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# Effect of Sprinkling Water Method on Soil Physical Properties and Growth and Yield of Onion (*Allium cepa* L.) Cultivars at Tomia Wakatobi Regency Conditions, Indonesia

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***Abstract*** **– In drought conditions in the land due to the dry season, water supply is very important to increase production. Apply water, soil water content (soil $\theta$) and soil bulk density (soil $\rho_{b,}$) are soil physical parameters that plays an important role in plant growth and development because they affects the chemical and biological properties of the soil and is an indicator of soil health. This study was aimed to analysis the effect of sprinkling method on soil parameters and on the growth and yield components of onions due to different levels of watering and varieties. This experiment uses four levels i.e. T0 (150 mm), T1 (250 mm), T2 (350 mm) and T3 (450 mm) and local onion (V1) and Bima Variety (V2) as seeds obtained from local market. The experiment was arranged using a completely randomized block (CRBD) design with 3 replications. The components of growth and yield of onions observed were plant height, width leaf, number of tillers, fresh and dry weight of bulbs/clump. The results showed that the water levels were highly significantly ($p<0.01$) influenced the soil $\theta$, soil $\rho_{b,}$ growth and yield components of onion. Mostly of parameters observed, the highest were recorded at T3 treatment followed by T2, T1 and T0. Variety V1 showed a better yield than V2 except for number of tillers. Location Usuku-2 is the highest yield than Usuku-1 and the lowest at Waitii. The value of T3 treatment, variety V1 and location Usuku-2 can be used as good basis for onion farmers in terms of optimum watering water use, for the planning, design and operation for the improve of onion production.**

***Keywords*** **– Water Use, Varieties, CRBD Design, Soil Physical Properties, Onions Growth and Yield.**

## I. INTRODUCTION

Onions (*Allium cepa* L.) are a commodity throughout the world apart from being traded [1] they are also as a kitchen spice for the essential ingredient [2, 3] and source of iron, zinc, vitamin C and thiamin [4] and richest sources of flavonoids in the human diet and flavonoid consumption has been associated with reduced risk of cancer, heart disease and diabetes [5].The medicinal and health advantages because onions contain anthocyanins, fructo-oligosaccharides and organosulphur [6]. How important onion for daily needs, many countries in the world from tropic, sub-tropic and temperate climate, cultivate onions by a big scale and small scale farmers and economically very important [7].

Water is a prerequisite for all plants. The yield of onions really depends on the adequacy of the water [8]. Onions need 450-540 mm of water throughout the growing period for the yield of 30-40 t $ha^{-1}$ [26]; thus the adequacy of the soil water content (soil$\theta$) through irrigation or watering is important in onion production. Apart from affecting groundwater content, watering water also affects soil bulk density (soil$\rho_b$). These two soil physical quantities often receive attention in agricultural activities. The soil $\theta$ may change some mechanical and physical properties, such as soil consistency, plasticity, compactness, bulk density, porosity, wetness, infiltration rates, and diversity, and activity of soil organism [9]. In a report [10] reviewed that soil $\rho_b$ is regarded as key factor is correlated with many physical, chemical, and biological properties of soil. In soil both of soil $\theta$ and soil $\rho_b$ are influenced each other. Investigated to three different soils by [11] obtained that if the soil $\theta$ increase, soil

$\rho_b$ decrease and vice versa. These findings are in line with the results of studies afterwards by [9] that the soil$\theta$ is the reciprocal of soil $\rho_b$. The soil $\rho_b$ can be used to calculate soil$\theta$, which is a significant property to regulate the amount of irrigation [12]. Therefore [13] revealed that soil $\rho_b$ is an important factor in soil$\theta$ dynamics. Reference [14] have investigated that soil $\rho_b$ is an indication of typical soil properties that affect water transport and was also found to be significantly correlated between soil $\rho_b$ and soil moisture content ($\theta$).

The effect of these two quantities separately on plants has been found by many previous authors. The effect of soil $\rho_b$ on plant growth by [15] concluded that a significant negative correlation between the increase in dry soil $\rho_b$ and overall length in forestry tree seedlings and dry mass. Reduction of the plant height of sesame plant occurred at soil $\rho_b$ level of 1.6 g/cm$^3$, which was due to the inability of the roots to penetrate deeper soil layers to absorb water and nutrients. And they also observed that the maximum root length was found under the soil $\rho_b$ level 1.4 g/m$^3$ and the length began decrease with the increase in soil ($\rho_b$) [16]. Reference [17] in a review wrote that the soil compaction negatively effects root growth, storage and supply of water and nutrients.

