
*Asian Journal of Research in Crop Science*

***7(4): 14-22, 2022; Article no.AJRCS.92261***
***ISSN: 2581-7167***

# Influence of Plant Spacing and Intercropping on the Growht and Septoria Leaf Spot of Tomato (*Lycopersicon esculentum* Mill)

**E. M. Nwokeji [a*], V. E. Ogwudire [a], L. C. Emmanuel-Okafor [a], C. A. Peter-Onoh [a], S. E. Okere [a], P. C. Anyanwu [a], C. M. Agu [a] and G. O. Ihejirika [a]**

*[a] Department of Crop Science and Technology, School of Agriculture and Agricultural Technology, Federal University of Technology, Owerri, Imo State, Nigeria.*

***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

***Article Information***

DOI: 10.9734/AJRCS/2022/v7i4141

**Open Peer Review History:**
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/92261

***Original Research Article***

***Received 23 July 2022***
***Accepted 29 September 2022***
***Published 07 October 2022***

## ABSTRACT

The influence of plant spacing and intercropping on the growth and septoria leaf spot disease incidence and severity of tomato were studied in Owerri, the south east of Nigeria, in the year 2011.The study was designed as a 4x4 factorial in a Randomized Complete Block Design with three (3) replications. Data on growth parameters and septoria leaf spot disease incidence and severity of tomato were collected and statistically analyzed by using Gensat version 4 analytical software, while the means were separated for difference using Fisher's Least Significant Difference Protocol. The result showed a significant ($P<0.05$) reduction of septoria leaf spot disease incidence to 0.00% by intercropping at the distance of 75 x 50 cm under tomato sole cropping arrangement. The intercrop combination of tomato/groundnut/soybean also significantly ($P<0.05$) reduced septoria leaf spot disease incidence (6.7%) under the spacing of 100 x 75 cm. Intercropping significantly ($P<0.05$) influenced septoria leaf spot disease severity at 6 weeks of transplanting. Similarly, plant spacing of 75 x 50 cm and under the tomato sole crop arrangement significantly reduced the tomato septoria leaf spot disease severity.

*Keywords: Septoria leaf; disease; plant spacing; tomato.*

**Corresponding author: E-mail: ephraimmaduako@yahoo.com;*

## 1. INTRODUCTION

Tomato (*Lycopersicon esculentum* MILL) belongs to the family of Solanaceae or Night Shade [1]. Jones et al. [2] described tomato as a recently adopted food crop that has achieved prominence and popularity. Its versatility in fresh and processed form and its adaptability have played major roles in its rapid and widespread use [2]. For example, tomatoes are a valuable source of food, minerals and vitamins , notably vitamins A and C. Gould [1] recognized tomato as an excellent source of lycopene which plays a medicinal role in the treatment of cancer disease. A medium-size ripe tomato can provide up to 40% of the Recommended daily Allowance of vitamin C and 20% of vitamin A [3].

The production of tomato is fraught with both pests and diseases. Tomato is more susceptible to numerous plant infections than other vegetables. At least twenty-five diseases infect the tomato plant [4]. Among the diseases that attack the tomato plant include vascular wilt, caused by *Fusarium oxysporum* [5], verticillium wilt, caused by *Verticillium albo-atrum* and *V. dahlia* [2], septoria leaf spot or septoria blight, caused by *Septoria lycopersici* [2], etc.

Septoria leaf spot has been described as one of the most destructive diseases of tomato foliage and widely distributed throughout the world wherever tomato is grown, and crop losses of up to 100% have been recorded in heavily defoliated fields [2,6]. Sharon [6] listed many approaches to the management of the effects of septoria leaf spot to include sanitary, cultural, and chemical methods. Ploet [7] reported the availability of fungicidal control of plant diseases and their disadvantages as, their expensive nature, high risk of environmental pollution and human and animal hazards. The emphases of many authors [2,6] on sanitary and cultural methods have dwelt specifically on elimination of initial sources of inoculum by destroying or removing debris, use of healthy and disease – free transplants, crop rotation, avoidance of overhead watering, control of susceptible weeds (e.g. Horse nettle) and staking of plants to improve air circulation and reduction of the contact between foliage and soil.

