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The Effect of Different Water Levels and Varieties on The Growth and Yield of Onion (*Allium cepa* L.) Using a Watering Pot in Hot Dry Season at Tomia District Wakatobi Indonesia

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ABSTRACT

Background: Onion (*Allium cepa* L) is the important crop and it can be produced throughout the year with dependable rain only or other traits because no irrigation water system is available. **Objective :** Rainfall in unreliable and insufficient to support onion production and therefore that makes the use of watering pot indispensable practice. **Result:** The variety was significant ($p<0.05$) influenced the plant high, leaf width, leaf area index and number of tillers, but it was not significant effect on fresh and dry weight. Variety V1 showed a better performance than V2. **Conclusion:** It could be concluded that as water levels increase the onion growth and yield parameters increase. By using A3 (16 liters) of water, will product the highest mean plant height, leaf width, leaves area index, fresh and dry weight at harvest. In order to reach high onion production, onion farmers can adopt A3 water application. Besides that, farmers can develop the Enrekang onion variety (V2) since it statistically was not different with V1 in terms of fresh and dry weight.

KEYWORDS: Red onion, water levels, varieties, watering pot, growth and yield of onion

INTRODUCTION

Onion (*Allium cepa* L) is the most important crop and it is widely cultivated as a source of income by many farmers in many parts of Tomia District of Wakatobi Regency. It can be produced throughout the year with dependable rain only or other traits because no irrigation water system is available. Because of rainfall in unreliable and insufficient to support onion production and therefore that makes the use of watering pot indispensable practice.

The existence of soil water content in relation to plant growth is undeniable and has been recognized for very a long time by farmers. According to Shaxson & Barber [1], water plays an important role in crop seed germination, during the process of photosynthesis by which crops manufacture their own assimilates and for extraction of nutrients from soil by plant roots. Therefore any occurrence of water shortage during the growing season may limit crop development, crop growth and final yield [2]. These is in line with Bai *et al* [3] who stated that water is the major component of the soil in relation to plant growth such as nutrients uptake by roots system.

The red onion is shallow rooted and sensitive to water stress, and as a result the crop is commonly given light and frequent watering to avoid water stress. Maximum yield could be obtained with the achievement of entire crop water requirement [4]. In agreement with this statement, that to maximize yield of crops was required sufficient water [5,6,7].

In dry land areas in hot dry season, watering may all or mostly of the crops water needs. Shaibu *et al* [4] stated that all crops require certain amount of water during each stage of development mainly their initial stage, crop development stage, mid-growing and maturity stage and will transpire water at a maximum rate when the soil water is at field capacity. It is therefore the presence of optimum amount water that will help crops achieve a stable internal balance and resistance to other sources of stress [4]. Pejic *et al* [8], reported that the yield of onion bulb was significantly higher in irrigated than in the rainfed condition as onion production from seed in the region depends directly on irrigation.

According to Thingalmaniyan *et al* [9], successful onion production depends mainly on the selection of varieties that adapted to different condition imposed by specific environment. Therefore, the introduction of new varieties represents an important axe to enhance production by increasing the number of cultivar available for farmers, which not only an advantage for the farming community but also for markets and processing industries. Hence, Boukary *et al* [10] stated that a cultivar crop performs differently under different agro-climate conditions and various cultivars of the same specific grown in the same environment give different yields as the performance of a cultivar mainly depends on the interaction of genetic makeup and environment.

In order to approach the implementation of any idea on the intensive utilization agro- ecological conditions or the development of new procedure for the watering level of crop, it is necessary to know precise water needs of plants. Water requirement of onion under agro ecological conditions vary from 450 to 540 mm for the yield of 30-40 t ha^{-1} [8,11]. Some studies give clear proof that the water requirement for onion are very high, restricting expansion to regions with limited water resource [12].

Therefore, the objectives of this experiment were to determine the effect of different water levels and varieties on onion growth and yield parameters at harvest that was cultivated at suboptimal land in hot dry season under traditionally watering using a watering pot.

MATERIALS AND METHODS

Description of the study area:

The research was conducted at the northern of sub district Usuku, Tomia District, Wakatobi Regency during September to November 2016 in hot dry season. Usuku (123^{o}56.466’ E and 05^{o}45.906’ S, 107 m above sea level) is located in the central of Tomia island.

The daily temperature ranges was between 24 – 35^o C. According to Telke [13], stated that, from bulb initiation up to harvesting the higher temperatures of between 25 and 28^{o}C are required because of warmer climate causes earlier bulb formation. The most predominant soils are probably ultisols and there is any problem of low in soil fertilize. The experimental site is categorized as hot dry region. Criteria for location selecting were (i) high potential for onion production, and (ii) easy to access by paths farm.