The role of soil $\theta$ in growth and production of plant can be explained through water use concept whether through irrigation or watering. Research conducted by [18] found that all the growth characteristic and seed yield of onion increased in drip irrigation applied daily or once in 3 days than other longer intervals. Also studied by [19] about the effect of drip irrigation and concluded that the marketable yield of onion linearly increased with more irrigation water applied.

Causally, soil$\theta$ depends on how much water is supplied to the surface of the soil, whether through rain, precitation or watering, while soil $\rho_b$ affects the rate of water infiltration in the soil. The objective of this research was to evaluate the productive response of onion plants, including plant height, leaf width, number of tillers, fresh and dry weight.

## II. MATERIALS AND METHODS

### 2.1. *Study Area and Its Description*

The experiment was conducted in Wakatobi Regency Southeast Sulawesi province, Indonesia. Wakatobi is located in eastern Indonesia with a distance from Jakarta is 1854 km and is a regency with a cluster of small islands, one of them is Tomia Island as to producer of onion in this area. Three research locations were selected in Tomia sub-district as presented in Table 1. The average maximum and minimum temperatures range between 35$^o$C-24$^o$C. The lowest and highest temperatures were recorded at 21.2$^o$C in March and 36.8$^o$C in December. During the study period (Sept.-Nov. 2018) the total amount of rainfall was 5 mm with 3 rainy days [20].

Table 1. The experiment locations.

| Locations | Latitudes and Longitudes | Above Sea Level (m) |
|---|---|---|
| USUKU-1 | S : 05$^o$46.741’ | 72 |
| | E : 123$^o$56.383’ | |
| USUKU-2 | S : 05$^o$.45.906’ | 107 |
| | E : 123$^o$56.466’ | |
| WAITII VILLAGE | S : 05$^o$44.937’ | 38 |

| Locations | Latitudes and Longitudes | Above Sea Level (m) |
|---|---|---|
| | E : 123°54.255' | |

## 2.2. *Experimental Materials*

Onions seed of local and Bima varieties were used as planting material for the experiment. The seed were obtained from local market and farmers. Water sources for watering were easily obtained freely from the wells of residents around the research location. The tools used were a hoe, shovel and crowbar to plow the land of the research location. The additional tools used were a knife, two plastic containers, writing tools, a standard ruler, a manual calipers, digital analytical scales, raffia ropes, and a water container specially made from tarpaulin.

## 2.3. *Site Selection and Soil Sampling*

The consideration of choosing a location is based on the ease of access, particularly the delivery of water to the land. Three representative composite soil samples were collected randomly from each location at 0–10 cm, and 10-20 cm soil depth before treatment using core sample. The laboratory analysis of selected soil properties were presented in Table 2.

Table 2. Physical - Chemical Properties of Soil.

| Locations | Chemical properties | | | | | | Texture | | |
|---|---|---|---|---|---|---|---|---|---|
| | pH | Ntot (%) | P (ppm) | K (me.100g$^{-1}$) | BO (%) | CO (%) | Sand (%) | Silt (%) | Clay (%) |
| Usuku-1 | 6.34 | 0.21 | 35.32 | 0.30 | 1.06 | 3.19 | 29.36 | 13.82 | 56.83 |
| Usuku-2 | 6.73 | 0.31 | 37.74 | 0.32 | 1.86 | 3.81 | 13.09 | 14.24 | 72.67 |
| Waitii | 6.44 | 0.24 | 36.26 | 0.29 | 1.92 | 23.7 | 26.57 | 2.95 | 70.47 |

According to [34] the criteria for the results of the soil analysis were pH is slightly acidic, medium N tot, medium P, medium K, very low organic matter (OM) and high organic carbon (OC). According to [20] the optimum pH for producing onions is in the range of 6-8. In accordance with this range, the soil pH at the research location is still classified as conducive to onion production. Total nitrogen, phosphorus, potassium and organic materials are in the intermediate category, and to achieve the required criteria NPK application is required for producing onions.

## 2.4. *Land Preparation*

The experimental field was hoed then separated gravel from soil and removed out and then it was made loosening and furthermore it was made it into 3 blocks with a distance of 0.5 m between block. Each block was marked into four plots for each block with the size of 0.90 m x 0.60 m with a distance between plots of 0.30 m. Plot beds were raised approximately 0.30 cm above the ground to make it easier to control the space and soil when it was moist [4]. Each plot consists of 3 rows of plants at a spacing of 15 cm x 15 cm so each plot contained 15 plants.

