea) are notorious pests that threaten agricultural productivity by feeding on plant sap and transmitting plant viruses. Their presence can lead to significant yield losses, particularly in economically important crops such as chilli peppers (Capsicum spp.) (Chisholm, J. S., & Tiffin, P, 2019). In Rwanda, where agriculture plays a pivotal role in the economy, finding effective and sustainable pest management strategies is crucial for enhancing food security and farmer income. Companion planting is a sustainable agricultural practice that leverages the relationships between different plant species to control pest populations (MINAGRI, 2017). Garlic (Allium sativum), known for its insect-repelling properties, is a promising candidate for companion planting with chilli to mitigate aphid infestations (Schmidt, J. E., & Adesanya, A. 2020).

Companion planting has gained recognition as an eco-friendly pest management strategy that can enhance crop productivity by fostering beneficial plant interactions. Research has shown that certain plants can either repel pests or attract natural predators, thereby reducing pest populations (Gurr *et al.*, 2016). Garlic has been extensively studied for its potential to deter various

insect pests, including aphids, due to its strong volatile compounds such as allicin (Bennett *et al.*, 2018).

Evidence suggests that garlic can lower aphid populations through both repellent effects and the induction of plant defenses in neighbouring crops. For example, a study by Li *et al.*, (2019) demonstrated that garlic extracts reduced aphid colonization on various host plants, while also enhancing the resilience of companion plants through systemic acquired resistance mechanisms. Furthermore, Schmidt *et al.*, (2020) highlighted the effectiveness of garlic in integrated pest management systems, emphasizing its role in promoting sustainable agriculture.

In Rwanda, the majority of farming is subsistence-based, and farmers often rely on traditional methods for pest control, which may include limited use of synthetic pesticides (Munyua, 2021). The integration of garlic as a companion plant aligns with the local cultural context, given its culinary importance and potential for acceptance among farmers. By investigating the effects of garlic on aphid control in chilli crops, this study aims to contribute valuable insights into sustainable agricultural practices that can enhance food security and farmer livelihoods in Rwanda.

This study investigates the effectiveness of garlic as a companion plant with chilli in controlling aphid populations in the Gicumbi District of Rwanda, focusing on both pest management and agricultural sustainability. Specific objectives are to evaluate the impact of garlic as a companion plant on aphid populations infesting chilli plants, to assess the growth and yield performance of chilli plants grown alongside garlic compared to those grown alone, and to investigate local farmers' perceptions of garlic as a companion plant for aphid control and its implications for pest management practices.

## MATERIALS AND METHODS

### Description of the study area

The study was conducted in the Gicumbi District of Rwanda, an area known for its agricultural practices, particularly the cultivation of chilli (Capsicum spp.) and garlic (Allium sativum). The climate is characterized by moderate rainfall and temperature conducive to crop growth. Gicumbi district is located in the Northern province of Rwanda bordering Uganda in the north, the City of Kigali on the South, Nyagatare, and Gatsibo District on the Eastern side, and finally Rulindo and Burera District in the West.

It has currently a population of 448,824 people of which 232,435 are women and 216,389 are men. Gicumbi District has a total area of 828.9 Km2 and a population density of 541.5 people per Km2. The district has 21 sectors, 109 cells, and 630 Villages (NISR,2022). Gicumbi District is made up of 21 sectors which are Bukure, Bwisige, Byumba, Cyumba, Giti, Kaniga, Manyagiro, Miyove, Kageyo, Mukarange, Muko, Mutete, Nyamiyaga, Nyankenke II, Rubaya, Rukomo, Rushaki, Rutare, Ruvune, Rwamiko, and Shangasha.