Athough some works have been done on the effects and management of crop diseases through plant spacing [8-14], specific attention was not directed to the control and management of septoria leaf spot of tomato. This paper, therefore, seeks to address this gap by determining the effects of plant spacing (density) and intercropping in the management of septoria leaf spot disease of tomato [15].

## 2. MATERIALS AND METHODS

This study was carried out in the 2011 cropping season at the Teaching and Research Farm of the Department of Crop Science and Technology, Federal University of Technology, Owerri, Imo State, Nigeria (5.4891$^0$N and 7.025853E). The study area is typical of the tropical environment with the following characteristics: heavy bimodal rainfall pattern, with mean annual rainfall of about 3,500 mm, spanning a period from March to October, with a short dry spell (August Break). The minimum and maximum mean annual temperatures are 22.5$^0$C and 31.9$^0$C, respectively [16,17].

The test (or main) crop, tomato (ROMA VF) was obtained from International Institute of Tropical Agriculture (IITA), Nigeria, and was intercropped with groundnut (*Arachis hypogaea*), soybean (*Glycine max*) and okra (*Abelmoschus esculentus*) which were obtained from the Imo State Agricultural Development Project, Owerri, Nigeria (the dwarf cultivar). The experiment was set up as a 4 x4 factorial in a Randomized Complete Block Design (RCBD), with three (3) replications (48 plots or treatment combinations). The treatments comprised (i). four levels of factor A : plants for the intercrop – $A_1$, $A_2$, $A_3$, $A_0$ ; (ii) four levels of factor B : plant spacing – $B_1$, $B_2$, $B_3$, $B_4$.

Where,

$A_1$: Groundnut + tomato + soybean
$A_2$ = Tomato + groundnut + soybean
$A_3$ = Soybean + tomato + okra
$A_0$ = Tomato sole
$B_1$= 100 x 75 cm
$B_2$ = 75 x 50 cm
$B_3$ = 50 x 50 cm
$B_4$ = 50 x 25 cm

The 16 treatment combinations are as follows:

$A_1B_1$= Groundnut + tomato (100 x 75cm) + okra
$A_2B_1$ = Tomato (100x 75cm) + Groundnut + soybean
$A_3B_1$= Soybean + tomato (100 x 75cm) okra
$A_0B_1$= Tomato sole (100 x 75cm)
$A_1B_2$ = Groundnut + tomato (75 x 50cm) + okra
$A_2B_2$ = Tomato (75 x 50cm) + groundnut + soybean

$A_3B_2$ = Soybean + tomato (75 x 50cm) + okra
$A_0B_2$ = Tomato sole (75 x 50cm)
$A_1B_3$ = Groundnut + tomato (50x50cm) + okra
$A_2B_3$ = Tomato (50x 50cm) + groundnut + soybean
$A_3B_3$ = Soybean + tomato (50 x 50)+okra
$A_0B_3$ = Tomato sole (50 x 50cm)
$A_1B_4$ = Groundnut + tomato (50 x 25cm) okra
$A_2B_4$ = Tomato (50 x 25cm)+ groundnut + soybean
$A_3B_4$ = Soybean + tomato (50x 25cm) + okra
$A_0B_4$ = Tomato sole (50 x 25cm)

The treatments were randomly assigned to the experimental plots by the random numbers [18]. Each block was separately randomized.

### 2.1 Transplanting of Seedlings to the Experimental Plots

ROMA VF tomato cultivars were transplanted in the month of June, 2011. The four spacing distances were 50 x 25cm, 50 x 50cm, 75 x 50 cm and 100 x 75 cm, giving the equivalent plant populations of 80,000, 40,000, 26,667 and 13,333 plants ha$^{-1}$, respectively. The components of intercrops (groundnut, soybean, and okra seeds), were sown in situ between the test (main) crop, tomato, three days after transplanting. Three seeds were planted, and later thinned out to two plants per stand, two weeks of planting.