## 2.5. *Experimental Design*

The experiment was arranged in Randomized Complete Block Design (RCBD) with three replications. The treatment consisted of 4 levels of water application and 2 varieties V1 (local variety) and V2 (Bima variety).

The water levels were 150 mm (T0), 250 mm (T1), 350 mm (T2) and 450 mm (T3). The experiment consisted of 8 treatment combinations with varying levels of sprinkling water throughout the growing season namely, T0V1, T0V2, T1V1, T1V2, T2V1, T2V2, T3V1 and T3V2.

### 2.6. *Agronomic Practices*

After the land was ready for planting, the animal manure and kitchen ash mixed well and sprinkled on the land and left for two weeks before planting. Before planting, the top of the seedlings cut off and planting was carried in the morning. Because of drought season reason, watering morning and late evening starts from the beginning of planting. Furthermore NPK fertilizer @5 tonnes $ha^{-1}$ [4] was given 21 days after planting and 35 days after planting. Timely application of nutrients in adequate amounts is important to enhance onion bulb yield [7]. Watering was carried out only once when the plants got physiologically mature and watering was stopped a week before harvest.

### 2.7. *Data Recorded*

The data recorded were all onion clumps present in all experimental plots. There were 15 plants per plot. All data collected for statistical analysis was taken as the average of all crops per plot. The method of data recording was carried out as follows:

*Plant Height:*

It was recorded as the average of the three tallest leaves in one clump in each plot using standard rulers in centimeters. It was counted from soil surface level to leaf tip, and then was taken as average to obtain the plant height in the plot.

*Leaf Width:*

Were recorded as a mean of the three widest leaves in one clump in each plot. It is expressed in centimeters and measures it by tearing off the center of the leaf and was measured using a standard ruler and the average in a plot was used for statistical analysis.

*Number of Bulbs:*

The number of onion bulbs in one clump in each plot was chopped to get the actual number and then was taken as a mean per plot to be used as statistical analysis.

*Fresh Weight Bulbs:*

Were recorded as the average weight of onion bulbs in one clump, weighed fresh using analytical scales with an accuracy of 0.01 g.

*Dry Weight Bulbs:*

Were recorded as dry weight in g per clump, and then averaged to obtain dry weight data per plot for use as statistical analysis using analytical balance with an accuracy of 0.01 g.

*The soil $\rho_b$ and Soil $\theta$:*

Were measured three times, at the stage of vegetation development, generative and maturity stage. The soil $\rho_b$

determined with core method and soil $\theta$ calculated with gravimetric method [21] through equation as follow:

$$\rho_b = \frac{M_s}{V_b} \quad (1)$$

With $M_s$ is soil mass and $V_b$ is bulk volume of soil. The soil $\theta$ calculated uses gravimetric method.

$$\theta = \frac{W_1 - W_2}{W_2} x\ 100 \quad (2)$$

With $W_1$ = weight of air dry soil, $W_2$ = weight of oven dry soil.

### 2.8. *Statistical Data Analysis*

All data recorded were analyzed statistically to identify and determine significant differences between treatments. Analysis of variance performed for the assessment of the variation at the 0.05 level using the LSD test.

## III. RESULTS AND DISCUSSIONS

### 3.1. *Results*

#### 3.1.1. *Effect of Different Water Levels and the Effect of Variety*

##### 3.1.1.1. *Soil Properties*

Analysis of variance revealed that the soil $\theta$ and soil $\rho_b$ was high significantly ($p<0.01$) affected by variation in water applications. As increased of water levels followed by an increased the soil $\theta$ and slightly decreased of soil $\rho_b$. Highest of soil $\theta$ of and the lower of soil $\rho_b$ were recorded at T3 followed by T2, T1 and T0 respectively at all study locations.

##### 3.1.1.2. *Vegetative Growth Components*

The experiment showed that effect of water levels supplied were differed highly significantly ($p< 0.01$) and the effect of variety was differed high significantly ($p<0.01$) in terms of growth parameters (Table 3, Table 4 and Table 5). Results in these tables showed the effect of different amount of sprinkling water and effect of variety on the growth parameters of onion *viz.* plant height and width leaf at three different locations.