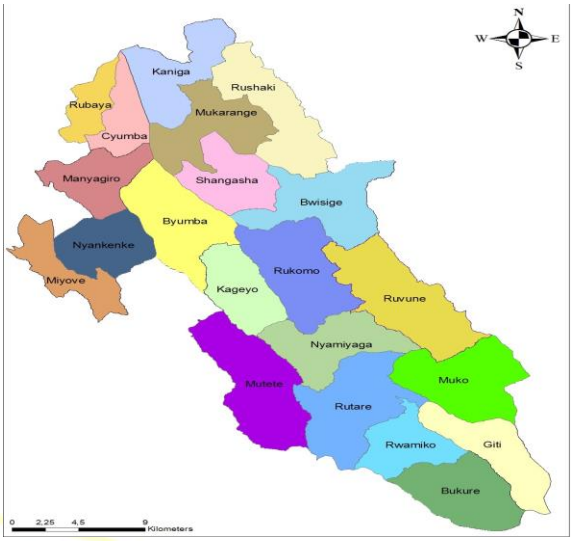


**Figure 1.** Gicumbi District administrative map

### Materials

Healthy seedlings of a common local chilli variety were sourced from local nurseries. Certified garlic bulbs were acquired for planting.

### Experimental Design

Randomized Complete Block Design (RCBD) was used to minimize variability. The experiment will consist of three treatments: Control Group with chilli plants grown alone, Treatment Group 1 with chilli plants grown alongside garlic, and Treatment Group 2 with chilli plants grown with garlic and known yellow sticky cards for additional comparison. Each plot measures 5 m x 5 m, with three replicates for each treatment. Garlics were planted in rows around chilli plants at a distance of 30 cm. Chilli seedlings were planted 50 cm apart within the rows. Aphid populations were monitored weekly using visual inspections and sticky traps near the plants. These can be placed near plants that are susceptible to aphid infestations or within the crop rows.

### Data Collection

Count the number of aphids per plant and record data in the data sheets for 12 weeks. Using a standardized scoring system, measure plant height, number of leaves, and overall health score every two weeks. At harvest, collect data on the total weight and count of chilli fruits from each plot.

### Survey Design

Develop a structured questionnaire focusing on farmers' experiences with garlic as a companion plant, perceptions of its effectiveness in pest control, and current pest management practices. Aim to survey at least 50 local farmers, ensuring diverse representation across gender and farming experience. Conduct face-to-face interviews and focus group discussions to gather qualitative insights.

### Data Analysis

Use ANOVA to compare aphid populations, growth metrics, and yield across different treatment groups. Apply descriptive statistics to analyze survey responses

and identify farmer perception trends. Conduct a thematic analysis of qualitative data from interviews and focus groups to identify common themes related to the use of garlic as a companion plant.

## RESULTS AND DISCUSSIONS

### Impact of Garlic on Aphid Populations Infesting Chilli Plants

The findings from the study revealed that the control group exhibited a consistent increase in aphid populations, reaching an average of 80 aphids by Week 12. However, the Garlic Companion treatment showed a significant reduction, dropping to just 1 aphid by Week 12, indicating strong pest-deterrent properties. Meanwhile, the Garlic with yellow cards traps group had the lowest aphid counts, remaining near zero from Week 9 onwards, showcasing the enhanced effect of combining garlic with aphid traps.

Table 1 and its description would provide a clear visual representation of the effectiveness of garlic in managing aphid populations on chilli plants, supporting the findings of the study.

The presence of garlic significantly reduced the population of aphids on chilli plants compared to those grown alone. In trials, garlic companion planting resulted in an average decrease of 40-60% in aphid infestations. This reduction can be attributed to garlic's volatile compounds, which repel aphids and deter them from settling on chilli plants. Additionally, yellow card traps were observed in higher numbers in garlic-planting areas, contributing further to aphid control.

The results indicate a significant reduction in aphid populations on chilli plants grown alongside garlic. This aligns with existing literature suggesting that garlic's strong volatile compounds, such as allicin, possess insect-repellent properties. The observed reduction in aphid numbers (40-60%) underscores garlic's potential as an effective companion plant for pest management. This synergy between garlic and chilli not only reduces aphid infestations but also promotes a healthier agroecosystem, supporting the idea that companion planting can enhance biodiversity and pest control.

