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Preliminary Studies on Growth and Fresh Weight of Lettuce (*Lactuca sativa*) as Affected by Clay Pot Irrigation and Spacing

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Abstract: An experiment (Completely Randomized Design) was set up to determine the effects of Clay Pot Sub-surface Irrigation (CPSI) and spacing on the growth and fresh weight of lettuce (*Lactuca sativa*). The treatments were: CPSI with spacing; 15×15 cm, 20×20 cm and 30×30 cm. Control treatments were Watering Can Irrigation (WCI) with the same spacing as above. Treatments were replicated three times given a total of 18 experimental units. Eighteen large enamel basins of 50/20 cm (diameter/height) were filled with good topsoil and a clay pot buried neck deep in each of the basins. Seedlings were planted in all the eighteen basins. Five Hundred mL of wastewater was applied daily to plants in each container having either clay pot or watering can treatment. Plant height increased from 2.50 to 4.25 cm within 6 Weeks after Transplanting (WAT) under CPSI and only increased from 2.14 to 2.99 cm under WCI. The CPSI also supported better leave growth and fresh weight. The fresh weight of lettuce increased almost two fold under 15×15 cm spacing compared to 20×20 and 30×30 cm.

Key words: Clay pot surface irrigation, lettuce planting density, wastewater

INTRODUCTION

Lettuce belongs to the family Asteraceae. In Ghana lettuce is used mainly by food vendors, hotels and restaurants in preparation of salads and sandwiches. Lettuce is known for its mild flavour and very high fibre content. The tender green leaves of lettuce are known to be an important source of calcium, iron and vitamin A (Maboko and du Ploy, 2008). The crop is grown mainly in urban areas of Ghana either as a main crop or associated crops in urban backyard and urban market gardens. Lettuce is the most commonly cultivated and consumed exotic vegetable in Ghana. It has a very short production cycle and is known to be cropped up to about 9-10 times a year (Oboubie *et al*., 2006).

One of the challenges facing vegetables production especially lettuce in urban Ghana is obtaining adequate quantity and quality of water for all year round production. Vegetable production in Ghana is largely rain fed. However, farmers are increasing noticing the benefit of producing vegetables in the dry season, using various techniques of informal irrigation. As a result the number of farmers involved in informal irrigation in urban market gardens has increased over the last decade. Over 50% of urban farmers do not have access to clean water for all year round production and therefore, rely on low quality water coming from storm water drains and sometimes untreated sewage water. For vegetables eaten raw, such as lettuce the quality of irrigation water is critical in ensuring the safety of consumers. The quality of water used for irrigation must be within the levels recommended by the World Health Organisation (WHO) and the Food and Agriculture Organisation (FAO) (WHO, 2006). In Ghana, the coliform levels of irrigation water at urban vegetable production site were shown to exceed that specified by FAO (Abubakari *et al*., 2011).

Watering cans are popularly used to supply water to plants in urban gardens. However, when wastewater is the only water available, the use of watering can results in direct contact between the wastewater and the vegetable crops and thus exposing them to potential pathogens. CPSI using indigenous clay pot is reported to be very efficient in delivering water to vegetables (Daka, 2001). The clay pot used was similar to the widely used indigenous clay pot made by local women in Ghana but it was modified by using a ratio of 1 part of sand to 2 parts of clay in moulding it. It has been found to be relevant for

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small scale producers as it is water saving, labour saving, prevents salt accumulation in the soils and also suppressed weed growth (Bainbridge, 2001). The CPSI could also significantly reduces the pathogen load on vegetables produced with wastewater, as there is no direct contact between the raw wastewater and the crop. This method may also have the potential of reducing the exposure of crops to heavy metals that may be in the wastewater. In temperate environments, lower planting densities are recommended for lettuce as the plant grow very big (Ware and McCollum, 1975). However, in tropical environments lettuce plants are much smaller and farmers try to maximize yield of lettuce by resorting to higher planting densities. As the installation of the clay pot takes up space in the soil, it is important to determine what spacing it could support.