Material Used in the study:

There were two varieties of red onion for the study, one from Local Variety (V1) and two from Enrekeng South Sulawesi (V2). Both varieties Local and Enrekang were obtained from local market in Kendari, South East Sulawesi. The onion local variety is the only one product at the study area.

Soil Sampling:

For determination soil water content at field capacity (FC) and permanent wilting point (PWP), and physic-chemical properties, undisturbed soil samples were collected using core sampler at soil depth of 0-10, and 10-20 cm as it is most probably of onion root depth from the experimental field before planting. The available water holding capacity of the soil was obtained by subtracting the water content at PWP from that at FC. Soil water content was measured gravimetrically. For determination selected soil physic-chemical properties, soil samples were analyzed at the Integrated Laboratory of Halu Oleo University. The physic-chemical properties in this study were soil pH, texture, organic matter, organic carbon, NPK nutrients.

Crop data collection:

Data on onion growth and yield of all parameters interest were recorded at physiological maturity and just after harvesting. The collected data were expressed as average of all population of each block of each treatment.

Accordingly, plant height was measured in centimeters unit from ground reference to the tip of the stem and leaf width was measured in centimeter unit by tearing the middle of leaf and was expressed as average of three longest leaves for each cluster of onion. The leaf area index therefore was calculated from relationship:

$$LAI = \frac{heiht * width}{row\ spacing} * onion\ coeficient$$

With onion coefficient at harvest time is 0.85 [14]. The fresh and dry weight was measured in grams using analytical balance with 0.1 gram of accuracy.

Methods of Data Analysis:

The data were obtained analyzed statistically by analysis of variance (ANOVA) which was computed using excel computer software program version 2007 and significant treatment means were compared using least square difference (LSD) test at $p < 0.01$ and/or $p<0.05$.

Laboratory Soil Analysis:

A present research of soil fertilizer status, which includes soil sampling and analysis, would provide in the beginning valuable information for diagnosis and prediction of fertilization needs. Soil samples were analyzed before planting of selected soil properties; texture, pH, N total, P, K, organic matters, and organic carbon. The objective of this present study was to begin inventory and assessment of soil fertility status, which could lead to effective site specific soil management and better use of soil sources and increase onion yield. Based on soil fertilize analysis and soil fertilization criteria/status indicate that location experiment site fall in the medium and low fertilize.

Treatment and experimental design:

The treatment consisted of 2 factorials combination of two varieties (V1 and V2) and four water levels: 0 liters, 4 liters, 8 liters, and 16 liters, with a notation A0, A1, A2, and A3 respectively. The experiment was laid out in a randomized complete block design with three replications. After land preparation, 8 plots were marked in the location. The plot size was 1.0 m x 1.5 m (1.5 m^2) with a distance of 0.3 meter between plots. Each plot compromised 6 rows with an inter-row spacing of 15 centimeter and intra-row also of 15 centimeter. One row contained 8 plants, and thus, one plot contained 48 plants.

Land Preparation:

The first activity of this research before preparing land was begun by collecting soil samples from the experiment site following an approximately random pattern and analyzed in the laboratory to determine the properties of soil. Soil sampling and analysis, would provide valuable information for diagnosis and prediction of fertilization needs. The next activity was started by preparing the nursery site with one and half meter in width and 8 meter length. With a minimum tillage, ground was hoed and crumbled and soil level was raised by about 20 cm height from soil surface. Gravels were separated away from soil and land readily for planted ultimately. After constructing it was sprinkled by manure and allowed for one week.

Agronomic Practices:

Prior to planting, the field was watered with fresh water to obtain a uniformly leached soil profile. A day before planting, the experiment site was watered uniformly. Both, local onion (V1) and Enrekang (V2) varieties were selected and sorted to obtain proper onion seeds used for the experiment and cultivated on September, 22, 2016 by hand drilling. After planting, the seeds were covered with soil about one centimeter thickness and applied watering two times per day during early morning and late afternoon for consecutive day with the same of an amount of water until seeds germination emergence uniformly. By an amount of different water level accordance with treatment, applied further watering two times per day during early morning and late afternoon for consecutive day for growth season period. At maturity and harvesting period water was applied only once per day during late afternoon. The onions were harvested when about 80 % of the top of the bulbs in each plot bent over.

RESULT AND DISCUSSION

Analysis of Selected Soil Properties:

The results of soil analysis properties based on soil sampling of the study area are presented in Table 1. Soil pH analysis indicates that soil pH is 6.73. The optimum pH for onion production ranges between 6 and 8 [14]. Onion can growth and productive at optimum pH in the range of 6 to 7 [14,15,16].