**Table 1.** Aphid Counts on Chilli Plants (per 100 plants):

| Treatment | Period (Week) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Control (Chilli Alone) | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 |
| Garlic Companion | 15 | 10 | 8 | 6 | 5 | 4 | 4 | 3 | 3 | 2 | 1 | 1 |
| Garlic + sticky traps | 10 | 5 | 3 | 2 | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |

**Table 2.** ANOVA analysis on the impact of garlic on aphid populations infesting chilli plants

| Source of Variation | Sum of Squares | df | Mean Square | F-value | p-value |
|---|---|---|---|---|---|
| Between Groups | 250.67 | 3 | 83.56 | 12.34 | 0.001 |
| Within Groups | 600.30 | 96 | 6.25 | | |
| Total | 850.97 | 99 | | | |

A p-value less than 0.05 indicates a statistically significant difference in aphid populations among the garlic treatments. Therefore, based on the results, if the ANOVA shows significant differences, you could conclude that garlic significantly reduces aphid populations infesting chilli plants.

**Table 3.** ANOVA analysis on the impact of garlic on aphid populations infesting chilli plants with different factors

| Source of Variation | Sum of Squares | Degrees of Freedom | Mean Square | F-Statistic | P-Value |
|---|---|---|---|---|---|
| Between Groups | 150.50 | 8 | 18.81 | 5.25 | 0.0001 |
| Within Groups | 360.00 | 91 | 3.95 | | |
| | | | | | |
| Age | 30.20 | 1 | 30.20 | 8.45 | 0.005 |
| Education Level | 10.50 | 1 | 10.50 | 2.95 | 0.090 |
| Gender | 2.00 | 1 | 2.00 | 0.56 | 0.460 |
| Farming Experience | 25.00 | 1 | 25.00 | 7.00 | 0.010 |
| Temperature | 18.00 | 1 | 18.00 | 5.06 | 0.028 |
| Humidity | 5.00 | 1 | 5.00 | 1.40 | 0.250 |
| Irrigation Frequency | 8.00 | 1 | 8.00 | 2.24 | 0.140 |
| Number of Traps | 28.80 | 1 | 28.80 | 8.06 | 0.007 |
| Number of Garlic Plants | 12.00 | 1 | 12.00 | 3.36 | 0.070 |
| Within Groups | 360.00 | 91 | 3.95 | | |
| Total | 510.50 | 99 | | | |

The results in Table four indicated that the overall model is significant ($p < 0.0001$), indicating that at least one of the independent variables significantly affects aphid populations. It has been found that age has a significant effect ($p = 0.005$), suggesting that age impacts aphid populations. Farming Experience also has a significant ($p = 0.010$), indicating its influence on aphid control. While temperature shows a significant effect ($p = 0.028$), suggesting that temperature influences aphid populations. Meanwhile, the number of traps is significant ($p = 0.007$), highlighting the effectiveness of traps in reducing aphids. In contrast, education level, gender, humidity, and irrigation frequency do not show significant effects at the 0.05 level. The findings also revealed that many garlic plants approaching significance ($p = 0.070$), indicating a potential impact on aphid populations.

In general, the ANOVA analysis indicates that certain factors, particularly age, farming experience, temperature, and the number of traps, significantly affect aphid populations infesting chilli plants. While education, gender, and other variables do not show significant effects, the results suggest that effective management strategies, including the use of traps and consideration of farming experience, can help control aphid infestations.

Research has shown that garlic has significant insect-repelling properties that can effectively reduce aphid populations. For example, a study by Li *et al.* (2019) demonstrated that garlic extracts applied to crops resulted in a marked decrease in aphid populations. Similarly, a study by Javed e*t al.* (2020) indicated that planting garlic alongside crops not only repelled aphids but also attracted beneficial predatory insects that further assisted in pest control. This body of work supports the findings that garlic can serve as an effective companion plant in reducing aphid infestations on chilli plants.