## 3. RESULTS AND DISCUSSION

Table 1 shows the influence of plant spacing and intercropping on the height (cm) of tomato per plant. Data on tomato plant height were not significantly (P>o.0.05) affected by plant spacing and intercropping. However, interaction effects occurred in the 8$^{th}$ week, where tomato plant heights were significantly (P<0.05) influenced by interactions between spacing and intercropping. The height of tomato at the spacing of 100 x 75 cm and in combination with groundnut and okra, recorded the tallest plant (38.7 cm) at the 8 weeks of transplanting. This is the tallest tomato plant among different intercrops, followed by the tomato plant at the spacing of 50 x 25cm (38.3 cm) at the 8 weeks of transplanting in the same week. Raveneet et al. [19] reported the existence of minimal crop competition among crops in reduced plant density, which gives rise to tall plants in the same row. In this case crops in the intercrops are exposed to more available plant nutrients. However, some authors have reported significant increase in plant heights as a result of higher plant density [20]. Wu et al. [21] explained this to be as a result of maximum light interception due to high density, which results to high growth rate and crop biomass.

The influence of plant spacing and intercropping on the number of tomato leaves was shown in Table 2. The number of leaves differed among treatments. However, the number of leaves was not significantly (P>0.05) affected by spacing and intercropping in all the weeks of transplanting. Similarly, spacing and intercropping did not significantly (P>0.05) influence the number of tomato leaves in all the weeks after transplanting. The number of tomato leaves was highest (12.67) under soybean/tomato/okra intercrop at the plant density of 50 x 50 cm in the last week of transplanting. In the same way, the least number of leaves (3.33) was recorded in the 8 weeks of transplanting. Further studies in order to investigate the effects of spacing and intercropping on the number tomato leaves is recommended.

**Table 1. Effects of plant spacing and intercropping on the height (cm) of tomato 2011**

| | **2 WAT Intercropping** | | | | |
|---|---|---|---|---|---|
| **Spacing** | **Gnut/ tomato/ okra** | **Tomato/ gnut/sbean** | **Sbean/ tomato/ okra** | **Tomato sole** | **Mean of spacing** |
| 100x75 | 16.17 | 15.13 | 11.37 | 11.03 | 13.43 |
| 75x50 | 11.17 | 14.90 | 10.90 | 12.33 | 12.47 |
| 50x50 | 13.20 | 13.80 | 10.90 | 11.00 | 12.22 |
| 50x25 | 18.77 | 15.00 | 15.53 | 12.00 | 15.32 |
| Mean of intercropping | 14.96 | 14.71 | 12.18 | 11.59 | |

LSD $_{(0.05)}$ for spacing= ns,
LSD $_{(0.05)}$ for intercropping= ns,
LSD $_{(0.05)}$ for spacing x intercropping= ns