The aim of this experiment was therefore to study the growth and fresh weight of lettuce as affected by clay pot and watering can irrigation using waste water under different planting densities.

MATERIALS AND METHODS

This experiment was carried out at University for Development Studies (UDS) glass house at Nyankpala between March and June, 2010. Nyakpala is located in Tolon-Kumbungu District of Northern Region of Ghana. Average monthly temperature in within the glass house was about 24/34°C (Night/day) during the experimental period.

The experiment was a two factorial experiment lay out as a Completely Randomised Design (CRD) with three replications. The two factors were Irrigation system and Spacing. The irrigation system comprised Clay Pot Sub-surface Irrigation (CPSI) and Watering Can Irrigation (WCI). The spacing comprised 15×15 cm, 20×20 cm and 30×30 cm. This gave six treatment combinations. The clay pot used was similar to the widely used indigenous clay pot made by local women in Ghana but it was modified by using a ratio of 1 part of sand to 2 parts of clay in moulding it. These pots were not glazed. The 18 pots were then fired for 5 h using 60 kg of firewood and 30 kg of straw. For this study the clay pot was designed as a reservoir of water, with a capacity of 2 L.

Experimental procedure: The seeds of lettuce ("great lake variety" or loose head variety, 90% germination) were acquired from Vansaddo Agro-input Enterprise in Tamale, Ghana. Good top soil was dug from a teak (*Tectona grandis*) plantation on the Nyankpala Campus. Table 1, present detail presentation of the properties of this top soil. The soil was sieved and used to fill large plastic containers measuring 50/20 cm (diameter/height). Eighteen of such containers were prepared and a clay pot partially buried in nine of the containers. The other nine containers had no buried clay pots and were under watering can irrigation.

Healthy and vigorous seedlings were selected and transplanted into the big containers in the space between the walls of the partially buried clay pot and the walls of the container. Other seedlings were also transplanted into the other nine containers with no buried clay pots. In all containers (with or without clay pots), the following spacing were applied in 3 replicates; 15×15 cm, 20×20 cm and 30×30 cm. Five hundred 500 mL of untreated sewage water (obtained from sewage system at Kamina Barracks, Tamale in Ghana and which is used by farmers in a community called Zagyuri) was put into each of the clay pots daily. The water then seeps through the walls of the clay pot into the soil and hence had to be refilled daily. The same quantity of sewage water was also applied daily, as over head irrigation using watering can to each of the other nine containers without CPSI.

Data collection and analysis: Data was collected from the 2nd week up to the 6th week when the lettuce was harvested. Three plants of which treatment combination was applied were randomly selected and tagged. The means of the following parameters were computed on the tagged plants: Plant height, number of branches, number of leaves, leaf spread, fresh leaf weight/plant, dry leaf weight/plant, Fresh root weight/plant and dry root weight/plant. All data collected were subjected to Analysis of Variance (ANOVA) using Genstat (Release 8.1) statistical package. The number of fruits/plant and the fresh weight/plant was square root transformed to normalize the error distribution before the analysis.

Table 1: Analysis of chemical properties of the top soil used for the study

Soil pH	% N	Avai. P	Exc. K (mg kg^{-1})	% Org. C	Exc. acidity (Cmol kg^{-1})	Ca (mg kg^{-1})	Mg (mg kg^{-1})	CEC (Cmol kg^{-1})	*T EB (Cmol kg^{-1})	% Base saturation
5.96	0.06	3.55	52.99	0.63	0.10	432.88	129.88	4.77	4.67	97.90

*Total extractable bases

RESULTS

CPSI performed significantly better than the watering can with respect to plant height in all the three spacing used (Fig. 1). The spacing of 20×20 cm and 30×30 cm under watering can irrigation resulted in significantly lower plant height than the 15×15 cm. The CPSI produced plants of the same height irrespective of the spacing used. As shown in Fig. 2, plant height was also strongly influenced by irrigation system X weeks interaction ($p<0.001$). Clay pot irrigation resulted in taller plants as compared to those produced under water can irrigation for all the weeks plant height was assessed.

