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Effects of Drip Irrigation Levels on the Performance of Lettuce Under Greenhouse Condition in Federal College of Forestry, Jos, Northern Nigeria.

[1]Popoola, A. S.; [2]Likita, M. S.; [3]Lapkat, L. G.; [4]Bako, A.; [5]Ademola, T. O.; [6]Maikano, S.; [7]Yahaya, U. F.; and [8]S. O. Okechalu

[1]Forestry Technology Department, Federal College Forestry, Jos Plateau State. [7]Agricultural Extension, Federal College Forestry Afaka, Kaduna State. [3, 4, 8]Horticulture and Landscape Technology Department, Federal College Forestry Afaka, Kaduna State. [2]Basic Science Department, Federal College Forestry Afaka, Kaduna State. [5]Agricultural Technology Department, Federal College Forestry Afaka, Kaduna State. [6]Forestry Technology, Federal College Forestry Afaka, Kaduna State.

Abstract

This study was carried out in agreenhouse in order to determine effects of different irrigation levels on lettuce yield, grown from October to December 2019, in Federal College of Forestry, Jos, Plateau State, Nigeria. Different irrigation water amounts based on Class-A-Pan evaporation were applied to the plants by drip irrigation system at four irrigation levels (120%CWR= 1.2, 100%CWR=1.0, 80%CWR=0.80, 60%CWR=0.6) in one week irrigation interval. Applied irrigation water and evapotranspiration of 100%CWR treatment were 118 and 125 mm, respectively. The highest average lettuce yield of 7.8 ton da-1 was obtained from the full-irrigation treatment (Kp1). Significant differences were not observed between Kp1 and Kp2 treatments in terms of lettuce yield. Maximum irrigation water use efficiency and total water use efficiency were obtained from Kp4 treatment respectively with 0.117 and 0.074 ton da-1 mm-1. Yield response factor (ky) was found to be 0.88. The research results showed that a 7 day irrigation

interval with Kp2 treatment could be used for irrigating lettuce under the unheated greenhouse conditions without any significant yield loss but increased water use efficiencies.

Keywords: *Drip irrigation, greenhouse, water stress, class A-pan evaporation*

Introduction

Efficient use of water is a key factor for irrigation management globally, with widespread efforts being made to increase water productivity and reduce the environmental impacts of irrigation. With future water scarcity and climate change, management of water will become an increasingly important issue in intensive vegetable production (Johnson *et al.*, 1998). Competition for water resources is acute, and the need for improved irrigation management is most important (NSW Agriculture, 2002). Intensive vegetable production is an important and expanding industry all over the world (Johnson et al., 1998). Many vegetable growers use potable water as the major water source (Dang, 2004). Competition for water with urban users has led to uncertainty about the security of future water supplies. The rainfall and mild temperatures enable vegetables to be grown year-round, but access to irrigation is required in most months to provide water security (Hollinger, 1998). Lettuce (Lactuca sativa) is grown year-round (McDougall, 2002) by direct seeding or, more commonly, by using nursery-raised 'transplants' (Tony, 2004). Lettuce is irrigated mostly by overhead sprinklers (Sutton and Merit, 1993). In other respects, drip irrigation should be suitable (Tony, 2004). The irrigation water requirement of drip irrigated plants can be less than half that of sprinkler irrigated plants (Sutton and Merit, 1993). Subsurface drip irrigation (SDI) is an alternative to conventional drip irrigation, which could become an attractive option to lettuce growers as the cost over the life of the product can be less than with surface tape, and because reduced tillage using semi-permanent beds (Senn and Cornish, 2000) has removed the need for deep cultivation between every crop.

Lettuce (Lactuca sativaL.) is the herbaceous plant that belongs to the Asteraceaes family. It is most popular vegetable consumed as fresh green salad and good source of vitamins and

minerals (Stagnari *et al.*,2015) throughout the world. As lettuce is a short cycle and rapid growth vegetable, it is very demanding in terms of climate conditions, water and nutrients supply; however, it provides fresh mass in rapid increments throughout its cycle. The strengthening of these needs can be better administered by cultivation in protected environments, in which Lettuce can achieve outstanding productions with excellent product quality. It happens because these environments provide a more propitious climate for crop development throughout the year, lessen problems with pests and diseases, protect against climate changes, lower leaching and reduce fertilization costs, enabling thusgreater production compared to open environments. However, it is of upmost importance the use of irrigation to reach highest yields (Stagnari *et al.*,2015). Lettuce which is a winter vegetable is mostly grown out in field. However, the higher yield can be obtained in greenhouses or under protective covers where environmental conditions are under control. In addition, supplying fresh fruits and vegetables to markets and taking advantage of using labors all year long instead of seasonal is possible only by greenhouse cultivation (Yuksel, 1989). Greenhouse cultivation is also a cultivation method that makes it possi-ble to grow plants outside of their seasons (Tuzel *et al.*, 2005). Hence, lettuce is recently grown on high or low tunnels in order to obtain a higher market value for the products.