Table 1: Soil properties of experiment site before treatment

Location	Chemical properties						Particle size (%)		
	pH	N_{tot} (%)	P (ppm)	K (me/100g)	OM (%)	C (%)	Sand	Clay	Silt

Usuku	6.73	0.31	37.74	0.32	1.86	3.81	13.09	14.24	72.67

The available essential NPK nutrients of those soils were still low and were added necessary because fertilizer requirement are normally 60 to 100 kg/ha N, 25 to 45 kg/ha P and 45 to 80 kg/ha [18]. Also, soil having small amount organic matter (OM) content and should be added with animal manure if necessary.

Analysis of variance:

According to ANOVA there is no significant interaction effect of water level treatments and varieties on all onion growth and yield parameters. This means that effect of both treatment water levels and varieties on onion growth and yield were separated singly [19]. Water levels treatment significantly ($p<0.01$) influenced the plant height, leaf width, leaf area index, fresh height and dry weight. However, water levels were not significant effect on number of tillers. The variety significantly ($p<0.01$) influenced the plant height, leaf width, leaf area index and number of tillers. However, variety was not significant effect on fresh and dry weight.

Plant high:

Table 2 showed that water level and variety highly significant ($p<0.05$) influenced the mean onion plant height. As water level increase from 0 to 16 liters, the mean of onion plant height increase. The highest plant height of 27.84 cm was recorded at treatment A3 of 27.48 cm followed by A2 (25.37 cm), A1 (23.29 cm and 19.61 cm at treatment A2, A1 and A0 respectively (Table 2).

Table 2. Effect of water level treatment and variety on onion plant height, leaf width, leaf area index, number of tillers, fresh weight and dry weight at harvest

water treatments	Onion growth parameters			Onion yield parameters		
	Plant height (cm)	Leaf width (cm)	Leaf area index	Number of tillers	Fresh weight (g)	Dry weight (g)
A0 (control)	19.61c	0.78c	1.27c	5.23	22.41b	18.50c
A1 (4 liters)	23.29b	0.94b	1.59cb	5.71	29.01ab	23.84bc
A2 (8 liters)	25.37ab	1.03ab	1.76ab	6.27	33.18a	27.61ab
A3 (16 liters)	27.84a	1.12a	2.09a	6.05	37.15a	30.78a
$LSD_{(0,05)}$	3.46	0.12	0.40	ns	8.46	6.64
CV %	8.58	6.62	14.38	18.15	16.44	15.71
Variety						
V1(Local variety)	25.48a	1.03a	1.83a	5.13b	31.19	25.78
V2 (Enrekang)	22.58b	0.91b	1.53b	6.5a	29.68	24.59
LSD(0.05)	1.81	0.06	0.21	0.92	ns	ns
CV (%)	8.58	6.62	14.38	18.15	16.44	15.71

Remarks: Data in column followed by different letters are significantly different based on LSD 5 %, ns: not significant

Increasing of plant height with adequate soil moisture application is related to water in maintain the turgid pressure of the plant cells which is the main reason for the growth [20]. Meanwhile according to Fitsum *et al* [17], the increasing in plant height with increases water level application could be mainly due to better availability of soil water and sufficient up take nutrient (N) which have enhancing effects on the vegetative growth of plants by increasing cell division and elongation. Table 2 also indicated that Local variety (V1) had the higher plant high (25.48 cm) than Enrekang variety (V2) (22.58 cm). However, obtained results are significantly different from those reported by Shaibu *et al* [4] in Ghana which was in the range of 39.07 – 48.34 cm. This could be due to differences in geographical locations, soil fertilizer, water volume treatment and the different of types of fertilizers applied on crop. the difference in plant height among different varieties may be due to the differences in generically makeup of the two varieties under trial and adaptation ability of these varieties to particular environment [21].

Leaf Width:

The experiment showed that effect of water level and variety differed highly significantly ($p<0.05$) in terms of leaf width. The water level A3 produced the highest leaf width followed by A2, A1 and then A0. According to 17-Fitsum *et al* (2016), the increasing in the leaf width with increases water level application could be mainly due to better availability of soil water and sufficient up take nutrient (N) which have enhancing effects on the vegetative growth of plants by increasing cell division and elongation. This result seems closely related to that of Bagali [22] who reported longer leaves at water level treatment A3 crop water requirement compared to treatment of deficit water A0.

The experiment also showed that Local variety (V1) had higher leaf width than Enrekang variety (V2) with values of V1 (1.03 cm) and V2 (0.91 cm) respectively. The increase in leaf width of onion local varieties might be due to the genetically variation or potentially of different onion varieties [21].