| | 2 WAT Intercropping | | | | |
|---|---|---|---|---|---|
| **Spacing** | **Gnut/ tomato/ okra** | **Tomato/ gnut/sbean** | **Sbean/ tomato/ okra** | **Tomato sole** | **Mean of spacing** |
| **Spacing** | | | **4WAT** | | |
| 100x75 | 26.7 | 2.05 | 30.1 | 27.9 | 26.3 |
| 75x50 | 17.4 | 18.4 | 23.0 | 19.0 | 19.5 |
| 50x50 | 25.6 | 20.3 | 14.5 | 25.0 | 21.4 |
| 50x25 | 22.7 | 18.2 | 27.4 | 17.9 | 21.6 |
| Mean of intercropping | 23.1 | 19.4 | 23.8 | 22.5 | |
| LSD $_{(0.05)}$ for spacing= ns, LSD $_{(0.05)}$ for intercropping= ns, LSD $_{(0.05)}$ for spacing x intercropping= ns | | | | | |
| **Spacing** | | | **6WAT** | | |
| 100x75 | 11.00 | 10.33 | 6.33 | 11.00 | 9.67 |
| 75x50 | 6.00 | 8.67 | 9.00 | 5.00 | 7.17 |
| 50x50 | 11.67 | 8.33 | 6.67 | 8.67 | 8.83 |
| 50x25 | 6.00 | 8.67 | 12.33 | 9.33 | 9.08 |
| Mean of intercropping | 8.67 | 9.00 | 8.58 | 8.50 | |
| LSD $_{(0.05)}$ for spacing= ns, LSD $_{(0.05)}$ for intercropping= ns, LSD $_{(0.05)}$ for spacing x intercropping= ns | | | | | |
| **Spacing** | | | **8WAT** | | |
| 100x75 | 38.7 | 8.0 | 19.4 | 33.3 | 24.8 |
| 75x50 | 11.0 | 20.0 | 27.7 | 0.0 | 14.7 |
| 50x50 | 22.6 | 21.0 | 10.6 | 26.0 | 20.0 |
| 50x25 | 15.5 | 17.9 | 38.3 | 15.8 | 21.9 |
| Mean of intercropping | 22.0 | 16.7 | 21.0 | 18.8 | |
| LSD $_{\mathbf{(0.05)}}$ for spacing= ns, LSD $_{(0.05)}$for intercropping =ns, LSD $_{(0.05)}$ for spacing x intercropping =25.62 | | | | | |

**Table 2. Effects of plant spacing and intercropping on the number of tomato leaves per plant in 2011**

| | 2 WAT Intercropping | | | | |
|---|---|---|---|---|---|
| **Spacing** | **Gnut/ tomato/ okro** | **Tomato/gnut/sbean** | **Sbean/ tomato/ okro** | **Tomato sole** | **Mean of spacing** |
| 100x75 | 5.00 | 4.67 | 4.67 | 6.00 | 5.08 |
| 75x50 | 4.33 | 5.33 | 4.67 | 5.33 | 4.92 |
| 50x50 | 5.33 | 4.33 | 4.33 | 4.33 | 4.58 |
| 50x25 | 6.00 | 5.00 | 5.67 | 5.00 | 5.42 |
| Mean of intercropping | 5.17 | 4.83 | 4.83 | 5.17 | |
| LSD $_{(0.05)}$ for spacing= ns, LSD $_{(0.05)}$ for intercropping= ns, LSD $_{(0.05)}$ for spacing x intercropping= ns | | | | | |
| | | | **4WAT** | | |
| 100x75 | 7.67 | 7.00 | 8.00 | 9.67 | 8.08 |
| 75x50 | 8.00 | 7.33 | 7.67 | 7.33 | 7.58 |
| 50x50 | 8.67 | 7.00 | 6.00 | 8.00 | 7.42 |
| 50x25 | 8.33 | 7.33 | 9.67 | 7.67 | 8.25 |
| Mean of intercropping | 8.17 | 7.17 | 7.83 | 8.17 | |

| | 2 WAT Intercropping | | | | |
|---|---|---|---|---|---|
| **Spacing** | **Gnut/ tomato/ okro** | **Tomato/gnut/sbean** | **Sbean/ tomato/ okro** | **Tomato sole** | **Mean of spacing** |
| LSD $_{(0.05)}$ for spacing= ns, LSD $_{(0.05)}$) for intercropping=ns, LSD$_{(0.05)}$ for spacing x intercropping=ns | | | | | |
| | | | **6WAT** | | |
| 100x75 | 11.00 | 10.33 | 6.33 | 11.00 | 9.67 |
| 75x50 | 6.00 | 8.67 | 9.00 | 5.00 | 7.17 |
| 50x50 | 11.67 | 8.33 | 6.67 | 8.67 | 8.83 |
| 50x25 | 6.00 | 8.67 | 12.33 | 9.33 | 9.08 |
| Mean of intercropping | 8.67 | 9.00 | 8.58 | 8.50 | |
| LSD ($_{0.05)}$ for spacing= ns, LSD$_{(0.05)}$for intercropping= ns, LSD$_{(0.05)}$ for spacing x intercropping= ns | | | | | |
| **Spacing** | | | **8WAT** | | |
| 100x75 | 10.33 | 2.67 | 9.00 | 11.33 | 8.33 |
| 75x50 | 8.33 | 8.67 | 10.00 | 3.33 | 7.58 |
| 50x50 | 9.33 | 6.33 | 6.33 | 10.33 | 8.08 |
| 50x25 | 6.00 | 9.00 | 12.67 | 11.00 | 9.67 |
| Mean of intercropping | 8.50 | 6.67 | 9.50 | 9.00 | |
| LSD $_{(0.05)}$for spacing =ns, LSD $_{(0.05)}$ for intercropping= ns, LSD$_{(0.05)}$for spacing x intercropping =ns | | | | | |