Despite recent increase in popularity of poly/green house cultivation in Nigeria, there is a lack of research on potential exploitation of this technology at different climatic regions, especially with regards to irrigation management. Such studies could optimize irrigation water use, enhancing crop yields and quality, especially for cultivars of high productive capacity. Thus, the present investigation aimed with the determination of the optimum irrigation requirements for Lettuce grown under a green house in Federal College of Forestry, Jos. This study is aimed at evaluating the growth and yield responses of Lettuce on different irrigation levels in the College greenhouse, with the following objectives; to determine the growth and yield responses of lettuce to surface irrigation levels in the green house

MATERIALS AND METHODS

Study site

The experiment was carried out in a greenhouse situated in the Federal College of Forestry Jos, in Jos North Local Government Area of Plateau State. The area

lies in the Northern Guinea Savannah zone, on latitude 9° 57' N and longitude 8° 54'E with a height of about 118mm above sea level. The mean annual rainfall for the location is between 1200mm and 1250mm and mean temperature of 23°C - 25°C The soil is sandy-loam light to darkish in colour. (University of Jos meteorological Station, 2000).

Materials used and their sources

The drip system consist of the following components: Strainer filer, 62 mm diameter main pipe line (5 m long Poly Vinyl Chloride (PVC), 16 mm LLDPE lateral line 17 m long and a pressure compensating drippers of 4 L h^{-1} discharge per 4 plants. The drip materials were sourced locally in Terminus Market, Jos Plateau State. Lettuce seeds was sourced locally in Faringada market, Jos. Other materials like Soil, PH meter, moisture detector and thermometer were sourced in the College premises.

Description of Method

The meteorological data on significant weather parameter during the crop growth period were collected on daily basis from the UniJos meteorological station. The data include maximum and minimum temperature, minimum and maximum relative humidity, actual sunshine hour and daily wind speed etc. The daily reference evapotranspiration (ET0) were estimated by using FAO based Penman-Monteith (Allen *et al.*,1998). The daily irrigation water requirement for the Lettuce crops were estimated by using the following relationship

$WR = ET_{0x}\ K_{c\ x}\ Wp\ x\ A$

Where, WR = Crop water requirement (L d^{-1}), ET_0= Reference evapotranspiration (mm d^{-1}), Kc= Crop coefficient , Wp = Wetting fraction (taken as 1 for close growing crops), A= Plant area, m^2(i.e.spacing between rows, m x spacing between plants, m)

The experiment was conducted in the FCF, Jos greenhouse, 12 m in length and 7 m in width, with heights at the center and sides of 3.0 and 1.7 m, respectively. The irrigation treatments was based on crop water requirement (CWR) for lettuce crop which was calculated by using climatological parameters inside the greenhouse. The detailed of the irrigation treatments are given as under; T_1: Drip irrigation with 120 per cent of Crop Water Requirement (CWR) inside the greenhouse; T_2: Drip irrigation with 100 per cent of CWR inside greenhouse T_3: Drip irrigation with 80 per cent of CWR inside greenhouse T_4: Drip

irrigation with 60 per cent of CWR inside greenhouse All treatments were arranged randomly with replications as R_1, R_2 and R_3 for each treatment. A surface drip irrigationsystem was designed and installed. The drip system consist of the following components: Strainer filer, 62 mm diameter main pipe line (5 m long Poly Vinyl Chloride (PVC) buried at depth of 0.5 m below ground level), 16 mm LLDPE lateral line 17 m long and a pressure compensating drippers of 4 L h-1 discharge per 4 plants. Lettuce were planted on soil bags (typifying a raised bed in the open field scenerio). The standard Agronomic management practices, such as weed control, protection against pests, etc. Were carried out throughout the experiment. All growth and yield parameters were measeure and recorded.

Experimental design and layout

The experiment was laid out on a completely randomized design (CRD) with four treatments and three replications. The irrigation treatments was based on crop water requirement (CWR) for lettuce crop which was calculated by using climatological parameters inside and outside the greenhouse.

Experimental Layout

Table 1: The experimental layout of the experiment.

Treatments/ Concentrations (g)	**Replicates**		
	R_1	R_2	R_3
120% CWR	120% CWR R_1	120% CWR R_2	120% CWR R_3
100% CWR	100% CWR R_2	100% CWR R_3	100% CWR R_1
80% CWR	80% CWR R_3	80% CWR R_1	80% CWR R_2
60% CWR	60% CWR R_1	60% CWR R_2	60% CWR R_3

Data collection (Parameter assessed/investigated)

Plant growth and yield parameters measurements include; Plant height, Canopy diameter, leaves fresh weight, and were be recorded.

