Effect of supplementary irrigation water and organic matter amounts on tomato yield and water productivity in a semi-arid climate

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ABSTRACT

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| Although promoted as an alternative to secure rain-fed agriculture, supplementary irrigation cannot ensure sustainable food production, regardless of the rational and optimal use of organic matter. Therefore, an experiment was set up in a sandy loam soil (bulk density =1.55 g/cm3; field capacity =18%; wilting point=1.4%) to determine the optimal combination of irrigation depth and compost rate. The experimental design was a split plot with four replications. The main factor was the irrigation water depths, which represented 50%, 75%, and 100% of the tomato crop’s water requirement (2800 m3/ha/Irrigation). The second factor consisted of two compost rates: 5 t/ha (C5) and 10 t/ha (C10). Six combinations were tested: C10 + 100%, C10 + 75%, C10 + 50%, C5 + 100%, C5 + 75%, and C5 + 50%. Fertilizers (NPK 14-23-14 and Urea 46%) were applied at the recommended rates of 250 kg/ha and 150 kg/ha, respectively, at 15 and 35 days after transplanting. The adopted irrigation interval was 2 days. After transplanting, a constant water depth (DI 100%) was applied, and water treatments were initiated 15 days after transplanting. Water application was postponed to the next irrigation if rain occurred.The results showed that, in general under supplementary irrigation, the addition of compost increase growth parameters, yield and water use productivity. However, when water requirement is reduced by half this increase is not consistent. Indeed, the higher yield was induced by C5 + 75% treatment. The combination of C10 + 50% improved water productivity by 70%. Therefore, the combination of C10 + 50% should be recommended for the sustainable management of land and water resources. |

***Keywords:*** *supplementary irrigation, land management, water productivity, tomato.*

1. INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is one of the most widely cultivated crops globally. Approximately 18 billion tons of tomatoes are produced annually in the world [1], [2]. In Burkina Faso, tomatoes are among the most important vegetables produced (t/ha/year) during both the dry and rainy seasons [3]. In Ouagadougou, tomatoes, alongside other vegetables, account for 80% of the local demand for vegetables and fruits. Their production provides employment, with around a hundred sites operating in the Kossodo area [4]. However, tomatoes are among the most water-demanding crops [5]. Excessive water application negatively affects the nutrient content of the crop [6], [7] and increases humidity, either in the atmosphere or in greenhouses, thus facilitating the spread of diseases and pests. Furthermore, over-irrigation leads to the leaching of soil nutrients and pesticides [8]. Conversely, water deficits can hinder plant development and significantly reduce yields [9], [10], [11], [12]. These studies have further suggested that tomatoes can develop adaptive mechanisms, such as reducing photosynthesis, under severe water stress.

Numerous researchers have studied the role of organic amendments in enhancing soil productivity. Findings indicate that these amendments improve soil quality, structure, nutrient availability, and overall plant productivity [13] . Organic amendments perform several functions, including nutrient storage and gradual release through mineralization, which helps meet the nutritional needs of plants. Additionally, they contribute to soil structuring and stability, protecting it from external threats such as water erosion. Organic amendments also stimulate biological activity, enhance soil aeration, and improve water retention capacity, which can reduce the frequency and volume of irrigation required. This water retention function is becoming increasingly important as it is viewed as an integrated approach to soil management, thus promoting agricultural production. When the application of organic matter is combined with supplemental irrigation, this approach offers a viable solution to challenges such as drought conditions and soil impoverishment [14]. The optimal application of supplemental irrigation paired with organic matter has the potential to significantly reduce irrigation water requirements while improving soil productivity.

Studies have examined the synergy between organic amendments and irrigation levels in crop growth and yield. For instance, organic amendments stimulate spinach growth; however, this improvement was not significant under deficient irrigation [15]. Some research recommended using low levels of organic amendments to mitigate the adverse effects of drought on spinach growth and yield [16]. Additionally, integrated fertilization systems have been found to be more reliable than conventional systems for producing high-quality forage barley in arid environments, especially under late-stage water stress or deficit irrigation systems. [17]

The responses of crops and soils to organic amendments and irrigation strategies depend on multiple factors, such as soil type, crop species, soil chemistry, and climatic conditions. Moreover, many producers apply organic matter either in excess or insufficient amounts, often combined with poorly managed irrigation practices. These situations lead to resource wastage and reduced agricultural productivity. It is essential, therefore, to assess the effectiveness of these techniques, particularly for water-intensive crops in arid regions characterized by nutrient-poor soils.

This study aims to enhance both soil and water productivity through a synergistic approach that combines water management and organic matter application (compost) in tomato cultivation. An experimental trial was conducted on a site with tomato crops, employing three irrigation regimes:

* Full irrigation, meeting 100% of the tomato's water requirements,
* Recommended irrigation, covering 75% of the crop's water requirements, and
* Reduced irrigation, covering 50% of the crop's water needs.