Clay pot irrigation resulted in significantly higher number of leaves than that of watering can in all the spacing except 15×15 cm (Fig. 3). The CPSI produced plants of the same number of leaves irrespective of the spacing used.

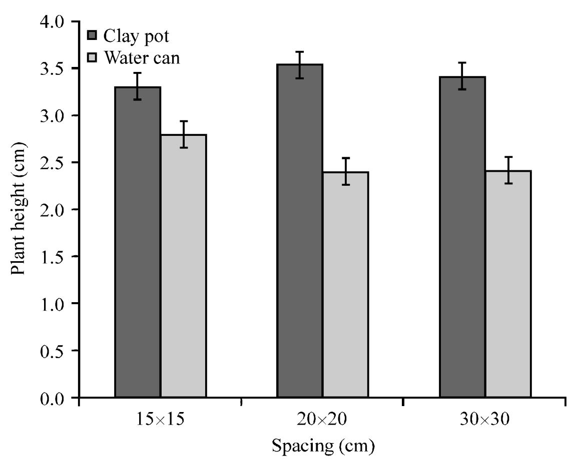

Fig. 1: Effect of irrigation types and spacing on plant height (Bars = 2x SED)

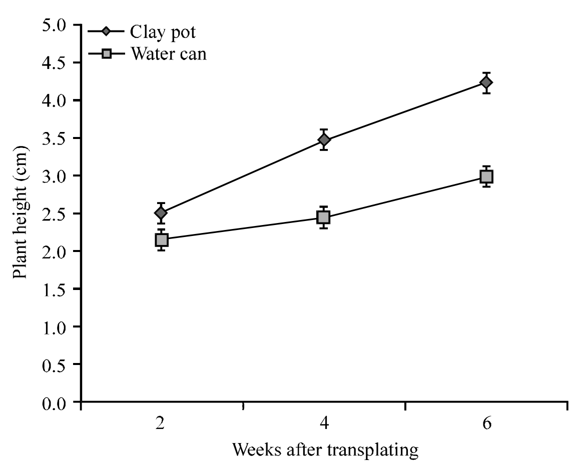

Fig. 2: Effect of irrigation types and weeks on plant height (Bars = 2x SED)

Leaf spread measures the radial spread of the plant leaves from the central stem of the plant. In this case, leaf spread was measured as the diameter of the central spread of leaves around the stem. As indicated in Fig. 4, Clay pot irrigation had a longer leaf spread per plant than that of watering can at all the spacing used. Again, the CPSI produced plants of the same leaf spread irrespective of the spacing used. Further, plants that clay pot irrigation was applied had wider leaf spread as compared to those that had the water can irrigation at both 4 and 6 weeks after transplanting (Fig. 5).

There were no differences in fresh weight of leaves and roots between plants under watering can irrigation and clay pot irrigation in the 15×15 cm spacing (Fig. 6, 7). However, the performance of Clay pot irrigation under 20×20 cm and 30×30 cm was superior to that of Watering

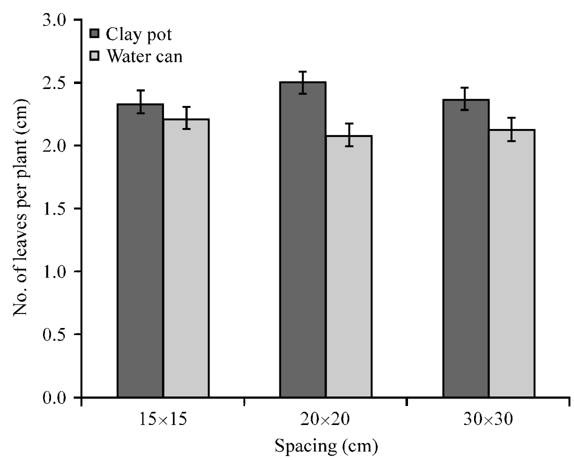

Fig. 3: Effect of irrigation types and spacing on number of leaves per plant (Bars = 2x SED)

