The Effect of Irrigation Frequency and Amount on the Growth and Yield of Kale (*Brassica Oleracea var. Acephala*)

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Abstract— *A study was conducted in which Kale (Brassica oleracea var. Acephala) was grown in a Randomized Block Design experiment at the Faculty of Agriculture at Luyengo Campus of the University of Eswatini to compare five different irrigation frequencies (treatments) on the production of kale. The five treatments were: Treatment 0 (T0) the control irrigated daily – applying 5.0 mm, treatment 1 (T1) irrigated after two days, treatment 2 (T2) irrigated after three days, treatment 3 (T3) irrigated after four days and treatment 4 (T4) irrigated after five days. Two litre (2 L) soft drink plastic bottles were used as the irrigation method. The results showed that irrigating kale every two days and applying 14 mm of water was the best option for the Luyengo area compared to applying 5 mm daily. Skipping more than two days between irrigations resulted in significantly lower yields. There were no significant differences in the other measured plant parameters: leaflength, leafwidth, plant height and the number of leaves per plant. The results of these parameters for treatment 1 (T1) were higher of that of the other treatments.*

Keywords*— *Kale, yield, Bottle drip, irrigation, frequency, amount.

I. INTRODUCTION

Kale is botanically known as Brassica oleracea var. Acephala, belonging to the family Cruciferae / Brassicaceae. It is regarded as a winter vegetable, easy to grow, and the leaves can be continuously harvested throughout its life cycle. It grows well in moist but well-draining soils. Kale tolerates slightly acidic soils with a pH range between 5.5 – 6.5 that has plenty of organic matter such as compost (Hodges, 1991). Cultivars of this vegetable differ primarily in plant size, leaf colour and texture. Some varieties that are sold as "flowering kale" are used as ornamental plants or for decoration.

Eswatini import approximately 37,300 metric tonnes of fruits and vegetable with a value of US$11,000,000 from South Africa (NAMBOARD, 2018). This is because the annual rainfall distribution in the country is skewed, with the most rainfall 1,500 mm received in the Highveld region and the least 450 mm in the Lowveld region (Dlamini and Khumalo, 2019). The Lowveld is the ideal place for vegetable production, but due to lack of water, rural communities struggle to make ends meet. Vegetable production can only be a success if grown under irrigated conditions. However, the energy requirement associated with irrigation makes its adoption difficult.

Vegetables are a necessity in rural communities as they provide the people with most of the required nutrients. Kale though a highly nutritious vegetable is hardly grown due to lack of water and the technical know-how on its agronomic requirements.

The adoption of low energy agricultural technologies like drip in the country is very slow, as the Eswatini government tends to promote conventional methods of water resource development as opposed to micro irrigation which is ideally suited to small holder farmers (Manyatsi and Magongo, 2008). Drip irrigation can be more efficient than sprinkler and furrow irrigation (Hunsaker et. al., 2019; Bajracharya and Sharma, 2005) since only the root zone of the cropped area is irrigated (Dukes et. al., 2006 and Hartz, 1999). It places water and nutrients were they are needed most with minimal energy requirements.

A majority of the soils where vegetables are grown are sandy with very low water holding capacities. These require frequent irrigation and fertigation to minimize crop stress and to attain maximum production. The main drawback with drip systems is the frequent emitter blockages (Zhou et. al., 2019). Vegetables are easier to grow and many like kale are considered as food components that significantly influence human health and well-being (Dunja et al., 2018). Dunja et al. (2018) also noted that other authors have also recognized that the vegetable kale, among cabbages, was the best source of vitamins (A, B1, B2, B6, C and E), folic acid and niacin, fatty acids, and essentials minerals (especially K, Ca, Mg, Fe and Cu) (Ayaz et al. 2006; Jahangir et al. 2009; Eryilmaz Acikgoz and Deveci 2011; Thavarajah et al. 2016) but their level may depend on the environmental and growing factors (Fadigas et al. 2010; Bjorkman et al. 2011; Westwood et al. 2014).