The highest value of plant height at location of (Usuku-1, Usuku-2 and at Waitii) as represented in Table 3 was obtained from water application of T3 treatment (30.17 cm; 30.8 cm; 23 cm) followed by T2 (26.83 cm; 29.0 cm; 21.3 cm), T1 (24.07 cm; 25.5 cm; 18.0 cm) and T0 (19.42 cm; 21.0 cm; 12.1 cm). Variety with the highest of plant height at location of (Usuku-1, Usuku-2 and Waitii) was recorded at V1 treatment (25.99 cm; 28.3 cm; 19.63 cm) followed by V2 (24.25 cm; 24.9 cm; 17.6 cm). The most appropriate location is Usuku-2 rather than Usuku-1 and the less viable is Waitii.

Table 3. Effect of water level and varieties treatment on soil $\theta$ and soil $\rho_b$ and plant height.

| Treatments | Usuku-1 | | | Usuku-2 | | | Waitii | | |
|---|---|---|---|---|---|---|---|---|---|
| | Soil $\theta$ (%) | Soil $\rho_b$ (g/cm$^3$) | Plant Height (cm) | Soil $\theta$ (%) | Soil $\rho_b$ (g/cm$^3$) | Plant Height (cm) | Soil $\theta$ (%) | Soil $\rho_b$ (g/cm$^3$) | Plant Height (cm) |
| T0 | 22.96$^a$ | 1.35$^a$ | 19.42$^d$ | 22.84$^a$ | 1.35$^a$ | 26.61$^d$ | 27.65$^a$ | 1.40$^a$ | 13.14$^d$ |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| T1 | 28.81[b] | 1.20[b] | 24.16[c] | 24.90[b] | 1.29[b] | 27.88[c] | 29.99[ab] | 1.39[a] | 17.82[c] |
| T2 | 31.69[b] | 1.12[b] | 26.69[b] | 27.15[b] | 1.24[b] | 29.10[b] | 31.69[b] | 1.34[b] | 21.30[b] |
| T3 | 33.90[b] | 1.01[b] | 30.20[a] | 28.52[b] | 1.20[b] | 30.30[a] | 39.08[c] | 1.03[c] | 23.20[a] |
| Variety | | | | | | | | | |
| V1 | | | 25.99a | | | 31.10[a] | | | 19.47[a] |
| V2 | | | 24.25[b] | | | 25.90[b] | | | 18.30[b] |
| Interaction (AxV) | | | NS | | | NS | | | NS |
| CV(%) | 6.32 | 5.94 | 8.56 | 6.32 | 5.94 | 8.56 | 6.32 | 5.94 | 8.56 |

Same letters in each column are not significantly different at 0.05 levels according to LSD test.

The highest value of leaf width at location of (Usuku-1, Usuku-2 and at Waitii) as shown in Table 4 was recorded at T3 treatment (1.2 cm; 1.2 cm; 0.98 cm) followed by T2 (1.05 cm; 1.15 cm; 0.85 cm), T1 (0.93 cm; 1.15 cm; 0.79 cm) and T0 (0.83 cm; 0.95 cm; 0.52 cm). Variety with the highest of leaf width at location of (Usuku-1, Usuku-2 and Waitii) was recorded at V1 treatment (1.04 cm; 1.2 cm; 0.82 cm) followed by V2 (0.97 cm; 1.03 cm; 0.75 cm). Locations with local environments that support good growth and yields are Usuku-2 followed by Usuku-1 and Waitii.

Table 4. Effect of water volume and varieties treatment on soil $\theta$ and soil $\rho_b$ and width leaf.

| **Treatments** | **Usuku-1** | | | **Usuku-2** | | | **Waitii** | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Soil $\theta$ (%)** | **Soil $\rho_b$ (g/cm$^3$)** | **Leaf Width (cm)** | **Soil $\theta$ (%)** | **Soil $\rho_b$ (g/cm$^3$)** | **Leaf Width (cm)** | **Soil $\theta$ (%)** | **Soil $\rho_b$ (g/cm$^3$)** | **Leaf Width (cm)** |
| T0 | 22.96[a] | 1.35[a] | 0.83[d] | 22.84[a] | 1.35[a] | 0.97[b] | 27.65[a] | 1.40[a] | 0.54[c] |
| T1 | 28.81[b] | 1.20[b] | 0.93[c] | 24.90[b] | 1.29[b] | 1.15[a] | 29.99[ab] | 1.39[a] | 0.79[b] |
| T2 | 31.69[b] | 1.12[b] | 1.05[b] | 27.15[b] | 1.24[b] | 1.15[a] | 31.69[b] | 1.34[b] | 0.85[b] |
| T3 | 33.90[b] | 1.01[b] | 1.20[a] | 28.52[b] | 1.20[b] | 1.21[a] | 39.08[c] | 1.03[c] | 0.98[a] |
| Variety | | | | | | | | | |
| V1 | | | 1.04[a] | | | 1.20[a] | | | 0.82[a] |
| V2 | | | 0.97[b] | | | 1.03[b] | | | 0.74[b] |
| Interaction (AxV) | | | NS | | | NS | | | NS |
| CV(%) | 6.32 | 5.94 | 6.62 | 6.32 | 5.94 | 6.62 | 6.32 | 5.94 | 6.62 |

Same letters in each column are not significantly different at 0.05 levels according to LSD test.