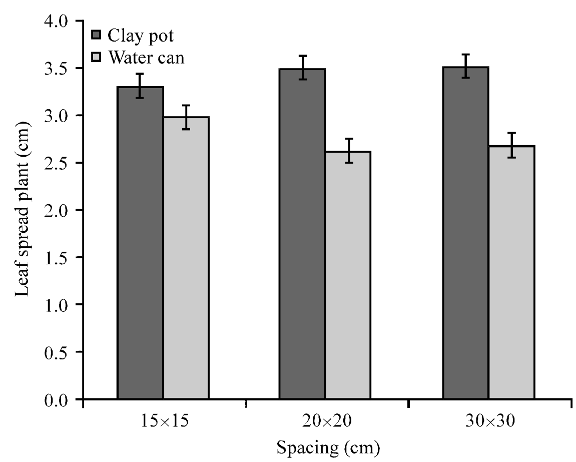

Fig. 4: Effect of irrigation types and spacing on leaf spread per plant (Bars = 2x SED)

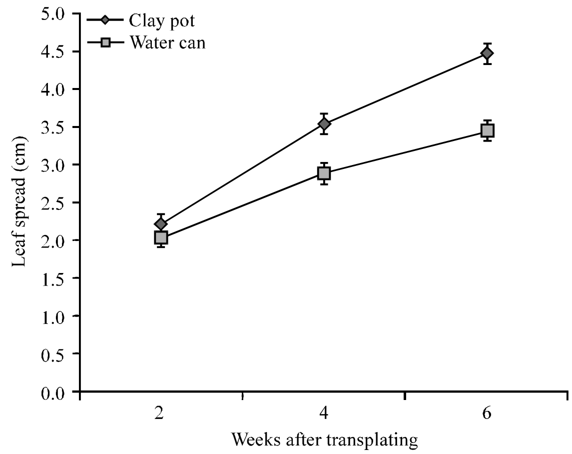

Fig. 5: Effect of irrigation types and weeks interaction on leaf spread per plant (Bars = 2x SED)

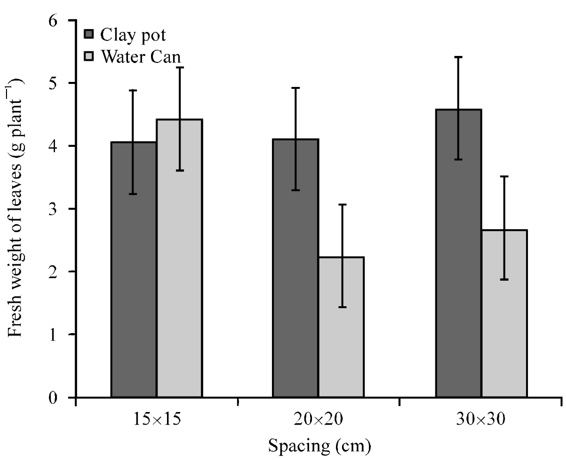

Fig. 6: Effect of irrigation types and spacing on fresh weight of leaves (Bars = 2x SED)

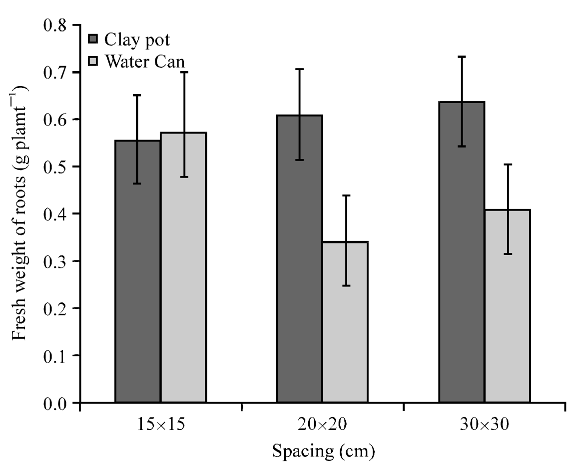

Fig. 7: Effect of irrigation types and spacing on fresh weight of roots (Bars = 2x SED)