Each irrigation treatment was combined with three organic matter application rates: 0 t/ha, 5 t/ha, and 10 t/ha. The tomato plants’ morphological parameters were monitored throughout the trial, while water productivity and yield were evaluated at harvest.

2. material and methods

2.1. Study area

The study was carried out at an experimental site located within the premises of IPD-AOS in Ouagadougou, Burkina Faso, at coordinates 12°23'N, 1°28'W, and an altitude of 294 meters. The soil was sandy loam with a bulk density of 1.55 g/cm3.The field capacity was 18% and a wilting point of 1.4%. The climate at the study site is classified as dry tropical, within the Sudanian-Sahelian zone. The region is characterized by a dry season, lasting six to eight months (from November to May), dominated by dry winds from the Sahara, and a rainy season, spanning four to five months (from June to September), dominated by humid winds from the Gulf of Guinea. On average, the area receives between 600 and 900 mm of rainfall annually, and the terrain is predominantly flat. The highest temperatures are recorded in April and May, reaching up to 43°C, while the lowest temperatures are recorded in December and January, with temperatures dropping as low as 16°C. The hydrographic network, including numerous wells and boreholes, facilitates the use of surface and groundwater for crop irrigation during the dry season.

2.2. **The plant material**

The tomato varieties used in the experiments were Tropimech Tri Active Blue and Cobra 26 F1. These are among the most commonly cultivated varieties in Burkina Faso and are well-suited for the rainy season. The Tropimech Tri Active Blue variety produces firm, elongated fruits weighing between 90 and 100 grams at maturity. It has an average production period of 65 to 70 days after transplanting and offers excellent shelf life. Similarly, the Cobra 26 F1 variety yields firm fruits with uniform coloration, weighing between 80 and 90 grams. Its average production period is approximately 65 days after transplanting, and it also has a long shelf life. These characteristics make both varieties ideal for local agricultural practices and market demands.

2.3. **The experimental design**

The experimental design was a split-plot with four replications and nine treatments (table 1). The primary factor was the irrigation dosage, while the secondary factor was the organic matter dosage. Each block consisted of three main plots, each corresponding to one of the three primary irrigation levels. These main plots were subdivided into three subplots, each representing one of the three organic matter application rates. This resulted in nine subplots per block and a total of 36 subplots across the entire experiment.

Each subplot measured 2 meters in length and 2 meters in width, covering an area of 4 square meters, and contained five furrows. Six tomato planting holes (poquets) were established per furrow, resulting in a total of 30 planting holes per subplot. Blocks were separated by a 1-meter distance, while subplots within each block were spaced 0.5 meters apart. The total experimental area covered 264 square meters.

Each treatment was a combination of an irrigation dosage and an organic matter dosage. Initially, compost was applied to the soil at rates of 0 t/ha, 5 t/ha, and 10 t/ha, corresponding to 0, 2, and 4 kilograms of compost per subplot, respectively. Irrigation water was then applied at field capacity levels of 100%, 75%, and 50%, corresponding to 3, 2, and 1 watering cans per furrow, equating to 36, 24, and 12 liters per furrow, respectively.

Table 1. Different treatments applied in this study

|  |  |
| --- | --- |
| **Treatment** | **Meaning** |
| C0 + 100% | 100% irrigation with no organic matter |
| C5 + 100% | 100% irrigation with 5 t/ha organic matter |
| C10 + 100% | 100% irrigation with 10 t/ha organic matter |
| C0 + 75% | 75% irrigation with no organic matter |
| C5 + 75% | 75% irrigation with 5 t/ha organic matter |
| C10 + 75% | 75% irrigation with 10 t/ha organic matter |
| C0 + 50% | 50% irrigation with no organic matter |
| C5 + 50% | 50% irrigation with 5 t/ha organic matter |
| C10 + 50% | 50% irrigation with 10 t/ha organic matter |

The corresponding irrigation treatments were applied 15 days after transplanting (DAT) and continued every two days until harvest, except on rainy days.

**2.3. TRIAL IMPLEMENTATION**

The experiment was conducted over two consecutive years. During both the first and second years, after the application of compost, tomato plants were transplanted at a density of six plants per row, with a spacing of 0.4 m between plants, resulting in 30 plants per experimental plot. The plants were irrigated daily for 15 days, with 12 liters of water per row per day. After this initial period, 250 kg/ha of NPK fertilizer was applied, and the different irrigation treatments started. Irrigation was subsequently applied every two days, except during rainfall. Then after 35 DAT urea (46% N) was applied 35 days after transplanting. Pesticides including BOMEC (abamectin), PACHA (lambda-cyhalothrin, acetamiprid), DEAN (imidacloprid) and CYPERCAL (cypermethrin).

**2.4. Observations and Measured Parameters**

**2.4.1. Morphological Parameters**

Morphological parameters were assessed at 15, and 35 days after transplanting (DAT). Observations were made on ten plants per experimental plot, selected alternately to ensure representative sampling. The parameters measured included:

* Plant height: Measured from the base to the topmost leaf using a graduated measuring tape.
* Collar diameter: Determined using a caliper at the collar of the plant.
* Number of leaves: Counted manually.

