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# PRODUCTIVITY OF TOMATO (*Lycopersicum esculentum* L) GROWN UNDER PITCHER IRRIGATION AS AFFECTED BY NUMBER OF PLANTS AND RATES OF POULTRY MANURE PER POT AT SUDANO-SAHELIAN REGION OF NIGERIA

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**ABSTRACT**
These experiments were conducted at Federal University Dutsin-Ma Teaching and Research Farm, Badole (Longitude 07$^0$29'29" E and Latitude 12$^0$27'18" N) during the dry seasons (November to March) of 2015 and 2016. The experiments were conducted to determine the optimum number of tomato plants and quantity of poultry manure per pot in a pitcher irrigation system. The treatments consisted of 2, 4, and 6 tomato plants per pot and 0, 1 and 2 kg of poultry manure per pot. The nine treatments were factorized and laid out in a randomized complete block design (RCBD) and replicated three times. The highest tomato fruit yield per pot was obtained from the treatment with four plants and 2kg of poultry manure per pot, while larger fruits were obtained in treatments with 2 plants and 2kg of poultry manure per pot. The number, size and weight of tomato fruits were significantly ($P<0.05$) affected by the number of plants and quantity of poultry manure per pot as compared with control. The treatments with four tomato plants and 2kg of poultry manure per pot proved the most productive in terms of total fruit yield and could be recommended as the best practice under pitcher irrigation in the Sudan-Sahel agro-ecological zone of Nigeria.

***Keywords***: *Clay pot, Pitcher irrigation, Poultry manure, Tomato fruit*

## INTRODUCTION

Irrigation is a crucial input for growing plants and accounts for the high water demand in agriculture. Water conservation measures using techniques such as drip irrigation require significant investment. In this context buried clay pot irrigation which is a cost effective traditional technique, can be adopted for controlled irrigation. (Vasudevan *et al.,* 2006). Pitcher irrigation (clay pot irrigation) consists, in its simplest form of unglazed baked earthen pitchers which are buried to their neck in the soil and filled with water. Water gradually seeps out through the porous walls into the root zone under hydrostatic pressure and/or suction, to maintain plant growth around the pitchers. Pitcher irrigation is an inexpensive small-scale irrigation method practiced in the semi-arid areas. When the pot is filled with water, the natural pores in the pot's walls allow water to spread laterally in the soil, creating the moist conditions necessary for plant growth. Pitchers are filled as needed, maintaining a continuous supply of water directly to the plant root zone. Pitcher irrigation is used for small scale irrigation where, water is either scarce or expensive, fields are difficult to level such as under uneven terrain, and more so, that the water is saline and cannot be normally used in surface methods of irrigation and in remote areas where vegetables are expensive and hard to come by (Dubey *et al.*, 1991).

Water poured into pot seeps slowly into the soil, feeding the seedling's roots with a steady supply of moisture. Pitcher irrigation uses water more efficiently than other systems since it delivers water directly to plant root zones, instead of broader areas of the field.

When a pot, filled with water and covered by a lid (wooden or clay), is buried in the soil, the water oozes out of the clay pot due to hydraulic head difference (moisture content difference) between the pot surface and the surrounding soil until it is in equilibrium with the surrounding area. The rate of seepage of water from pitcher will depend on the type of plant and soil and climatic conditions around the pot. The movement of water is as a result of the uptake by the crops and it continues as long as the plants take it up and it evaporates. The system is therefore self-regulating. The surrounding soil is almost always at field capacity (approximately 80 per cent of soil pores filled with water) as long as the pot is not allowed to dry up completely due to evapo-transpiration. Pitcher irrigation is ideal for sandy to loamy soil with good porosity (40-60 per cent) and for small scale farmers. Pitcher irrigation is a traditional system (Mondal, 1974; Das, 1983) of irrigating plants and considered several times more efficient than a conventional surface irrigation system (Das, 1983). This mode of irrigation was known traditionally in arid and semi-arid areas where besides acute water scarcity and extreme temperatures, problems of water and soil salinity have to be faced. This method of irrigation not only conserves water but also provides employment to the potters and labourers. It is easy to install, operate and maintain. Amongst many subsurface irrigation techniques available pitcher irrigation appears to be more economical and water saving (Vasudevan *et al*., 2006)

Sub-Saharan Africa is about 65% arid and semi-arid and the proportion is even higher in West

Africa. The Sahel region of West Africa1 (comprising mainly Burkina Faso, Mali, Mauritania,

Niger and Senegal as well as the northern parts of Benin, Ghana, Togo and Nigeria) are almost

100% arid or semi-arid and thus face very limiting natural precipitation. These areas also tend to be the poorest and the most food insecure parts of West Africa (Vasudevan *et. al.* 2006)