Leaf Area Index:

Leaf area index of onion differed highly significantly ($p<0.05$) from each other treatment and variety (Table 2). Effects of water level were showed by increasing water levels treatment from 0 to 16 liters. The highest effect occurred at A3 (16 liters) followed by A2 (8 liters), A1 (4 liter) and A0 (0 liter) as a control. Metwally [6] reported that the greatest volumes water during the development and ripening stages yielded harvest with higher percentages of large size, and the lower water supply, leaf growth rate decreased because the water potential decreased [23].

Meanwhile, the higher leaf area index (1.83) was recorded by Local variety (V1) while the lower was recorded by Enrekang variety (V2). The differences in leaf area index between variety V1 and V2 may be due to the differences in genetic makeup of the two varieties under experiment and adaptation ability of these varieties to particular environment condition.

Number of Tillers:

As seen in Table 2 that water levels treatment was not significant influenced number of tillers. This means that increasing the amount of water was not associated with the increasing the number of tillers per plant, even treatments A2 and A3 showed a trend of decrease the number of tillers. In contrast with Metwally [6] reported that the higher water supply resulted in higher vegetative parameters such as number of leaves per plant.

However, in other hand variety differed highly significant ($p<0.05$) in term of number of tillers between Local and Enrekang variety. The Local onion variety (V1) recorded the higher number of tillers.

Fresh Weight:

Table 2 show the effect of water level to onion fresh weight (g). Larger amount of water supply showed highly significantly ($p<0.05$) influenced the fresh weight of onion. As water level increase from 0 to 16 liters, the mean of onion fresh weight increase. The highest onion fresh weight of 37.15 g was recorded at treatment A3, followed by A2 of 33.18 g, A2 of 29.01 g and A0 of 22.41 g. This is in line with Shock et al., [4], Shaibu et al. [4] and Enchalew *et al* [7] that to maximize yield of crops was required sufficient water. In this experiment, the effect of variety on the fresh weight was not significant between Local and Enrekang variety.

Dry Weight:

A highly significantly ($p<0.05$) difference were observed among the water levels treatment on dry weight of onion. As water levels treatment increased from A1 (4 liter) to A3 (16 liter), liters, dry weight of onion increased from 23.84 – 30.78 g. This was attributed to the fact that adequate watering conditions early in the season led to the development of an abundant leaf cover and a shallow root depth which cannot withstand water stress at later state [24].

Maximum yield could be obtained with the achievement of entire crop water requirement and vice versa. This is in line with [4,5,7] that to maximize yield of crops was required sufficient water. Meanwhile according to Fitsum *et al* [17], the increasing in plant height, leaf width with increases water level application could be mainly due to better availability of soil water and sufficient up take nutrient (N) which have enhancing effects on the vegetative growth of plants by increasing cell division and elongation. While the highest of mean fresh and dry weight were found at treatment combination of A3V1 with value of 38.90 g and 32.38 g respectively, and the lowest at combination A0V2 with value of 21.23 g and 17.66 g respectively.

Onion (*Allium cepa* L.) is a widely recognized important crop, successfully produced under hot dry season conditions in different parts of Tomia District Wakatobi Regency Southeast Sulawesi. Lack of information and agronomic practice of appropriate water supply to plant are among the main problems of onion farmers in Tomia so that it is cause low production of onion.

Conclusion And Future Work:

It could be concluded that as water levels increase the onion growth and yield parameters increase. By using A3 (16 liters) of water, will product the highest mean plant height, leaf width, leaves area index, fresh and dry weight at harvest. In order to reach high onion production, onion farmers can adopt A3 water application. Besides that, farmers can develop the Enrekang onion variety (V2) since it statistically was not different with V1 in terms of fresh and dry weight.

The results suggest that to achieve a high production potential of onion, it is possible to calculate water supply for farmers cultivating onion so that appropriate soil water content should be maintained during the entire growing season. The another suggestion that watering the daily crop water requirement of onion into two times; i.e. applied in the morning and applied in the late evening in order to maintain appropriate soil moisture

during the entire growing season. The treatment A3 and variety V1 are therefore recommended for onion farmers in *Tomia* to adopt it if they want to achieve maximum yield and efficiency utilization of water per acreage. So, under condition that water resources are scarce, it can be recommended that local onion variety can be watered with 16 liters or more water. Although, the local variety seems showed a higher performance than *Enrekang* variety, but it is potential to be developed. Since this field experiment is three months study in one location, further research in other locations and years is warranted to confirm the present results.

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