Since the capital cost of drip irrigation is beyond the reach of many rural farmers (von Westarp et. al., 2004; Sandhu et al., 2019; Holmer and Schnitzler, 1997) including Eswatini, the bottle drip system (Dlamini and Khumalo, 2019; Darouich et al., 2014) offers a feasible option for economic production in areas of low rainfall or during periods of water scarcity. A bottle drip system is an easy way of watering plants (Darouich et al., 2014), no costs is involved in purchasing the bottles as old material is useful, no power or piping required to supply the water and it's very easy to make (Isaac, et al., 2013).

The purpose of this study was to evaluate the effectiveness of using spent two (2 L) litre plastic bottles as a medium of irrigation on the growth and yield of kale (*Brassica Oleracea var. Acephala*) grown at Luyengo, Eswatini.

II. MATERIALS AND METHODS

In order to test the response of kale (*Brassica oleracea var. Acephala*) to the method of water delivery by the used two litre (2 L) plastic bottle drip-irrigation systems, a Randomised Design field plot experiment was established in the Agricultural and Biosystems Engineering plot of the University of Eswatini at Luyengo campus. The plot is located in the Middleveld of Eswatini at $21^0 34'$ S and $31^0 12'$ E at an altitude of about 730 m above sea level. The average seasonal temperature of the area is 18^oC. The experiment was conducted during the months of August to September 2021.

The crop was transplanted and allowed to establish for 10 days, in which all the treatments received the same amount of water which was equal to that of the control treatment. There after the treatments were applied and the crop grown for six weeks. The numbers of leaves were counted weekly and simultaneously measurements of leaf height, leaf width and plant height were taken. At the end of the experiment in week six, the wet and dry weight of harvested kale was measured. The data was then analysed to check for differences in the treatments.

2.1 Experiment Design

The experiment was a Randomized Block Design with five treatments that were replicated three times. There were three blocks, each block with three replicates. Kale was planted at a spacing of 45 cm within rows and 90 cm between the rows. There were five plants per treatment, each plant with a two litre (2 L) used plastic bottle as the method of irrigation.

The experiment had five treatments as summarized in Table 1. The daily water use of kale is estimated to range between 3.6 mm to 5.7 mm depending on the location (Chakwizira et al., 2014). A daily water use of 5 mm was selected to be the control.

TABLE 1
THE FIVE TREATMENTS THAT WERE APPLIED IN THE EXPERIMENT

Treatment	Description	Daily Equivalent depth of water applied (mm)
T0	Control – irrigated daily with 350 mL water	5.0
T1	2000 mL water applied every two days	14.1
T2	2000 mL water applied every three days	9.4
T3	2000 mL water applied every four days	7.1
T4	2000 mL water applied every five days	5.7

2.2 Bottle drip equipment

Two litre (2 L) used soft drink plastic bottles with holes 2 mm in diameter drilled on the lids were used to irrigate the kale plants. The aim was to have a uniform discharge from the holes in all the bottles. A hole was dug next to each plant and the bottle buried approximately one-third deep with the bottom facing up (Fig. 1)