That makes irrigation in the Sahelian countries an important, if not the only, option for food security and poverty alleviation, especially in this era of worldwide food, fuel and financial crises. Irrigated agriculture is the most viable means of reducing food crop failure, hunger, and malnutrition in Africa, and an effective means for improving the competitiveness of smallholder farming in the Sahel and other parts of Africa. The need to identify, study and generate information that could facilitate up scaling of low cost small scale irrigation technologies that could enhance food production, prevent further deterioration of the food security situation and avoid additional deterioration of livelihoods of small scale farmers in the area under study could not be over emphasized. There is dearth of information on appropriate agronomic techniques for maximum yield of vegetables under pitcher irrigation system, therefore this study is to bridge the knowledge gap and generate data and information in this area of study. To address the challenges of increasing food and nutrition insecurity and increasing poverty in the face of a rapidly changing climate, there is need to move towards an innovative and water efficient irrigation system such as pitcher irrigation. The use of clay pot for irrigation by small scale farmers and farmers in inaccessible areas with no possibility for modern irrigation facilities has not been exploited sufficiently. In the light of the above, the study was undertaken to determine the optimum number of tomato plants and quantity of poultry manure per pot in a pitcher irrigation system.

## MATERIAL AND METHODS

These experiments were conducted during the dry seasons of 2015 and 2016 at the Federal University Dutsin-Ma Teaching and Research Farm Badole (Longitude $07^0$29'29" E and Latitude $12^0$27'18" N) in Sudano-Sahelian ecological zone of Nigeria.

The treatments consists of three factors by three (3 x 3) and were factorized making a total of nine treatments per replications, they consisted of 2, 4, and 6 tomato plants/pot and 0, 1 and 2 kg of poultry manure/pot.

These treatments were randomized and laid out in a randomized complete block design (RCBD), replicated three times. A pit 30cm wide and 30cm deep were dug out and poultry manure was mixed with the top soil as per the treatments and used to bury the pots up to the neck. Pots were spaced 120cm apart in both directions and an access road of one meter was allowed between replications. A total of twenty seven (27) clay pots of uniform sizes (6- 8liters capacity), nine pots per replication were used for the experiments. Each pot was covered with a lid made from palm leaves to reduce evapo-transpiration. Each pot represents a treatment and was filled with water once a week.

Three weeks old tomato seedlings (Roma variety) were transplanted around each pot 5-10 cm away from the pot according to the treatments on $20^{th}$ and $25^{th}$ of November for 2015 and 2016 drying season cropping respectively.

Data collected are number of fruits per plant and per pot, average fruit size and average fruit weight. Data collected was subjected to statistical analysis of variance (ANOVA) as described by Gomez and Gomez 1984 using SAS package 9.0 (SAS Institute, 2002). The differences between means was separated using Duncan's multiple range test (Duncan, 1995)

## RESULTS

Number of fruits per plant were significantly ($P<0.05$) affected by number of plants and quantity of poultry manure per pot in both years of experimentation (table. 1). The highest numbers of tomato fruits per plant were 70 and 66 fruits which were recorded in the treatments with four plants per pot and two kg of poultry manure in 2015 and 2016 respectively. Lowering the number of plants per pot to two plants or increasing it to six plants leads to decrease in number of fruits per plant.

Addition of poultry manure significantly ($P<0.05$) effected the number of tomato fruits per plant in both years of the research (table.1) Treatments with 2 kg of poultry manure per pot produced significantly high yield (40 and 58 fruits per plant) in 2015 and 2016 respectively, this is 24 and 32 more fruits compared with control respectively for both years of the experimentation. Addition of one kg of poultry manure per pot also increase number of fruits per plant but not as significant as addition of two kg of poultry manure. This confirmed the assertion that clay pot alone can be used to grow tomato but not sufficient enough in achieving a high yield of tomato, therefore a combination of clay pot with organic manure can significantly affect number of fruits per plant and consequently yield of tomato.

Table 1. The effects of number of plants and rates of poultry manure per pot on number of fruits per plant and tomato fruit size in 2015 and 2016 and combined.

| | **Number of fruit per plant** | | | **Size of fruits (cm)** | | |
|---|---|---|---|---|---|---|
| **Treatment** | 2015 | 2016 | Combined | 2015 | 2016 | Combined |
| **Number of plants per pot** | | | | | | |
| 2 plants | 38 | 46 | 42 | 4.3 | 6.6 | 5.5 |
| 4 plants | 70 | 66 | 68 | 5.8 | 7.6 | 6.7 |
| 6 plants | 50 | 62 | 56 | 5.4 | 6.6 | 6.0 |
| SE± | 0.12 | 0.16 | 0.09 | 0.61 | 0.4 | 0.39 |
| **Poultry Manure Kg/Pot** | | | | | | |
| 0 | 16c | 26 | 21b | 3.7c | 7.0 | 5.4c |
| 1 | 27bc | 45 | 36b | 4.8bc | 6.9 | 5.9bc |
| 2 | 40ab | 58 | 49a | 6.4a | 7.4 | 6.9a |
| SE± | 0.15 | 0.13 | 0.08 | 0.54 | 0.36 | 0.35 |

Means followed by the same letter(s) within the same column and treatment are not significantly different at 5% level of probability using DMRT.