### 3.1.1.3. *Yield Components*

The water levels treatment had significantly ($p<0.01$) and the variety had significantly ($p<0.01$) influenced on yield components of onion namely number of tillers, fresh and dry weight at all study locations (Table 5, Table

6 and Table 7). Data in these tables showed the effect of variation in water supply and effect of variety on yield components.

As seen in Table 5, the effect of water level on number of tillers indicated there is irregularity in the changing of values and locations. Except that, the varieties treatment showed the highest of number of tillers at location of (Usuku-1, Usuku-2 and Waitii) was recorded at V2 (6.75; 7.0 and 5.34) followed by V1 (4.83; 6.0 and 4.9). The location with the biggest of number of tillers was Usuku-2 followed by Usuku-1 and Waitii.

Table 5. Effect water volume and varieties treatment on soil $\theta$ and soil $\rho_b$ and number of tillers.

| Treatments | Usuku-1 | | | Usuku-2 | | | Waitii | | |
|---|---|---|---|---|---|---|---|---|---|
| | Soil $\theta$ (%) | Soil $\rho_b$ (g/cm$^3$) | Number of Tillers | Soil $\theta$ (%) | Soil $\rho_b$ (g/cm$^3$) | Number of Tillers | Soil $\theta$ (%) | Soil $\rho_b$ (g/cm$^3$) | Number of Tillers |
| T0 | 22.96$^a$ | 1.35$^a$ | 4.4$^b$ | 22.84$^a$ | 1.35$^a$ | 4.5$^c$ | 27.65$^a$ | 1.40$^a$ | 4.3$^b$ |
| T1 | 28.81$^b$ | 1.20$^b$ | 5.5$^a$ | 24.90$^b$ | 1.29$^b$ | 6.5$^b$ | 29.99$^{ab}$ | 1.39$^a$ | 5.5$^a$ |
| T2 | 31.69$^b$ | 1.12$^b$ | 6.5$^a$ | 27.15$^b$ | 1.24$^b$ | 7.5$^a$ | 31.69$^b$ | 1.34$^b$ | 5.4$^a$ |
| T3 | 33.90$^b$ | 1.01$^b$ | 6.3$^a$ | 28.52$^b$ | 1.20$^b$ | 7.5$^a$ | 39.08$^c$ | 1.03$^c$ | 5.3$^a$ |
| Variety | | | | | | | | | |
| V1 | | | 4.93$^b$ | | | 5.4.0$^b$ | | | 5.0$^a$ |
| V2 | | | 6.4$^a$ | | | 7.8$^b$ | | | 5.34$^a$ |
| Interaction (AxV) | | | NS | | | NS | | | NS |
| CV (%) | 6.32 | 5.94 | 18.15 | 6.32 | 5.94 | 18.15 | 6.32 | 5.94 | 18.15 |

Same letters in each column are not significantly different at 0.05 levels according to LSD test.

The water treatment with highest of fresh weight at location of (Usuku-1, Usuku-2 and Waitii) was found at T3 treatment (43.0 g; 50.0 g and 20.1 g) followed by T2 (35.8 g; 48.0 g and 20.0 g), T1 (29.3 g; 44.0 g and 14.5 g), T0 (15.8 g; 37.5 g and 11.8 g) (Table 6). The variety treatment with highest of fresh weight at location of (Usuku-1, Usuku-2 and Waitii) was recorded at V1 treatment (32.9 g; 47.5 g; 17.4 g) followed by V2 (29.0 g; 42.3 g; 15.8 g). Locations with the best results of fresh weight were recorded at Usuku-2 followed by Usuku-1 and Waitii.

The biggest of dry weight at (Usuku-1, Usuku-2 and Waitii) was obtained at T3 (36.0 g; 42.3 g and 15.9 g) followed by T2 (30.1 g; 39.5 g and 14.6 g), T1 (25.2 g; 36.3 g and 11.6 g), T0 (14.0 g; 26.8 g and 9.2 g) (Table 7). Variety treatment with the biggest of dry weight was obtained at V1 (28.4 g; 37.8 g; 13.83 g) followed by V2 (24.3 g; 34.7 g; 11.82 g).