**Table 3. Effects of plant spacing and intercropping on tomato Septoria leaf spot disease incidence (%) per plot in 2011**

| | 2 WAT intercropping | | | | |
|---|---|---|---|---|---|
| **Spacing** | **Gnut/ tomato/ okra** | **Tomato/ gnut/sbean** | **Sbean/ tomato/ okra** | **Tomato sole** | **Mean of spacing** |
| 100x75 | 36.7 | 13.3 | 48.4 | 22.2 | 30.2 |
| 75x50 | 2.7 | 39.5 | 38.4 | 27.9 | 37.1 |
| 50x50 | 25.7 | 22.3 | 15.9 | 37.2 | 25.3 |
| 50x25 | 22.2 | 43.2 | 27.4 | 37.8 | 32.7 |
| Mean of intercropping | 31.8 | 29.6 | 32.5 | 31.3 | |
| LSD $_{(0.05)}$ for spacing= ns , LSD $_{(0.05)}$forintercropping =ns, LSD $_{(0.05)}$ forspacing x intercropping =ns | | | | | |
| **Spacing** | | | **4WAT** | | |
| 100x75 | 50.3 | 30.0 | 30.7 | 33.4 | 36.1 |
| 75x50 | 27.6 | 35.9 | 30.3 | 31.4 | 31.4 |
| 50x50 | 40.5 | 46.7 | 47.7 | 30.6 | 41.4 |
| 50x25 | 36.6 | 31.1 | 39.2 | 44.5 | 37.8 |
| Mean of intercropping | 38.7 | 35.9 | 37.0 | 35.0 | |
| LSD $_{(0.05)}$ for spacing= ns , LSD $_{(0.05)}$ forintercropping= ns, LSD$_{(0.05)}$forspacing x intercropping =ns | | | | | |

| | 2 WAT intercropping | | | | |
|---|---|---|---|---|---|
| **Spacing** | **Gnut/ tomato/ okra** | **Tomato/ gnut/sbean** | **Sbean/ tomato/ okra** | **Tomato sole** | **Mean of spacing** |
| **Spacing** | | | **6WAT** | | |
| 100x75 | 44.5 | 17.9 | 31.5 | 28.8 | 30.7 |
| 75x50 | 32.0 | 41.7 | 22.3 | 13.9 | 27.5 |
| 50x50 | 33.4 | 32.4 | 41.7 | 28.7 | 34.1 |
| 50x25 | 36.1 | 40.8 | 38.9 | 32.4 | 37.1 |
| Mean of intercropping | 36.5 | 33.2 | 33.6 | 26.0 | |
| LSD $_{(0.05)}$ for spacing= ns , | | | | | |
| LSD $_{(0.05)}$ forintercropping =ns, | | | | | |
| LSD $_{(0.05)}$forspacing x intercropping =ns | | | | | |
| **Spacing** | | | **8WAT** | | |
| 100x75 | 24.1 | 6.7 | 37.8 | 8.4 | 19.2 |
| 75x50 | 19.5 | 44.5 | 29.7 | 0.0 | 23. 4 |
| 50x50 | 19.5 | 15.3 | 22.3 | 13.0 | 17.5 |
| 50x25 | 16.8 | 18.6 | 29.6 | 15.8 | 20.2 |
| Mean of intercropping | 20.0 | 21.2 | 29.8 | 9.3 | |
| LSD $_{(0.05)}$ for spacing= ns**,** | | | | | |
| LSD $_{(0.05)}$for intercropping =14.08, | | | | | |
| LSD$_{(0.05)}$ for spacing x intercropping= ns | | | | | |