**2.4.2. Production Parameters**

After each harvest, the following parameters were recorded for the ten selected plants per plot:

* Number of fruits per plant: Counted for each of the selected plants.
* Fruit dimensions: Length and diameter measured with a caliper.
* Fruit weight: Assessed using a precision balance.

The yield was calculated using the formula:

R(kg/ha)=P(kg)×41600

Where:

R: Yield (kg/ha)

P: Average weight of fruits per plot

**2.4.3. Water Use Efficiency**

Water use productivity was determined using [18]equations for:

$$WUE(kg/m^{3})=R/W\_{u}$$

$WUE: $Water use efficiency

$R$: The yield

$W\_{u} $**:** Water quantity used for the irrigation of the plot

**2.5. Effective rainfall calculation**

The effective rainfall was obtained using the CROPWAT 8.0 software by employing USDA method. Climatic data were retrieved from WAPOR data base. Two years data were used.

$P\_{eff}=\left(P×\left(125-0.2×3×P\right)\right)/125$ when $P\leq 250/3 $mm

$P\_{eff}=\left(\frac{125}{3}\right)+0.1×P $ when $P>250/3 $mm

|  |  |  |
| --- | --- | --- |
| $$P\_{eff}$$ | : | Effective rainfall |
| $$P$$ | : | Rainfall |

**2.6. Data Processing and Statistical Analysis**

Data entry was performed using Microsoft Excel 2017. The collected data were analyzed through analysis of variance (ANOVA) using SPSS software version 21. For comparing treatment means, the Newman-Keuls test was employed when ANOVA indicated statistically significant differences at the 5% significance level.

3. results and discussion

3.1. Results

3.1.1. Climate data

Figure 1 below shows monthly rainfall, effective rainfall, and temperatures from May to October for both years of experimentation. The results indicate that during the period from May to October, the second year of the experiment recorded 32% more precipitation and a 14% increase in effective rainfall compared to the first year of the experiment. Moreover, the lowest and highest temperatures were recorded during the second year of the experiment.

Figure. 1. Monthly rainfall, effective rainfall, maximum and minimum temperature for 2023 and 2024 years of study area

3.1.2. Effect of supplementary irrigation dose and organic matter dose on tomato growth parameters

3.1.2.1. Plant Height

Table 2 presents the results of the effects of treatments on the height of tomato plants over two years of experimentation for 15 DAT and 25 DAT. Statistical analysis revealed no significant impact of treatments on plant height at any growth stage, despite the application of compost. However, the tallest plants were consistently recorded in the C10+75% plot during both years, while the shortest plants were observed in the C5+50% plot. Additionally, tomato plants showed greater growth in the second year compared to the first. These findings indicate that, aside from the C5+50% and C10+75% treatments, which produced the shortest and tallest plants respectively, the treatments resulted in similar plant heights regardless of the addition of organic matter.

 **Table 2. Effect of treatment on plants Height (cm) at 15 and 25 DAT during the first and the second year of experimentation**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **treatment** | **Height1 at 15 DAT**  | **Height2 at 15 DAT**  | **Average**  | **Height1 at 25 DAT**  | **Height2 at 15 DAT**  | **Average**  |
| C10 + 100% | 23.81± 1.30 | 24.82±1.06 | 24.32±0.84 | 34.54± 1.83 | 46.40±2.34 | 40.47±1.62 |
| C5+ 100% | 22.85± 1.94 | 25.42±0.95 | 24.14±1.09 | 31.66± 1.72 | 46.46±1.69a | 39.06±1.46 |
| CO + 100% | 24.41± 1.32 | 25.45±0.87 | 24.94±0.79 | 33.90± 1.66 | 48.57±1.84a | 41.24±1.48 |
| C10+ 75% | 25.63± 1.30 | 26.27±0.91 | 25.96±0.79 | 36.41± 1.56 | 51.00±1.81 | 43.8±1.45 |
| C5 + 75% | 23.82± 1.14 | 23.08±0.77 | 23.46±0.69 | 34.43± 1.47 | 43.83±1.80 | 39.13±1.27 |
| CO + 75% | 23.84± 1.10 | 23.41±0.91 | 23.63±0.71 | 33.31± 1.66 | 44.69±1.42 | 39.01±1.26 |
| C10 + 50% | 23.81± 1.12 | 25.44±0.97 | 24.63±0.75 | 32.38± 1.64 | 46.48±1.76 | 39.43±1.44 |
| C5 +50% | 23.14± 1.02 | 23.26±0.83 | 23.21±0.66 | 31.81± 1.53 | 45.03±2.04 | 38.43±1.47 |
| CO + 50% | 23.43± 1.04 | 23.25±1.03 | 23.34±0.73 | 34.02± 1.33 | 42.70±1.92 | 38.36±1.26 |
| Probability | 0.92 | 0.86 | 0.252 | 0.54 | 0.075 | 0.156 |
| Signification | ns | ns | ns | ns | ns | ns |