Table 6. Effect of water volume and varieties treatment on soil $\theta$ and soil $\rho_b$ and fresh weight.

| Treatments | Usuku-1 | | | Usuku-2 | | | Waitii | | |
|---|---|---|---|---|---|---|---|---|---|
| | Soil $\theta$ (%) | Soil $\rho_b$ (g/cm$^3$) | Fresh Weight (g) | Soil $\theta$ (%) | Soil $\rho_b$ (g/cm$^3$) | Fresh Weight (g) | Soil $\theta$ (%) | Soil $\rho_b$ (g/cm$^3$) | Fresh Weight (g) |
| T0 | 22.96$^a$ | 1.35$^a$ | 16.5$^d$ | 22.84$^a$ | 1.35$^a$ | 39.3$^d$ | 27.65$^a$ | 1.40$^a$ | 11.7$^c$ |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| T1 | 28.81[b] | 1.20[b] | 28.3[c] | 24.90[b] | 1.29[b] | 44.2[c] | 29.99[ab] | 1.39[a] | 14.5[b] |
| T2 | 31.69[b] | 1.12[b] | 35.8[b] | 27.15[b] | 1.24[b] | 44.4[b] | 31.69[b] | 1.34[b] | 20.3[a] |
| T3 | 33.90[b] | 1.01[b] | 43.0[a] | 28.52[b] | 1.20[b] | 48.10[a] | 39.08[c] | 1.03[c] | 20.1[a] |
| Varieties | | | | | | | | | |
| V1 | | | 30.9[a] | | | 46.6[a] | | | 17.04[a] |
| V2 | | | 29.0[b] | | | 41.4[b] | | | 16.2[b] |
| Interaction (AxV) | | | NS | | | NS | | | NS |
| CV (%) | 6.32 | 5.94 | 16.44 | 6.32 | 5.94 | 16.44 | 6.32 | 5.94 | 16.44 |

Same letters in each column are not significantly different at 0.05 levels according to LSD test.

Table 7. Effect of water volume and varieties treatment on soil $\theta$ and soil $\rho_b$ and dry weight (g).

| Treatments | Usuku-1 | | | Usuku-2 | | | Waitii | | |
|---|---|---|---|---|---|---|---|---|---|
| | Soil $\theta$ (%) | Soil $\rho_b$ (g/cm$^3$) | Dry Weight (g) | Soil $\theta$ (%) | Soil $\rho_b$ (g/cm$^3$) | Dry Weight (g) | Soil $\theta$ (%) | Soil $\rho_b$ (g/cm$^3$) | Dry Weight (g) |
| T0 | 22.96[a] | 1.35[a] | 13.5[d] | 22.84[a] | 1.35[a] | 32.8[d] | 27.65[a] | 1.40[a] | 9.2[c] |
| T1 | 28.81[b] | 1.20[b] | 24.3[c] | 24.90[b] | 1.29[b] | 35.6[c] | 29.99[ab] | 1.39[a] | 13.5[b] |
| T2 | 31.69[b] | 1.12[b] | 29.9[b] | 27.15[b] | 1.24[b] | 38.5[b] | 31.69[b] | 1.34[b] | 14.5[a] |
| T3 | 33.90[b] | 1.01[b] | 35.7[a] | 28.52[b] | 1.20[b] | 40.7[a] | 39.08[c] | 1.03[c] | 16.1[a] |
| Variety | | | | | | | | | |
| V1 | | | 28.4[a] | | | 38.4[a] | | | 14.7[a] |
| V2 | | | 24.3[b] | | | 35.3[b] | | | 11.9[b] |
| Interaction (AxV) | | | NS | | | NS | | | NS |
| CV (%) | 6.32 | 5.94 | 15.71 | 6.32 | 5.94 | 15.71 | 6.32 | 5.94 | 15.71 |

Same letters on each column are not significant different at 0.05 levels according to LSD test.

### 3.1.3. *Effect of the Interaction*

Results in Table 3 to Table 7 revealed that there is no significant interaction effect of water level treatments and varieties on all growth and yield parameters of onion.