Size and weight of tomato fruits were significantly (P<0.05) influenced by number of plants and quantity of poultry manure per pot in both years of experiments (table.2). The biggest sized tomato fruits (7.4cm) and the heaviest (40g) were obtained in treatments having two plants and two kg of poultry manure per pot. Treatments without poultry manure (control) produced the smallest sized tomato fruits which are significantly smaller (P<0.05) compared with treatment with poultry manure. Number of plants per pot has significant influence in the size and weight of fruits in both years. The higher the number of plants per pot the lower the size of fruit recorded.

Table 2: Effects of number of plants and rate of poultry manure per pot on weight of tomato fruits per plant and per pot in 2015, 2016 and combined.

| | **Weight of tomatoes per plant (kg)** | | | **weight of tomato per pot (kg)** | | |
|---|---|---|---|---|---|---|
| **Treatment** | 2015 | 2016 | Combined | 2015 | 2016 | Combined |
| **Number of plants per pot** | | | | | | |
| 2 | 0.76b | 0.9b | 0.83b | 1.5 | 1.8b | 1.6b |
| 4 | 1.75a | 1.5a | 1.60a | 7.0 | 6.2ab | 6.6ab |
| 6 | 1.1a | 1.2ab | 1.1ab | 6.6 | 7.2a | 6.9a |
| SE± | 0.008 | 0.003 | 0.004 | 0.019 | 0.091 | 0.015 |
| **Rates of poultry manure kg** | | | | | | |
| 0 | 0.9b | 0.8b | 0.85b | 1.7b | 1.8c | 1.75b |
| 1 | 1.2b | 1.5b | 1.4b | 5.3b | 6.4bc | 5.85ab |
| 2 | 1.9a | 2.2a | 2.1a | 6.7a | 5.9a | 6.8a |
| SE± | 0.061 | 0.039 | 0.003 | 0.055 | 0.074 | 0.065 |

Means followed by the same letter(s) within the same column and treatment are not significantly different at 5% level of probability using DMRT.

The weight of tomato fruits per pot and per plant are significantly (P<0.05) affected by number of plants and quantity of poultry manure per pot. Treatments with four (4) plants per pot produced heavier tomato fruit compared with control. Similarly, addition of poultry manure has significant (P<0.05) effect on tomato fruit weight. The highest tomato fruit weight was recorded under application of 2kg poultry manure and was significantly (P<0.05) higher compared with control (table 2) The highest yield in 2016 (6.7kg/pot) was recorded in treatment with 2kg of poultry manure per pot, this is 5.0kg higher compared with control.

**DISCUSSION**

The highest fruit yield of tomato that were recorded under the treatment with four plants and two kg of poultry manure per pot could be attributed to higher number of fruits per plant, bigger fruit size and heavier fruit as was recorded in this treatments. The above could be due to enhanced availability of nutrients and steady moisture supply under this treatment. Mondal (1983) reported similar results. Similarly decrease in tomato yield as the number of plant per pot decreases (treatments with fewer

numbers of plants per pot (2/pot)) could be due to luxuriant vegetative growth in the expense of fruit development which ultimately led to decrease in number of fruit, size and weight of fruit per plant, consequently leads to reduction in yield. Bainbridge (2001) reported similar observation. Increasing the number of plants per pot up to six plants leads to reduction in fruit yield; this could be due to intensive competition between plants for the available nutrients, water, and space which led to reduced availability of these factors to individual plants consequently affecting their productivity and yield. The works of Bainbridge. (1987, 1988a, 1988b and 2001) reported similar observations. Organic manure notably poultry manure plays a very important role in plant nutrition by containing high amount of nitrogen which is essential for plant growth and productivity. Addition of poultry manure generally improved availability of Nitrogen and enhance the physical properties of the soil. Treatments with addition of poultry manure recorded significantly high fruit yield per plant and per pot in both years of experiment. This could be attributed to the steady supply of moisture to plants growing under pitcher irrigation system and enhancement of bio-physical condition of the soil
Mondal (1983) reported similar findings.

## CONCLUSION

In both years of experimentation we recorded appreciable yield of tomato by using clay pot only without addition of organic matter (control) but application of organic matter significantly ($P<0.05$) affected all the yield parameters of tomato, therefore this system work best when combined with application of organic manure. Pitcher irrigation and addition of organic manure can contribute to achieving good yield of tomato thereby enhancing family food security and livelihood of the small scale farmers that practices it.

Pitcher irrigation (clay pot irrigation) creates employment opportunities for the farmers, pot makers, lid makers and marketers of vegetables. Therefore, pitcher irrigation or (clay pot irrigation) should be up scaled to cover wider areas of the Sahel region of Nigeria.

Based on the results of this experiment, we recommend four tomato plants and 2 kg of poultry manure per pot for maximum productivity of tomato under pitcher irrigation system in the Sudano- Sahel region of Nigeria.


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