*ns means no significant*

*Height1 at 15 DAT means the height of plant in the first year of experimentation at 15 days after transplanting.*

*Height2 at 15 DAT means the height of plant in the second year of experimentation at 15 days after transplanting.*

*Height1 at 25 DAT means the Height of plant in the first year of experimentation at 25 days after transplanting.*

*Height2 at 25 DAT means the height of plant in the second year of experimentation at 25 days after transplanting.*

3.1.2.2. Stem diameter

Table 3 illustrates the effect of different treatments on the stem diameter of tomato plants over two years of experimentation. Statistical analysis revealed that treatments significantly influenced stem diameter at 25 days after transplanting (DAT). The application of organic matter demonstrated varying effects across irrigation levels. At the D100% irrigation level, applying 10 t/ha of organic matter resulted in a significant of 9% increase in stem diameter compared to the average of the C0+D100% and C5+D100% treatments. Similarly, at the D75% level, a 10 t/ha organic matter application led to an 11% increase in stem diameter compared to the C0+D75% treatment. In contrast, no significant effect was observed at the D50% irrigation level for applications of 5 and 10 t/ha of organic matter. Additionally, plants from the first year of experimentation generally exhibited larger stem diameters than those from the second year. These findings suggest that in supplementary irrigation conditions, the growth phase and the application of 10 t/ha of organic matter significantly influence the stem diameter of tomato plants.

Table 3. Effect of treatment on stem diameter (mm)at 15 and 25 DAT during the first and the second year of experimentation

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Treatment** | **S. Diameter 1 at 15 DAT** | **S. Diameter2 at 15 DAT** | **Average** | **S. Diameter 1 at 25 DAT** | **S. Diameter 2 at 25 DAT** | **Average**  |
| C10 + 100% | 5.13± 0.197 | 3.87±0.15a | 4.51±0.14 | 6.38±0.19abc | 6.15±0.26a | 6.27±0.16a |
| C5 + 100% | 4.56± 0.27 | 3.72±0.12a | 4.15±0.16 | 5.72±0.2abc | 5.60±0.15ab | 5.67±0.13ab |
| C0+ 100% | 4.57± 0.15 | 3.61±0.13a | 4.09±0.11 | 6.02±0.22abc | 5.62±0.15ab | 5.82±0.13ab |
| C10+ 75% | 5.04± 0.16 | 3.71±0.12a | 4.38±0.13 | 6.49±0.19a | 5.98±0.18a | 6.23±0.14a |
| C5 + 75% | 5.18±0.18 | 3.64±0.11a | 4.42±0.14 | 6.19±0.28abc | 5.14±0.20b | 5.67±0.18ab |
| C0 + 75% | 4.73± 0.15 | 3.48 ±0.11ab | 4.11±0.12 | 5.78±0.23abc | 3.39±0.15b | 5.59±0.14b |
| C10 + 50% | 4.66± 0.20 | 3.55±0.10ab | 4.11±0.13 | 5.39±0.3abc | 5.65±0.14ab | 5.52±0.16b |
| C5 +50% | 4.54± 0.17 | 3.18±0.15bc | 3.8±0.13 | 5.13±0.21c | 5.37±0.18b | 5.25±0.14b |
| C0+ 50% | 6.54± 2.12 | 2.59 ±0.14c | 4.75±1.08 | 5.59±0.18abc | 5.35±0.17b | 5.47±0.13b |
| Probability | 0.64 | 0 | 0.8 | 0 | 0.003 | 0 |
| Signification | ns | \*\*\* |   ns | \*\*\* | \*\* |  \*\*\* |

*ns means no significant*

*\*\* means significant when P˂ 0,01*

\*\*\* *means significant when P˂ 0,001*

*S. Diameter 1 at 15 DAT means the stem diameter of plant in the first year of experimentation at 15 days after transplanting*

*S. Diameter2 at 15 DAT means the stem diameter of plant in the second year of experimentation at 15 days after transplanting*

*S. Diameter 1 at 25 DAT means the stem diameter of plant in the first year of experimentation at 25 days after transplanting*

*S. Diameter 2 at 25 DAT means the stem diameter of plant in the second year of experimentation at 25 days after transplanting*