Table 2: Effect of irrigation types and spacing on the dry weight of leaves and roots (g)

	Spacing (cm)		
Parameter	15×15	20×20	30×30
Clay pot irrigation	0.921 (0.1821)*	1.142 (0.2431)	1.254 (0.2562)
Water can irrigation	1.154 (0.2205)	0.645 (0.1520)	0.754 (0.1715)
2 SED		0.392 (0.0536)	

*Root dry weight figures are in bracket

can with regards to fresh weight of leaves and roots. Similar patterns were shown with respect to the dry weights of leaves and roots (Table 2). The CPSI produced plants of the same fresh and dry weights of leaf irrespective of the spacing used.

DISCUSSION

The results revealed that, the treatments had significant effects on the parameters measured. The Clay pot irrigation was more effective in promoting vegetative growth and development (plant height, number of leaves, leaf area index and leaf spread) of lettuce than watering can treatment. This may be attributed to the fact that, CPSI supplied water more evenly resulting in more consistent growth and development. The strength of the CPSI lies in its ability to release water more gradually allowing a more stable soil moisture regime than the watering can irrigation. These results agree with the observation of Ware and McCollum (1975) that lettuce thrives best in relatively well drained soils.

The effect of CPSI and spacing on the growth of lettuce was further reflected in the fresh and dry weights of leaves and roots. Generally, the fresh and dry weights of lettuce increased significantly under CPSI than under WCI. The fresh and dry weights of lettuce did not change significantly with changing plant population under CPSI. This means that CPSI is efficient in water use and could support lettuce growth and fresh weight under higher plant population density. According to Daka (2001), the CPSI is 60-70% more efficient in water use than watering irrigation. Further, the superior performance of plants under CPSI might have been due to the reduction of salts, as wastewater contained substantial amount of salt. Clay pot irrigation has been shown to significantly reduce salinity around root zones of crops (Pace Project, 2011). The WCI was only comparable with the CPSI in promoting selected vegetative growth parameters, as well as fresh and dry weights under the shortest spacing (15×15 cm). This could be due to the fact that the shortest spacing in WCI effectively utilised the water supplied than the lower planting densities. It was observed in the WCI treatment with the lower planting densities that water supplied was not quickly absorbed and created water logging conditions that might have impeded vegetative development which reflected in the poor fresh and dry weights obtained. This conforms to the findings of Ware and McCollum (1975). that fluctuation in moisture regime is detrimental to lettuce growth and development especially when too much water in the soil occurs under higher temperatures. The fact that CPSI could support higher planting densities would be encouraging to small scale farmers who always try to maximize output by resorting to higher planting densities. Installation of clay pot already takes up space in the soil and therefore closer planting could be the only way to maximize yield. Higher planting densities also have the advantage of reducing competition from weeds, reduce evaporation of water from the soil and would ultimately result in the reduction of irrigation frequency. Further Studies is in progress to determine pathogen reduction, salt accumulation at root zones and reduction of heavy metals in soils by CPSI.

CONCLUSION AND RECOMMENDATION

The Clay Pot Sub-surface Irrigation promoted vegetative growth, vegetative development as well as fresh and dry weights of lettuce better than the Watering Can Irrigation. The fresh and dry weights of lettuce also appear to increase substantially in 15×15 cm than 20×20 cm and 30×30 cm. It was clear from the experiment that growths as well as fresh and dry weights parameters were increased significantly by Clay pot irrigation and 15×15 cm either acting independently or in combination. When waste water is the only option for irrigation, then it will be very useful to use Clay pot irrigation at spacing of 15×15 cm. Further studies to compare the performance of lettuce under clean water and sewage water need to be done. Additional studies to compare the ability of both CPSI and WCI to save labour and water need to be carried out.

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