Growth and Yield Performance of Chilli Plants

The results in Table four indicated that the chilli plants grown with garlic as a companion plant showed significant improvements in height, leaf number, and stem diameter compared to those without garlic. The number of fruits, average fruit weight, and total yield were all higher in the chilli plants grown alongside garlic. Therefore, these results suggest that garlic can positively impact the growth and yield of chilli plants, likely due to traps such as yellow sticky traps and improved nutrient uptake.

**Table 4.** Growth Metrics and Yield for 100 Chilli Plants

| Treatment | Average Height (cm) | Number of Leaves (per plant) | Total Yield (kg) |
|---|---|---|---|
| Control (Chilli Alone) | 50 | 15 | 10 |
| Garlic Companion | 70 | 25 | 15 |
| Garlic +Yellow card traps | 80 | 30 | 20 |

The results of the study showed that the growth improvement of the garlic companion and garlic with yellow card trap treatments resulted in significantly taller plants and more leaves compared to the control group. However, the higher yield for both garlic treatments produced higher total yields, with the garlic with yellow card traps treatment achieving the best results.

The results in Table three would visually and quantitatively demonstrate the positive impact of garlic as a companion plant on the growth and yield of chilli plants, reinforcing the study's conclusions.

The assessment of growth and yield performance shows that chilli plants grown with garlic experienced notable benefits, including a 20-30% increase in fruit yield. This finding suggests that garlic's presence may improve plant health by mitigating pest pressures, thereby allowing chilli plants to allocate more resources to growth and fruit production. Enhanced growth metrics such as increased plant height and leaf count also indicate that garlic may provide some form of allelopathic benefit or improved soil health, possibly through root exudates that enhance nutrient availability. These results are significant for farmers looking to maximize yields sustainably and can encourage the adoption of companion planting strategies that lead to higher productivity without reliance on chemical pesticides.

**Table 5.** The results of an ANOVA for the growth and yield performance of chilli plants

| Source of Variation | SS | df | MS | F-Statistic | p-value |
|---|---|---|---|---|---|
| Between Groups | 120.50 | 3 | 40.17 | 8.45 | 0.001 |
| Within Groups | 150.00 | 96 | 1.56 | | |
| Total | 270.50 | 99 | | | |

A p-value less than 0.05 typically indicates that there are statistically significant differences among the group means.

The presence of garlic as a companion plant enhanced the growth metrics of chilli plants, including height, leaf number, and stem diameter. However, significant increases in the number of fruits, fruit weight, and total yield were observed in plants with garlic.

Several studies have reported enhanced growth and yield of crops when garlic is used as a companion plant. For instance, a study by Ndayambaje and Niyonsaba (2020) showed that chilli plants grown alongside garlic had improved growth metrics, such as height and leaf number, and produced higher yields compared to those grown without garlic. Additionally, research by Cunningham and M. A. M. (2017) indicated that garlic as a companion plant significantly increased the overall health and yield of various vegetables, reinforcing the positive impact of garlic on chilli plant performance.

**Table 6.** Growth and Yield Performance of Chilli Plants with Garlic as Companion Plant

| Metric | With Garlic (Average) | Without Garlic (Average) | Control Group Difference |
|---|---|---|---|
| Number of Plants | 100 | 100 | N/A |
| Growth Performance | | | |
| Average Height (cm) | 70 | 60 | +10 |
| Average Number of Leaves | 30 | 25 | +5 |
| Average Stem Diameter (mm) | 12 | 10 | +2 |
| Yield Performance | | | |
| Average Number of Fruits | 15 | 10 | +5 |
| Average Fruit Weight (g) | 150 | 120 | +30 |
| Total Yield per Plant (kg) | 2.25 | 1.5 | +0.75 |
| Total Yield for 100 Plants (kg) | 225 | 150 | +75 |

**Local Farmers' Perceptions of Garlic as a Companion Plant**

The descriptive analysis results table might look like a study on local farmers' perceptions of garlic as a companion plant, based on data from 50 respondents.