3.1.2.3 Number of leaves

Table 4 shows the effect of treatments on the number of leaves of tomato plants over two years. Statistical analysis indicates that, overall, the treatments did not have a statistically significant effect on this parameter. However, significant effects were observed at 15 days after transplanting (DAT) during the first year and at 25 DAT in the second year of experimentation. Although no significant differences were noted globally, the application of 10 t/ha of organic matter promoted an increase in leaf number across all irrigation levels, unlike the 5 t/ha application, whose effects were less consistent. These findings suggest that applying 10 t/ha of organic matter, combined with supplementary irrigation, may enhance leaf number, even if this increase is not consistently statistically significant.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Treatments** | **Number of Leave1(15 DAT)** | **Number of Leave2(15 DAT)** | **Average** | **Number of Leave1(25 DAT)** | **Number of Leave2(25 DAT)** | **Average** |
| C10 + 100% | 9.82±0.50ab | 6.40±0.21ab | 8.11±0.33 | 14.95±1.01a | 10.60±0.36 | 12.78±0.59 |
| C5+ 100% | 8.37±0.44b | 6.40±0.20ab | 7.39±0.27 | 11.42±0.65b | 10.95±0.29 | 11.19±0.36 |
| CO + 100% | 9.02±0.42ab | 6.23±0.21abc | 7.63±0.28 | 12.85±0.92ab | 10.80±0.30 | 11.83±0.5 |
| C10+ 75% | 10.52±0.58a | 6.55±0.22ab | 8.54±0.38 | 15.02±0.94a | 10.78±0.27 | 12.87±0.54 |
| C5 + 75% | 9.77±0.57ab | 6.30±0.22ab | 8.04±0.36 | 15.10±1.36a | 10.18±0.37 | 12.64±0.76 |
| CO + 75% | 9.47±0.47ab | 5.60±0.16c | 7.54±0.33 | 13.97±1.01ab | 10.18±0.24 | 12.08±0.56 |
| C10 + 50% | 9.50±0.59ab | 6.70±0.21a | 8.1±0.35 | 13.50±1.24ab | 10.38±0.33 | 11.94±0.66 |
| C5 +50% | 9.12±0.32ab | 5.90±0.24bc | 7.51±0.27 | 11.57±0.64b | 10.15±0.29 | 10.86±0.36 |
| CO + 50% | 9.35±0.35ab | 6.13±0.22abc | 7.74±0.27 | 12.72±0.66ab | 10.23±0.33 | 11.48±0.4 |
| Probability | 0.14 | 0.014 | 0.205 | 0.03 | 0.437 | 0.09 |
| Signification | ns | \* |   | \* | ns | ns |

**Table 4. Effect of treatment on the number of leaves at 15 and 25 DAT during the first and the second year of experimentation**

*ns means no significant*

*\* means significant when P˂ 0,05*

*Number of Leave1 (15 DAT) means the Number of leaves in the first year of experimentation at 15 days after transplanting.*

*Number of Leave 2(15 DAT) means the Number of leaves in the second year of experimentation at 15 days after transplanting.*

*Number of Leave1 (25 DAT) means the Number of leaves in the first year of experimentation at 25 days after transplanting.*

*Number of Leave1 (25 DAT) means the Number of leaves in the second year of experimentation at 25 days after transplanting.*

3.1.3. Effect of supplementary irrigation dose and organic matter dose on fruit characteristics

*3.1.3.1. Dimensions of fruit*

Table 5 illustrates the effect of treatments on fruit height and diameter. Statistical analysis indicates that, overall, treatments did not have a significant impact on these two parameters. However, during the first year of experimentation, a significant influence of treatments on fruit height was observed. Additionally, although no statistically significant differences were noted globally, the application of organic matter appeared to reduce fruit height while increasing fruit diameter. These findings suggest that, under supplementary irrigation, the application of organic matter, while not having a statistically significant effect, may tend to slightly decrease fruit height and increase fruit diameter.

**Table 5. Effect of treatment on fruit length (mm) and fruit diameter (mm) during the first and the second year of experimentation**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Treatments** | **Fruit length1**  | **Fruit length2**  | **Average**  | **Fruit diameter1**  | **Fruit diameter2**  | **Average**  |
| C10 + 100% | 33.92 | 56.9 | 56.38 | 30.71 | 55.98 | 55.41 |
| C5+ 100% | 29.16 | 50.34 | 50.14 | 25.73 | 54.62 | 54.34 |
| CO + 100% | 28.89 | 57.06 | 56.98 | 25.12 | 46.93 | 46.88 |
| C10+ 75% | 31.15 | 50.64 | 50.28 | 27.54 | 49.28 | 48.89 |
| C5 + 75% | 34.32 | 51.1 | 50.68 | 29.83 | 49.32 | 48.83 |
| CO + 75% | 30.66 | 51.87 | 51.21 | 27.31 | 49.07 | 48.4 |
| C10 + 50% | 34.17 | 50.67 | 50.36 | 30.42 | 48.27 | 47.93 |
| C5 +50% | 36.74 | 50.62 | 50.39 | 32.49 | 48.86 | 48.57 |
| CO + 50% | 41.79 | 51.06 | 50.97 | 31.98 | 49.21 | 49.03 |
| P | 0.02 | 0.698 | 0.68 | 0.23 | 0.471 | 0.47 |
| Significant | \* | ns | ns | ns | ns | ns |