Statistical/Data analysis

Statistical analysis will be performed using Statistical Package for Social Sience (SPSS) software package to test the significance of different treatments individually as well as in combinations experimental ANOVA will be

performed by the method described by Gomez and Gomez (1984). The comparisons between the treatment means and variance will be tested at 5% significance level. Duncan multiple range test will be conducted to know the significance level between the treatments and groups of treatments.

Result and Discussion

The total irrigation water applied during the experimental period and water use of lettuce were given for each irrigation treatment (Table 2). Drip-irrigated plots receiving irrigation water varying from a low of 35 mm in 120 CWR to a high of 123 mm in 100% CWR treatment. Seasonal cumulative ET of lettuce varied from a low of 54 mm to a high of 129 mm based on water stress level.The yield, IWUE and TWUE values of drip-irrigated lettuce treatments were also summarized in Table 2 for two growing seasons. The highest yield was obtained as 7.6 ton da-1 in 100% CWR treatment. However, there was no significant difference in yield between 100% CWR and 80% CWR. These suggest that lettuce under greenhouse conditions can be grown without significant yield loss with a seasonal water application of average 113mm. The lowest yield was in 60%CWR treatment as 5.0 ton da-1. Table 2 shows that as the amount of irrigation water applied decreases, lettuce yield also diminishes. The heights IWUE and TWUE, 0.117 ton da-1 mm-1 and 0.074 ton da-1 mm-1, respectively, were obtained from 120% CWR treatment. Table 2 indicates that IWUE and TWUE increase with decreased amount of irrigation water applied. Although yield was similar in 100% CWR and 80% CWR treatment, IWUE and TWUE were significantly increased in 100% treatment compared to 120% CWR treatment. Based on Table 2, it can be said that 80% CWR treatment can be suggested for lettuce crop in Jos under unheated greenhouse conditions.

Table 2. Applied irrigation water (I mm), Evapotranspiration (ET, mm), Yield (ton da-1), IWUE (ton da-1 mm-1), TWUE (ton da-1 mm-1) of drip irrigated lettuce under greenhouse conditions

Treatments	I	ET	Yield	IWUE	TWUE
120% CWR	35	54	3.6	0.117c	0.074
100% CWR	123	129	7.6	0.066a	0.062
80% CWR	93	113	6.2	0.085a	0.065
60% CWR	64	81	5	0.095b	0.069

Figures 1 and 2 show that there was a good relationship among yield, applied irrigation water and water use of lettuce. The relationship between applied irrigation water and yield was defined as y = 0.047 I + 2.5822 (R2 = 0.96). On the other hand, relationship between water use and yield was as y = 0.0547 ET + 1.0708 (R2 = 0.98).

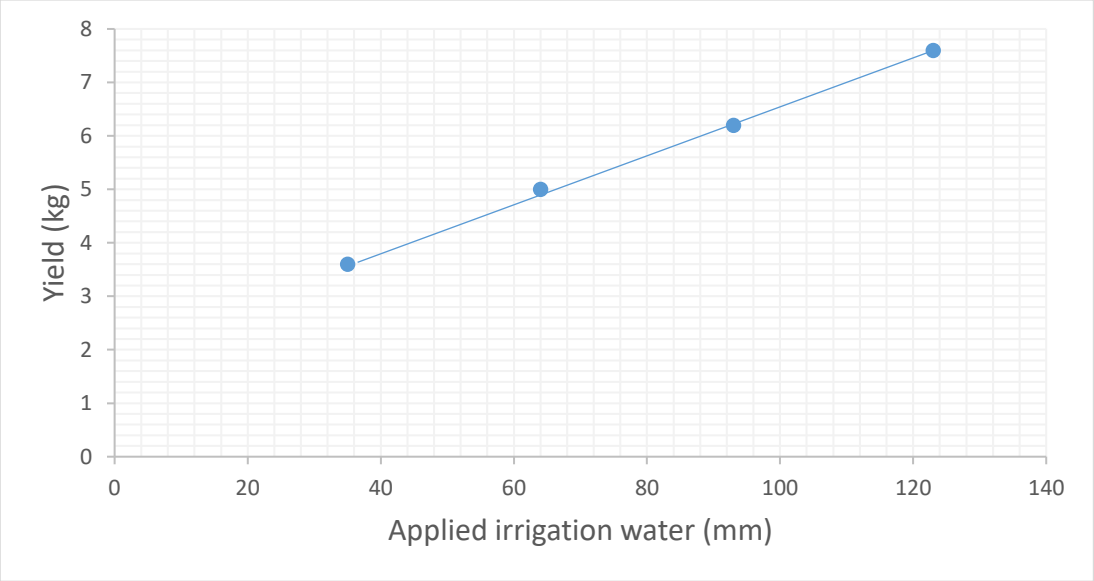

Figure 1. The relationship between yield and applied irrigation water for drip irrigated lettuce under greenhouse