## 3.2. *Discussion*

### 3.2.1. *Soil physics properties*

Soil physical properties described as soil $\theta$ and soil $\rho_b$ was clearly affected by sprinkling water application. The effect of water on soil $\theta$ and soil $\rho_b$ has been investigated by [12] with the commented that soil $\rho_b$ can be used to calculate soil water content, which was a significant property to regulate the amount of irrigation. Reference [11] when investigated the different soils obtained that soil $\theta$ an increasing tendency with decreasing soil $\rho_b$ and vice versa. A similar finding was argued by [8, 35] that the soil $\theta$ is the reciprocal of soil$\rho_b$. An increase in soil $\rho_b$, a decrease in soil porosity or a change in the proportion of pores with water and air, and an

increase soil strength. When there is an increase in the volume of treatment water, it is followed by an increase in soil water content and a slight decrease in the bulk density of the soil and in this situation the plants easily absorb nutrients from the soil through the roots, which in turn helps plant growth. Conversely, if the bulk density of the soil is high, it can lead to limiting root growth and poor movement of air and water through the soil, and consequently can produce shallow root systems, reduced water and nutrient supply, poor plant growth and affect crop yields [36, 37].

### 3.2.2. *Plant Growth Components*

Plant growth represented as parameters of plant height and leaf width were clearly affected by water level treatment. The results are in agreement with statement given by [9] that the growth and yield of any crop are related to the amount of water used. The variable amount of water contained in soil, and its energy state is important factors affecting the growth of plants. The relationship between increased treatment water and increased onion growth has been reported by [23] by stating that with increasing soil water supply, recorded plant growth parameters such as plant height and leaf width were significantly increased.

The increase in plant height with increased irrigation water could be mainly due to better availability of soil $\theta$ and slightly decreased of soil $\rho_b$ and that have enhanced effects on the vegetative growth of plants by increasing cell division and elongation [24]. The increasing plant height with sufficient of the depth of application of irrigation also indicates a beneficial effect of water in maintaining the turgor pressure of the cells, which is a major prerequisite for growth [38]. The maximum of plant height also observed by [30] who reported that with increasing soil water supply, plant growth parameters (plant height) were significant increased.

Similar to the effect observed in leaf width, with an increase in the water application, the leaf width of onion plants increased significantly. Thus, plants treated with application at the sufficiency of water at all growth stages produced leaves with the widest diameter [36]. The increase in leaf diameter with the increase in water application at all growth stages could be associated with a better supply of soil water contents and properly of soil bulk density in order to onion plants can uptake nutrients in soil.

### 3.2.3. *Plant Yield Component*

Plant yields represented by parameters of the number of tillers, fresh weight and dry weight were clearly influenced by the amount of treatment water application. The relationship between increased treatment water and increased onion yield has been reported by [23] by stating that with increasing soil water supply, recorded plant yield parameters such as number of tillers, fresh bulb and dry bulb were significantly increased.

The increase in number of tillers per plant at higher irrigation level and shorter irrigation interval was obviously due to maintenance of soil moisture regime in the root zone closer to field capacity as reported by [39]. Reference [40] also observed in an experiment that at depth of 25 cm water table is best water availability conditions for growing number of tillers because it closer to root zone compared to 40 cm depth of water table.

The fresh and dry yield of onions has the highest performance in subsurface irrigation and there is no significant difference between flood irrigation and sprinkler methods [41]. Onion crop yield obtained from different treatment has been studied by [25]. They reported that the maximum yield was observed in treatment with full irrigation (5630 $m^3.ha^{-1}$) and the lowest was observed in treatment of (28.1 $m^3.ha^{-1}$). While [26] concluded that onion bulb yield under rain-fed conditions without irrigation was significantly lower than the

yield recorded under irrigation conditions. A similar result was also reported by [27] that good bulb yield when irrigation is sufficient and low bulb yield when not. While [28, 29, 30, 31] opined that to maximize the yield of crop, sufficient water is required. This result is also in agreement with the result of [24] who reported that the optimum amount of watering water application resulted in the highest bulb yield.

### 3.2.4. *Cultivar*

The differences in plant growth and yield between V1 and V2 may be due to the differences in genetic makeup of the adaptation ability of the varieties to existing local environment [32, 7]. Regarding to existing local environment, [26] reported that the onion yield production depends on evaporation-transpiration rate of onion (ET) in particular region/seasonal with a correlation coefficient of r = 0.87. The difference of onion yields (V1 and V2) among locations, with Usuku-2 being the best followed by Usuku-1 and Waitii respectively may be attributed to differences in local environmental conditions such as solar radiation intensity and wind speed locally [42, 2].