*ns means no significant*

*\* means significant when P˂ 0,05*

*Fruit length1 means fruit length in the first year of experimentation*

*Fruit length2 means fruit length in the second year of experimentation*

*Fruit diameter1 means the fruit diameter in the first year of experimentation*

*Fruit diameter2 means the fruit diameter in the second year of experimentation*

*3.1.3.3. Weight of fruit*

Table 6 highlights the effect of different treatments on fruit weight. Statistical analysis reveals that the treatments had a significant impact on this parameter, both globally and for each year. However, in the first year, the effect of the different treatments on fruit weight was quite mixed. In contrast, during the second year, within the D75 and D100% irrigation levels, the application of organic matter at rates of 10 and 5 t/ha led to an increase in fruit weight. Conversely, at the D50% irrigation level, the application of organic matter resulted in a decrease in fruit weight. Overall, the treatments produced relatively uniform fruit weights, except for the treatment C0+D100%, which resulted in a 9% reduction in fruit weight compared to the average of the other treatments. These findings emphasize that, under supplementary irrigation, the application of organic matter is indispensable for achieving higher fruit weights. However, when water requirements are reduced by half, the application of organic matter could be detrimental to fruit weight.

**Table 6. Effect of treatment on fruit weight (g) during the first and the second year of experimentation**

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatments** | **Weight of fruit1** | **Weight of fruit2** | **Average**  |
| C10 + 100% | 20.15± 1.26ab | 64.80±0.62a | 63.78±0.66a |
| C5 + 100% | 15.25± 1.14b | 64.91±1.04a | 64.42±1.05a |
| CO + 100% | 22.75± 7.84ab | 59.07±0.70b | 58.95±0.7b |
| C10 + 75% | 23.00± 2.38ab | 65.19±0.62a | 64.41±0.64a |
| C5 + 75% | 22.65± 2.18ab | 65.47±0.61a | 64.38±0.65a |
| CO + 75% | 17.04± 1.51b | 64.14±0.66a | 62.61±0.71a |
| C10 + 50% | 19.50± 1.93ab | 64.08±0.80a | 63.23±0.82a |
| C5 +50% | 27.88± 3.47a | 64.94±0.66a | 64.21±0.67a |
| CO + 50% | 28.60± 5.16a | 65.56±0.72a | 65.15±0.73a |
| P | 0.01 | 0.001 | 0 |
| Significant | \*\* | \*\*\* | \*\*\* |

*\*\*means significant when P˂ 0,01*

\*\*\* *means significant when P˂ 0,001*

*weight of fruit1(g) means weight of fruit in the first year of experimentation*

*Weight of fruit2(g) means weight of fruit in the second year of experimentation*

3.1.4. Effect of supplementary irrigation dose and organic matter dose on yield component

*3.1.4.1. Effect of supplementary irrigation dose and organic matter dose on yield*

Table 7 shows the effects of various treatments on tomato yield over two years. Statistical analysis indicates that the treatments did not significantly influence yield. However, the best yields were obtained with the C0+75% treatment. In addition, the application of organic matter at 5 and 10 t/ha increased yield, except at the D50% irrigation level, where the addition of 5 t/ha of organic matter resulted in a decrease in yield. Moreover, during the first year of experimentation, the application of organic matter at both 5 and 10 t/ha led to a reduction in tomato yield at the D50% irrigation level. These findings highlight that, although the addition of organic matter generally promotes higher yields, it becomes ineffective when water availability is reduced by half, leading to a decline in yields.

**Table 7. Effect of Treatment on yield (t/ha) during the first and the Second year of Experimentation**

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatments** | **Yield1** | **Yield2** | **Average** |
| C10 + 100% | 19.3± 3.35ab | 31.65±4.5 | 30.24±4.02 |
| C5 + 100% | 20.3± 2.77ab | 30.89±2.17 | 30.38±2.08 |
| CO + 100% | 15.1± 1.42b | 26.2±1.93 | 25.72±1.87 |
| C10 + 75% | 27.9± 5.52ab | 30.81±2.01 | 30.58±1.89 |
| C5 + 75% | 38.6± 9.95a | 31.1±2.01 | 31.17±1.97 |
| CO + 75% | 21.2± 3.69ab | 29.26±1.88 | 28.87±1.79 |
| C10 + 50% | 19.4± 5.58ab | 28.96±2.33 | 28.43±2.21 |
| C5 +50% | 22.7± 6.39ab | 25.14±1.98 | 24.74±1.87 |
| CO + 50% | 23.8± 7.34ab | 26.98±1.92 | 26.76±1.85 |
| Probability | 0.33 | 0.45 | 0.21 |
| Signification | ns | ns | ns |

*ns means no significance.*

*Yield1 means the yield in the first year of experimentation*

*Yield2 means the yield in the second year of experimentation*

*3.1.4.1.* *Effect of supplementary irrigation dose and organic matter dose on water use efficiency (WUE)*

The effect of supplementary irrigation dose and organic matter dose on WUE is summarized in Table 8. Statistical analysis reveals a significant impact of the treatments on us. Although the addition of organic matter did not show a statistically significant effect at every irrigation level, it improved water use productivity at the d100 and d75 irrigation levels. Conversely, at the D50 irrigation level, the application of 5 t/ha of organic matter resulted in a decrease in WUE , while the application of 10 t/ha enhanced organic matter accumulation comparative with C0+ D50%. Consequently, the C10 + D50 treatment provided the highest WUE. Furthermore, during the first year of experimentation, the use of organic matter generally led to a reduction of WUE across all irrigation levels. This reduction was particularly pronounced at the D50 level, where the application of 10 t/ha of organic matter caused a significant 79% decline. These findings suggest that, within the context of supplemental irrigation, the application of organic matter can enhance WUE however, its effectiveness is highly dependent on the irrigation level.