Table 3 illustrates the influence of spacing and intercropping on the septoria leaf spot disease incidence (%) of tomato per plot. The analysis of variance indicated no significant (P>0.05) difference in the interaction between spacing and intercropping in all the weeks of transplanting. On the other hand, intercropping significantly (P<0.05) affected the septoria leaf spot disease incidence at 8$^{th}$ week of transplanting. Furthermore, in the result, intercropping significantly (P<0.05) reduced the septoria leaf spot disease incidence to 0.00% under 75 x 50 cm spacing distance under sole cropping. In the 8 weeks of transplanting, the highest septoria leaf spot disease incidence (44.5%) was observed in tomato/groundnut/soybean crop combination at the crop density of 75 x 50 cm. Tomato/groundnut/soybean intercrop also significantly (P<0.05) reduced septoria leaf spot disease incidence (6.7%) under 100 x 75 cm spacing.. This is less than 8.4% leaf spot disease incidence in the same distance regime in the sole cropping pattern.

From the foregoing, there was no correlation between the leaf spot incidence and the interaction between plant spacing and intercropping; whereas intercropping exhibited a correlation with leaf spot incidence, lower densities of 75 x 50 cm and 100 x 75 cm positively correlated with the septoria leaf spot disease incidence. This means the less plants in a population, the less disease incidence and vise versa. This is corroborated by Burdon and Chilvers [22] who stated that higher local plant densities can directly increase disease prevalence as a result of more susceptible individuals crowded together , thereby, facilitating transmission.

Table 4 shows the influence of spacing and intercropping on the tomato septoria leaf spot disease severity. Analysis of variance showed that intercropping significantly (P<0.05) influenced the septoria leaf spot disease severity at 6 weeks of transplanting. Intercropping significantly (P<0.05) reduced the septoria leaf spot disease severity to 28.3 in tomato sole cropping at the spacing distance of 75 x 50 cm. This was followed by a reduction of 33.4 under tomato sole cropping and at the spacing of 50 x 50 cm, at 6 weeks of transplanting. The highest septoria leaf spot disease severity (79.4) was observed at 100 x 75 cm spacing distance, under the intercrop of tomato/groundnut/soybean at 6 weeks of transplanting. The significant effects occurred only at the 6 weeks of transplanting. Septoria leaf spot disease severity was not significantly (P>0.05) influenced by plant spacing in all the weeks, while intercropping also did not significantly (P>0.05) affect septoria leaf spot disease severity in weeks 2, 4, and 6.Similarly, spacing and intercropping interactions did not significantly (P>0.05) affect septoria leaf spot disease severity.

In this study, septoria leaf spot disease severity was lowest when tomato was planted alone (28.3). Higher septoria leaf disease severity was recorded in lower density of 100 x 75 cm under tomato/groundnut/soybean intercrop. This means that smaller number of tomato in a population increased septoria leaf spot disease severity. This is at variance with Ihejirika [23] who reported high disease severity as a result of high crop density. In the study, also, sole cropping resulted to lowest septoria leaf spot disease severity. This could be explained as a result of absence or limited cross – infection from other surrounding crops in a plot .However, other authors [24], reported a reverse effect by intercropping where significant disease reduction occurred as a result of intercropping.