In this study also revealed that there is no significant interaction effect of water level treatment and varieties on all growth and yield parameters of onion plants. Regarding these results, [33] stated that the effect of water treatments and varieties on growth and yield of onions were separated singly.

## IV. CONCLUSION

The study shows that increased amount of water application increased the soil $\theta$, the growth and yield of onion and slightly decreased of soil $\rho_b$. The overall of parameters observed show that by increasing number of water applications followed by an increase in the value of the growth and yield components. The vegetative growth (plant height, width leaf ) and the yield components (number of tillers, fresh weight and dry weight) under local environmental conditions Usuku-2 were significantly highest than Usuku-1 and the lowest were observed at Waitii. Variety V1 seems to have good performance but V2 has the potential to be developed. The determined maximum produces yield of onion can be good basis for onion growers in the region in relation to the optimum watering use, planning, and utilization of watering methods.

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*Source Data*

| **Location 1 (Usuku-1)** | | | | | | |
|---|---|---|---|---|---|---|
| **No** | **Plots** | **Plant Height (cm)** | **Width Leaf (cm)** | **Number of Tillers** | **Fresh Bulb Weight (g)** | **Dry Bulb Weight (g)** |
| 1 | A3V1 | 31.62 | 1.24 | 5.7 | 46.10 | 38.20 |
| 2 | A2V1 | 27.50 | 1.12 | 5.1 | 31.04 | 32.52 |
| 3 | A1V1 | 25.43 | 0.93 | 4.6 | 26.17 | 27.31 |
| 4 | AoV1 | 19.40 | 0.91 | 4.2 | 16.5 | 13.52 |

| Location 1 (Usuku-1) | | | | | | |
|---|---|---|---|---|---|---|
| **No** | **Plots** | **Plant Height (cm)** | **Width Leaf (cm)** | **Number of Tillers** | **Fresh Bulb Weight (g)** | **Dry Bulb Weight (g)** |
| 5 | A3V2 | 28.79 | 1.15 | 6.8 | 40.56 | 33.14 |
| 6 | A2V2 | 25.88 | 0.99 | 7.8 | 38.67 | 27.27 |
| 7 | A1V2 | 22.89 | 0.94 | 6.4 | 30.45 | 21.25 |
| 8 | AoV2 | 19.44 | 0.75 | 4.5 | 16.50 | 13.50 |
| **Location 2 (Usuku-2)** | | | | | | |
| **No** | **Plots** | **Plant Height (cm)** | **Width Leaf (cm)** | **Number of Tillers** | **Fresh Bulb Weight (g)** | **Dry Bulb Weight (g)** |
| 1 | A3V1 | 32.16 | 1.30 | 5.0 | 49.68 | 41.92 |
| 2 | A2V1 | 31.58 | 1.20 | 5.9 | 49.29 | 41.81 |
| 3 | A1V1 | 30.98 | 1.20 | 6.0 | 45.35 | 35.17 |
| 4 | AoV1 | 29.50 | 1.10 | 4.5 | 42.00 | 34.9 |
| 5 | A3V2 | 28.39 | 1.12 | 7.3 | 46.53 | 39.21 |
| 6 | A2V2 | 26.59 | 1.09 | 8.0 | 39.47 | 35.1 |
| 7 | A1V2 | 24.77 | 1.09 | 6.3 | 43.02 | 36.04 |
| 8 | AoV2 | 23.71 | 0.85 | 5.6 | 36.5 | 30.7 |
| **Location 3 ( Waitii)** | | | | | | |
| **No** | **Plots** | **Plant Height (cm)** | **Width Leaf (cm)** | **Number of Tillers** | **Fresh Bulb Weight (g)** | **Dry Bulb Weight (g)** |
| 1 | A3V1 | 24.27 | 0.93 | 5.9 | 20.93 | 17.02 |
| 2 | A2V1 | 22.21 | 0.89 | 5.0 | 19.69 | 16.19 |
| 3 | A1V1 | 18.96 | 0.74 | 5.1 | 15.29 | 12.50 |
| 4 | AoV1 | 12.43 | 0.56 | 4.6 | 12.25 | 9.58 |
| 5 | A3V2 | 22.13 | 0.86 | 5.6 | 19.10 | 15.21 |
| 6 | A2V2 | 20.44 | 0.80 | 5.8 | 20.94 | 12.77 |
| 7 | A1V2 | 16.67 | 0.75 | 5.9 | 13.75 | 10.79 |
| 8 | AoV2 | 13.85 | 0.53 | 4.0 | 11.19 | 8.77 |

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