**Table 8. Effect of treatment on water use efficiency (Kg/m3)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatments** | **WUE1** | **WUE2** | **Average**  |
| C10 + 100% | 2.53 ± 0.43bc | 3.70±0.52c | 3.57±0.47a |
| C5+ 100% | 5.46 ± 1.08abc | 3.60±0.25c | 3.57±0.24ab |
| CO + 100% | 8.68 ± 2.35ab | 3.06±0.22c | 3.02±0.22ab |
| C10+ 75% | 2 .65 ± 0.36bc | 5.40±0.35b | 5.39±0.33b |
| C5 + 75% | 7.57 ± 1.95abc | 5.45±0.35b | 5.56±0.36b |
| CO + 75% | 8.24 ± 2.31ab | 5.14±0.33b | 5.11±0.32ab |
| C10 + 50% | 1.97 ± 0.17bc | 10.16±0.81a | 10.05±0.77c |
| C5 +50% | 4.16 ± 0.72abc | 8.82±0.69a | 8.77±0.66c |
| CO + 50% | 9.54 ± 2.81a | 9.46±0.67a | 9.47±0.65c |
| P | 0 | 0.001 | 0.000 |
| Signification | \*\*\* | \*\* | \*\*\* |

*\*\*means significant when P˂ 0,01*

\*\*\* *means significant when P˂ 0,001*

WUE1 *means the water use productivity in the first year of experimentation*

WUE2 *means the water use productivity in the second year of experimentation*

**3.2. Discussion**

In the context of supplementary irrigation, the effectiveness of organic matter application on agronomic performance remains a complex and not systematically conclusive issue. Regarding plant height, often used as a key indicator of vegetative vigor, the results show no significant variation throughout the growth phases of tomato plants, consistently across the two years of experimentation. Variability in irrigation doses and organic matter application tended to homogenize plant height. Similar results were reported by [19]who observed comparable plant height growth in tomatoes despite the application of compost at rates of 30, 40, 50, and 60 t/ha. Conversely [20]observed greater tomato height growth following the application of organic fertilizer. However, it should be noted that these organic fertilizers consist of a complex mixture of elements, including organic matter, nutrients, nitrogen-fixing and nitrifying bacteria, vitamins, and amino acids, which accelerate plant metabolism and growth. Organic matter had a fortifying effect on mineral elements, making them more available to plants. Furthermore, studies by [21] highlighted the positive correlation between nitrogen application and plant height growth. In this study, our results may be explained by the fact that the organic matter was insufficiently mineralized to release nitrate nitrogen, as suggested by [22]Additionally, nitrogen in compost is provided in organic form, requiring transformation into mineral nitrogen for optimal plant assimilation [23]. Concerning collar diameter, the results revealed that, overall, under supplementary irrigation conditions, growth phases and the application of 10 t/ha of organic matter significantly influenced this parameter. This finding extends to the number of leaves, although the observed increase in leaf number was not statistically significant. Specifically, results show that in the first year, the effects of treatments on these two parameters were significant only at 25 days after transplanting (DAT). Conversely, at 15 DAT, these parameters were not significantly affected by treatments. Studies have demonstrated that sufficient moisture combined with organic matter application promotes an increase in leaf number and collar diameter. The results of this study may be attributed to uniform daily irrigation of all plots with 15,000 mm of water per plot during the [0–15 DAT] period in the first year to ensure the vigor of young transplanted plants. Furthermore, during this period, the applied compost might not have reached an advanced mineralization stage. The application of varying irrigation doses, initiated at 16 DAT, introduced variability that likely influenced collar diameter and leaf number significantly, despite the compost not completing its mineralization process. However, in the second year, the effects of treatments on these parameters were significant at 15 DAT, whereas at 25 DAT, only collar diameter was significantly affected. This difference might be due to second-year rainfall and minerals from the decomposition of compost applied in the first year, which could have significantly influenced collar diameter and leaf number during the [0–15 DAT] period. This effect persisted after applying different irrigation doses up to 25 DAT for collar diameter. However, for leaf number, treatments had no significant effect at 25 DAT in the second year, possibly due to plants reaching a maximum leaf number before 25 DAT under favorable conditions. The results further reveal that compost application at 10 t/ha systematically increased collar diameter and leaf number, although this increase was not always statistically significant. Conversely, a compost dose of 5 t/ha resulted in less consistent increases. These findings suggest that applying organic matter at 10 t/ha enhances water efficiency on plant growth parameters. Studies by [24] showed significantly more pronounced results, demonstrating that higher organic matter doses of 25 and 50 t/ha under all irrigation regimes notably favored plant height growth and increased leaf numbers across nearly all growth stages. Similarly, [25]reported that 100% soil-incorporated compost led to greater aerial growth compared to 25% and 50% rates. Thus, our findings indicate that while organic matter plays a critical role in crop growth, its optimal efficacy appears to be at a dose of 10 t/ha, with lower doses potentially constraining crop development.