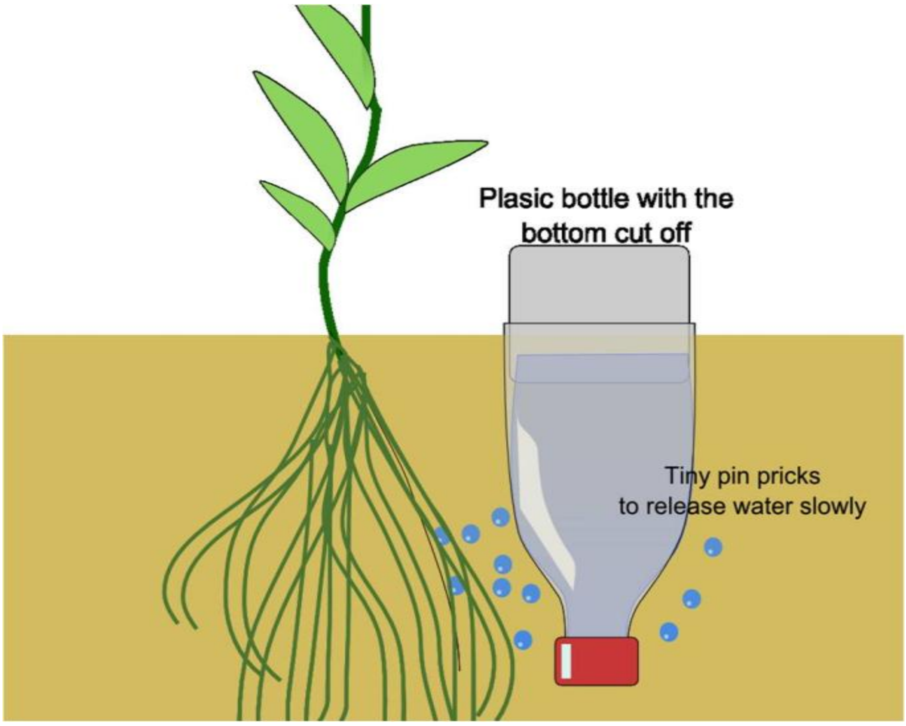

FIGURE 1: An example of a two (2 L) spent plastic cold drink bottle drip irrigation system (Dlamini and Khumalo, 2019)

2.3 Transplanting

Seedlings were obtained from Vickery Seedlings, a local company that supply ready to be planted seedling located at Malkerns. Basal fertilizer dressing was done using N:P:K; 2:3:2 (37) fertilizer at a rate of 100 kg/ha. The seedlings were planted 10 cm away from the bottle drip system. Initially two kale plants were planted and later thinned to one plant a week after transplanting. Top dressing was done when the plants were about 10 cm tall at a rate of 5 grams per plant.

III. RESULTS AND DISCUSSION

3.1 Yield and growth parameters

Results of yield and growth parameters (number of leaves, leaf length (mm), leaf width (mm), plant height (mm), wet and dry weights (g)) are summarised in table 2.

TABLE 2
MEAN YIELD AND GROWTH PARAMETERS FOR THE KALE EXPERIMENT AT HARVEST.

	Treatment Means						
	T0	T1	T2	T3	T4	Level of Significance (P < 0.05)	LSD
Number of leaves	7.6	8.6	7.8	8.9	7.9	NS	2.8
Leaf Length (mm)	260.1	271.3	266.6	252.7	263.8	NS	79.6
Leaf Width (mm)	169.8	187.0	185.1	176.1	181.0	NS	50.9
Plant Height (mm)	194.2	191.4	231.1	195.6	207.9	NS	88.3
Wet Weight (g)	547.1	653.6	613.0	598.0	532.0	**	2.0
Dry Weight (g)	87.2	105.0	98.5	96.2	85.7	**	1.7

Values showing ** stand for significant differences at P < 0.01 probability level, whereas NS represents a non-significant value. LSD – least significant difference

The results show that there were no significant differences in all the measured growth parameters except for the wet and dry weights at harvest. There were highly significant differences ($P < 0.01$) in the results for fresh and dry kale mass for treatments T1 and T2 when compared to T0, T3, and T4. The application of 14.1 mm every two days resulted in the best kale yields.

Although all the other parameters were not statistically significant ($P > 0.05$), the treatment that was irrigated every two days showed superior qualities compared to the others. This means that irrigating kale every two days and applying 14 mm was the optimum irrigation schedule for the Luyengo environment. Delaying irrigation until the fifth day was not the best option for the site, as this resulted in the lowest averages for the parameters.

Irrigating kale every day and applying 5 mm resulted in significantly lower yields compared to scheduling irrigation every two days and applying 14 mm. This could mean that for the Luyengo site, the estimated average 5.0 mm of evapotranspiration was not suitable for kale production as this figure included evaporation and kale transpiration.

IV. CONCLUSION

It was concluded that the home-made bottle drip irrigation method could be recommended for rural people in Eswatini who cannot afford to buy commercial drip system for the production of vegetables for household consumption. For the conditions of the experiment, irrigating kale every two days and applying 14 mm was the best option. It was observed that a kale evapotranspiration figure of 5 mm per day was an under-estimate for the Luyengo site. The growth of kale was significantly affected by both the timing and amount of water applied.

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