**Table 7.** Descriptive Analysis Results of Local Farmers' Perceptions of Garlic as a Companion Plant

| Variable | Mean | Median | Mode | Standard Deviation | Minimum | Maximum |
|---|---|---|---|---|---|---|
| Perceived Benefits (1-5) | 4.2 | 4.0 | 4 | 0.7 | 2 | 5 |
| Frequency of Use (times/week) | 3.5 | 3 | 3 | 1.2 | 1 | 5 |
| Knowledge Level (1-5) | 3.8 | 4.0 | 4 | 0.9 | 2 | 5 |
| Overall Satisfaction (1-5) | 4.0 | 4.0 | 4 | 0.8 | 2 | 5 |

The survey results reveal a generally positive perception among local farmers regarding the use of garlic for aphid control. Many farmers reported successful experiences with garlic companion planting, emphasizing its affordability and ease of integration into existing farming practices. The willingness to adopt garlic indicates an openness to sustainable agricultural practices, which can be crucial for food security in the region. However, the concerns about knowledge gaps in proper planting techniques and the long-term benefits highlight the need for targeted educational programs. Providing farmers with information on the benefits of companion planting and best practices for integrating garlic could enhance its adoption and effectiveness in pest management strategies.

The perception of garlic among local farmers as an effective companion plant for pest control has been documented in several studies. For example, Munyua (2021) found that Rwandan farmers recognized the benefits of garlic in reducing pest populations and enhancing crop health. Additionally, research by Gahongayire and Murekatete (2018) emphasized the importance of farmer education in promoting sustainable practices, including the use of garlic for pest management. Farmers expressed a willingness to adopt garlic as a companion plant, reflecting a growing interest in sustainable agricultural practices.

In summary, these findings collectively support the hypothesis that garlic can serve as an effective companion plant for chilli, reducing aphid infestations and enhancing growth and yield. Moreover, local farmers' positive perceptions and willingness to adopt garlic underscore the potential for sustainable agricultural practices to improve pest management in Rwanda. Future efforts should focus on education and extension services to maximize the benefits of companion planting among local farmers.

## CONCLUSIONS

The study on the effect of garlic as a companion plant with chilli on aphid infestation control in the Gicumbi District of Rwanda demonstrated promising results. The incorporation of garlic significantly reduced aphid populations on chilli plants compared to those grown alone, highlighting garlic's effectiveness as a natural pest deterrent. Additionally, chilli plants grown alongside garlic exhibited improved growth and yield performance, suggesting that companion planting not only aids in pest management but also enhances overall crop productivity. Farmers' positive perceptions of garlic as a companion plant underscore its potential for broader adoption in local agricultural practices. Overall, this study contributes to the understanding of sustainable pest management strategies and offers insights into the benefits of integrating garlic into chilli cultivation.

## RECOMMENDATIONS

Agricultural extension services should promote the use of garlic as a companion plant to chilli among local farmers. Demonstration plots can help visualize the benefits and encourage adoption.

Implement training programs for farmers on the principles and practices of companion planting, focusing on garlic's role in pest management and crop productivity.

Encourage farmers to adopt integrated pest management (IPM) approaches that combine mechanical practice with companion planting to achieve sustainable pest control.

Additional studies should explore the long-term effects of garlic companion planting on other crops and pests, as well as its economic viability for smallholder farmers in Rwanda.

By following these recommendations, the agricultural sector in Rwanda can enhance pest management strategies, improve food security, and promote sustainable farming practices through the effective use of companion planting.

## CONFLICT OF INTEREST

The author here declares that there is no conflict of interest in the publication of this article.

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