**Table 4. Effects of plant spacing and intercropping on the tomato Septoria leaf spot disease severity per plot in 2011**

| | **2 WAT Intercropping** | | | | |
|---|---|---|---|---|---|
| **Spacing** | **Gnut/ tomato/ okra** | **Tomato/ gnut/sbean** | **Sbean/ tomato/ okra** | **Tomato sole** | **Mean of spacing** |
| 100x75 | 46.6 | 16.7 | 48.9 | 35.3 | 36.9 |
| 75x50 | 53.4 | 38.8 | 58.9 | 48.9 | 50.0 |
| 50x50 | 27.9 | 33.3 | 40.0 | 35.6 | 34.2 |
| 50x25 | 24.1 | 48.9 | 15.9 | 53.3 | 35.6 |
| Mean of intercropping | 38.0 | 34.4 | 40.9 | 43.3 | |
| LSD $_{(0.05)}$for spacing =ns ,<br>LSD $_{(0.05)}$) for intercropping= ns,<br>LSD $_{(0.05)}$forspacing x intercropping=ns | | | | | |
| **Spacing** | | | **4WAT** | | |
| 100x75 | 48.5 | 67.2 | 64.1 | 58.1 | 59.5 |
| 75x50 | 52.6 | 37.0 | 52.3 | 51.1 | 48.3 |
| 50x50 | 50.0 | 47.6 | 49.5 | 39.8 | 46.7 |
| 50x50 | 48.6 | 53.3 | 53.4 | 57.2 | 53.1 |
| Mean of intercropping | 49.9 | 51.3 | 54.8 | 51.6 | |
| LSD $_{(0.05)}$for spacing= ns '<br>LSD $_{(0.05)}$for intercropping=ns,<br>LSD $_{0.05)}$forspacing x intercropping= ns | | | | | |
| **Spacing** | | | **6WAT** | | |
| 100x75 | 62.5 | 79.4 | 42.2 | 56.3 | 60.1 |
| 75x50 | 33.4 | 76.7 | 64.7 | 28.3 | 50.6 |
| 50x50 | 55.5 | 58.6 | 62.9 | 33.4 | 52.6 |
| 50x25 | 56.0 | 56.1 | 41.1 | 57.6 | 52.7 |
| Mean of intercropping | 51.8 | 67.7 | 52.7 | 43.9 | |
| LSD $_{(0.05)}$ for spacing =ns ,<br>LSD $_{(0.05)}$for intercropping =17.53,<br>LSD $_{(0.05)}$ for spacing x intercropping = ns | | | | | |
| **Spacing** | | | **8WAT** | | |
| 100x75 | 37.5 | 40.2 | 41.3 | 40.1 | 39.8 |
| 75x50 | 43.5 | 50.0 | 67.2 | 20.0 | 45.2 |
| 50x50 | 34.9 | 26.8 | 11.1 | 33.3 | 26.5 |
| 50x25 | 19.2 | 44.5 | 47.2 | 25. 4 | 34.1 |
| Mean of intercropping | 33.8 | 40.4 | 41.7 | 29.7 | |
| LSD $_{(0.05)}$) for spacing= ns ,<br>LSD $_{(0.05)}$ for intercropping = ns,<br>LSD $_{(0.05)}$ forspacing x intercropping =ns | | | | | |