Regarding fruit dimensions, the results indicate that, under supplementary irrigation, the effect of organic matter on fruit size depends on the irrigation dose. While organic matter application did not significantly impact fruit dimensions, its incorporation under D100 and D75 irrigation levels resulted in reduced fruit height and increased diameter. Conversely, under D50 irrigation, organic matter application reduced both fruit length and diameter. A similar trend was observed for fruit weight and yield. Under supplementary irrigation, organic matter application appears essential for achieving favorable fruit dimensions. However, when water availability is reduced by half, organic matter application may be detrimental. This observation could be attributed to inadequate water supplies preventing root systems from effectively absorbing necessary mineral elements. Water deficits negatively impact plant physiological processes, including nutrient uptake, photosynthesis, and overall growth, despite adequate mineral fertilization [26]. Studies by [15] similarly affirmed that organic matter's effectiveness is limited under severe water stress. For D100 and D75 doses, the results align with [20] who reported significantly larger fruits following organic fertilizer application. Likewise,[27] noted doubled maize length and weight after compost incorporation. Studies by[14] [28][29] also reported improved yields following compost application. Organic matter contributes essential nutrients, enhances nutrient uptake efficiency, and creates optimal soil moisture conditions. [30]demonstrated that the high adsorption capacity and porous characteristics of biochar allow water and nitrogen to remain longer in the soil, promoting water-nitrogen synergy and enhancing yields. These results underscore the crucial importance of organic matter application in enhancing both fruit dimensions and yields. The beneficial effects of organic matter may be limited under severe water stress conditions.

The results indicated a linear relationship between reduced water requirements and irrigation water productivity. Specifically, a reduction of 25% and 50% in water requirements led to respective increases in WUE of 58% and 178%. Enhancing water productivity is vital and critical in water-scarce regions [31]. Numerous authors have highlighted this linear relationship between reduced water requirements and increased WUE [32], [33], [34] However, this relationship is not consistent when considering organic matter application. Generally, compost application by 10t/ha and 5t/ha increased WUE under the D100 and D75 irrigation regimes. Conversely, it is observed that within the D50% irrigation dose, the application of compost at 10 t/ha led to an increase in WUE, whereas an application of compost at 5 t/ha resulted in a decrease in WUE. Overall, the combination C10+50% (10.05 kg/m³) resulted in the highest WUE, followed by C0+50% (9.47 kg/m³) and C5+50% (8.77 kg/m³). These results can be attributed to the ability of compost to enhance the soil’s water retention capacity and stabilize nutrients by reducing leaching[35]. However, when water availability is reduced by half, the water retained with a compost application of 5 t/ha is insufficient to meet both the plant’s water and nutrient requirements. Consequently, the lowest yields were observed with the C5+50% treatment (see table 8).

These findings reaffirm the critical role of organic matter application in stimulating crop growth, increasing fruit size, improving yields, and optimizing water productivity. However, they also highlight that, under severe water stress conditions, organic matter application can become a limiting factor for tomato production and water use efficiency. Thus, in the context of supplemental irrigation, the management of organic matter should be adjusted based on the severity and frequency of drought episodes and the availability of water to offset periodic water deficits. It is an alternative to mitigate yield losses due to the reduction of irrigation water depths [36]

4. Conclusion

In this study, under supplemental irrigation conditions, treatments combining different irrigation levels with varying doses of compost were compared to evaluate the effect of compost application on tomato productivity and water use efficiency. The results showed that applying compost at a rate of 10 t/ha significantly improves tomato growth parameters. Moreover, the findings suggest that when the water requirements of tomatoes are fully met or reduced by 25% (D100 and D75), compost application at 5 or 10 t/ha enhances fruit size, yield, and water productivity. However, when water availability is reduced by 50% (D50), compost application by 5t/ha may adversely affect tomato production and WUE. Therefore, the results recommend applying 5 t/ha of compost in combination with irrigation covering 75% of the plant’s water needs under supplemental irrigation conditions. Conversely, in scenarios where recurrent drought and limited or insufficient supplemental water are anticipated, the findings suggest applying 10t/ha of compost to avoid yield losses.

These recommendations can be adapted to dry climates and arid soils, particularly in regions where winter drought episodes constrain agricultural production.

DISCLAIMER (ARTIFICIAL INTELLIGENCE) 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 manuscripts.

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