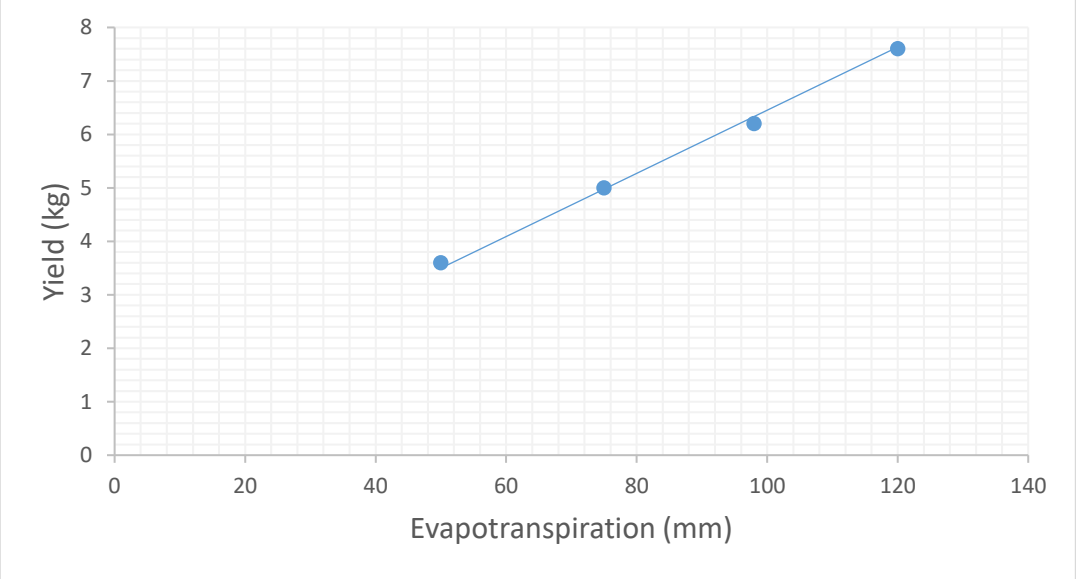

Figure 2. The relationship between yield and water use for drip irrigated lettuce under greenhouse

Table 3 shows that plant vegetative growth significantly influenced by the irrigation treatments. The average canopy diameter, plant height and shoot dry matter were obtained from 100% CWR treatment as 25.8 cm, 36.2 cm and 26.3 g plant-1, respectively. Plant vegetative growth parameters increased with increasing I and ET as with lettuce yield. The lowest growth parameters were obtained from the 60% CWR treatment. However, as in yield, there was no significant changes between 100% CWR and 80% CWR treatments in terms of vegetative growth parameters. Shoot dry matter decreased with decreasing water use and water applications (Table 2 & 3). Our results were in agreement with findings of Sammis *et al.* (1988) and Yazgan *et al.* (2008) who concluded that limited irrigation resulted in reduced growth and yield in lettuce

Table 3. Influence of different amounts of applied irrigation water on canopy diameter (cm), plant height (cm) and shoot dry matter (g/plant) of greenhouse grown lettuce

Treatments	Canopy diameter	Plant height	Shoot Fresh weight
120% CWR	18.6 c	23.0 c	17.2 c
100% CWR	25.8 a	36.2 a	26.3 a
80% CWR	25.1 a	35.1 a	25.7 a
60% CWR	21.9 b	27.4 b	21.3 b

Schulbach (1995) using a Bowen ratio energy balance system, estimated values of 100-190 mm for lettuce from planting to harvest at nearby sites in the central coast region of California under out-door conditions. Ciolkosz *et al.* (1998) determined the water use of lettuce as 150 g per plant in greenhouse condition. Hanson et al. (1997) applied an average of 200 mm irrigation water to lettuce via surface drip irrigation system. The values of IWUE and TWUE for lettuce obtained in this experiment were a little bit lower to those for lettuce in field studies (Gallardo et al., 1996; Sale,1966). These changes may be explained because of different environmental conditions and agricultural management strategies followed in the studies carried out. According to Gallardo *et al.* (1996), the major constraint on efficient water use in lettuce is its shallow root system.

Conclusion

The study demonstrated that a moderate deficit irrigation, which is replenishment up to 70% Class A Pan, can be successfully used to improve WUE in semi-arid climatic conditions under the unheated greenhouse. Yield response was found to be 7.6tons/hectre.The lettuce growers in the region

should be aware of crop sensitivity to applied amount of irrigation in the last 4 weeks of the season. The study showed that irrigation should be initiated as the tension reading was not more than 20kPa for clay-textured soils.

Recommendation

Based on the result of this findings, it is recommended that 80% crop water requirement is suitable for growing Letuce when water management is of a concern. Further study should be carried out to validate this findings in the study area.

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