## 4. CONCLUSION

The outcome of the study has shown the effect of plant spacing and intercropping on the tomato growth parameters and the tomato septoria leaf spot disease incidence and severity. From the experiment, intercropping played a significant role in the reduction of tomato septoria leaf disease incidence and severity, especially at the last weeks of the experiment. Planting tomato as a sole crop and under the plant spacing of 75 x 50 cm, should be adopted in the management of tomato septoria leaf spot disease. In terms of tomato plant height, the spacing of 100 x 75 cm and in the combination with groundnut and okra, should be adopted as this resulted to the tallest plant. There is also the need for further research on the effect of plant spacing and intercropping on tomato leaf production, since there was no significant relationship between the two.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. Gould WA. Tomato production, processing and quality evaluation. 2nd Ed. 1983;34-45.
2. Jones JB, Jones JP, Stall RE, Zutter TA. Compendium of tomato diseases. The American phytopathology society. MN. 1993;34.
3. Kelley WT, Boyhan G. Commercial tomato production handbook, The University of Georgia and Ft. Fort Valley, GA: Valley State University; 2010.
4. Denton OA, Swarup V. Tomato cultivation and its potential in Nigeria. act. Horticultural. 1983;123.
5. Nesmith WC, Harman JR. Tomato wilt problems. 1982;821-2.
6. Sharon MD. Septoria Leaf spot of tomato. PP048 (11/03R). 123 Huntington street: Department of Planr Pathology and Ecology. The Connecticut Agricultural Experiment Station; 2022.
7. Ploetz R. Diseases and Pests, A review of their importance and management. In: Informusa, Internat. Journal on Banana and Plantain. 2004;13(2):11-6.
8. Antonovics J, Levin DA. The Ecological and genetic consequences of density – dependent regulation in plants. Annu Rev Ecol Syst. Ann. Rev Syst. 1980;11(1):411-52.
9. Burdon JJ, Chilvers GA. Host Density as a Factor in Plant Disease Ecology. Annu Rev Phytopathol. 1982;20(1):143-66.
10. Cowling EB. Agricultural and forest practices that favour epidemics. In: Horsfall JG, Cowling EBEd, editors, Plant disease – an advanced treatise. Vol. 11. How Disease Develops in Population. New York: Academic Press. 1978;361-381.
11. Thurston HD. Bacterial wilt of potatoes in Columbia. Ann. Potato J. 1992;40:381-90.
12. Jeranyama P, Hesterman OB, Wedding SR, Harwood RR. Relay. Intercropping of sunhemp and cowpea into a small holder maize system in Zimbabwe. Agron J. 2002;244:92-239.
13. Andrews DJ. Intercropping with sorghum, Samaru Rrsearch Bulletin, No. 238; 1975.
14. Okigbo BN. Cropping Systems and related research in Africa. 10th Anniversary of S.A accessional publications series O.T.I. April. 1978;1978.
15. Harry GT, Ohanuna MO. Evaluation of performance of yam mini sett intercropped with maize in the River State. Paper presented at the 4th Annual Farming System Research and Extension Workshop in South Eastern Nigeria, Umudike, 21 – 24th Jan. 1990; 1990.
16. FDALR. (Federal department of agriculture and land resources). The Reconnaisance of soil, survey of Imo State soil [report]. 1985;133.
17. Nwosu AC, Adeniyi EO. A survey of Resourses for development. Ibadan: NISER. 1980;310.
18. Wahua TAT. Applied statistics for scientific studies. 1999;347.
19. Ravneet K, Sandhu N, Boy S, Lincoln Zotarelli S, Agehara, Peres N. Effect of planting density on the yield and growth of intercropped tomatoes and peppers in Florida in Hort. Science. 2021; 2127:1556720.
20. Hussen SMK, Waise M. Effect of Intra – row spacing on growth and development of tomato (*Lycopersicon esculentum* Mill.) var ROMA VF at the Experimental site of Wollo University, South Wollo Ethiopia. Int J Sci Basic Appl Res (IJSBAR). 2013;10(1):19-24.
21. Wu L, Deng Z, Cao L et al. Effect of plant density on yield and quality of Perilla Sprouts. Sci Rep. 2020;10(1):9937.
22. Burdon J, Chilvers GA. Annual review of phytopathology. Physiol. Host Density as a

Factor in Plant Disease Ecology. 2003. 20(1):143-66.
23. Ihejirika GO. Effect of maize intercropping on incidence and severity of leafspot disease and nodulation of groundnut (International Journal of Agricultural Research). 2007;2:504-507.
24. Zinsou V, Windra, Ahohuendo B, Hau B. Effects of intercropping and Soil amendment with urea and calcium oxide on the incidence of bacterial wilt of tomato and survival of soil – born Pseudomonas solanacearum in Taiwan. Plant Pathol[R].. 2004;46:600-10.



*Peer-review history:*
*The peer review history for this paper can be accessed here:*
*https://www.sdiarticle5.com/review-history/92261*