

INFLUENCE OF DRIP-IRRIGATION METHOD ON PERFORMANCE AND YIELDS OF CUCUMBER AND TOMATO

Bajracharya, R.M., Sharma, S.
Dept. of Environmental Science and Engineering,
Kathmandu University, P.O. Box: 6250, Kathmandu, Nepal

Corresponding Author: rmbaj@ku.edu.np

ABSTRACT

The conservation of water is crucial to sustainable agricultural production in areas of low rainfall or uneven precipitation distribution. Under such circumstances, drip irrigation methods offer a useful option for economic production of vegetable crops. This preliminary study examined the efficacy and performance of two drip irrigation methods on cucumber and tomato crops grown out of season. The initial results of the study indicated surface drip irrigation to give better establishment of the crop and higher yields than sub-surface drip method. Further work is needed, however, to establish the cause-effect relationships and actual viability of sub-surface drip irrigation method.

INTRODUCTION

An important constraint to agricultural production is the availability of water for crop growth. Water is often a major limiting factor in regions of low rainfall (semi-arid and arid regions) or in agro-climatic zones where rainfall is unevenly distributed throughout the year. Such is the case over much of Nepal, which has a distinct rainy season (monsoon) followed by a prolonged dry season (UNEP 2001). Moreover, the production of out-of-season vegetables like cucumber, tomato, capsicum and cauliflower requires supplemental water. In many parts of the country, an abundant supply of water is not available during the dry period (typically from November to May or June), hence water conservation and minimizing its use for irrigating crops is crucial for sustainable economic production of vegetable and other cash-crops (Randhawa and Abrol 1990). To this effect, drip irrigation offers a feasible option for economic production in areas of low rainfall or periods of water scarcity. Drip irrigation refers to any system of watering cultivated crops in which the water is delivered directly to each individual plant on a gradual and continuous basis (Swhwab et al., 1993). The purpose of this preliminary study was to evaluate the efficacy of two different methods of drip irrigation, namely surface and sub-surface drip, on the performance and yields of cucumber and tomato in the central Nepal mid-hills.

MATERIAL AND METHOD

In order to test the response of vegetable crops to method of water delivery by drip-irrigation, a field plot experiment using a randomized complete block design was established within the Kathmandu University campus, Dhulikhel, Kavre. The experiment had two crops (cucumber and tomato) in separate blocks, two drip delivery techniques (surface and sub-surface) and four replications of each treatment (see figure 1 for details of plot layout). The main treatment was to test the effect of water delivery technique, i.e., via surface or sub-surface drip, on water use efficiency as reflected by the growth and yield of vegetable crops.

The two blocks were enclosed by plastic sheeting overhead to prevent rainwater falling upon the experimental plot, and wire mesh along the sides to prevent stray animals entering. Control of water delivery to each row of crops was achieved by means of individual plastic buckets with lids fitted with taps and drip-irrigation pipes (see plates 1 and 2 for details of the set-up). The set-up for drip-irrigation was developed by IDE (2005) as a low-cost option for small-scale vegetable production.

Each experimental plot had eight rows with surface and sub-surface drip delivery randomly assigned (Figure 1). The water application was maintained at a low single rate of 8 liters every 48 hours (alternate days) for all treatments. For sub-surface drip irrigation, a narrow furrow of about 10 cm depth was made using a pointed hand-hoe, and the irrigation pipe was laid down in the furrow. Each irrigation opening in the pipe was covered with a small clay plate (see plate 3) to prevent clogging of the opening by soil, and then the pipe was buried by filling the furrow with soil. A single plant of cucumber or tomato was manually planted 6-8 cm to one side of the irrigation pipe adjacent to a water opening.

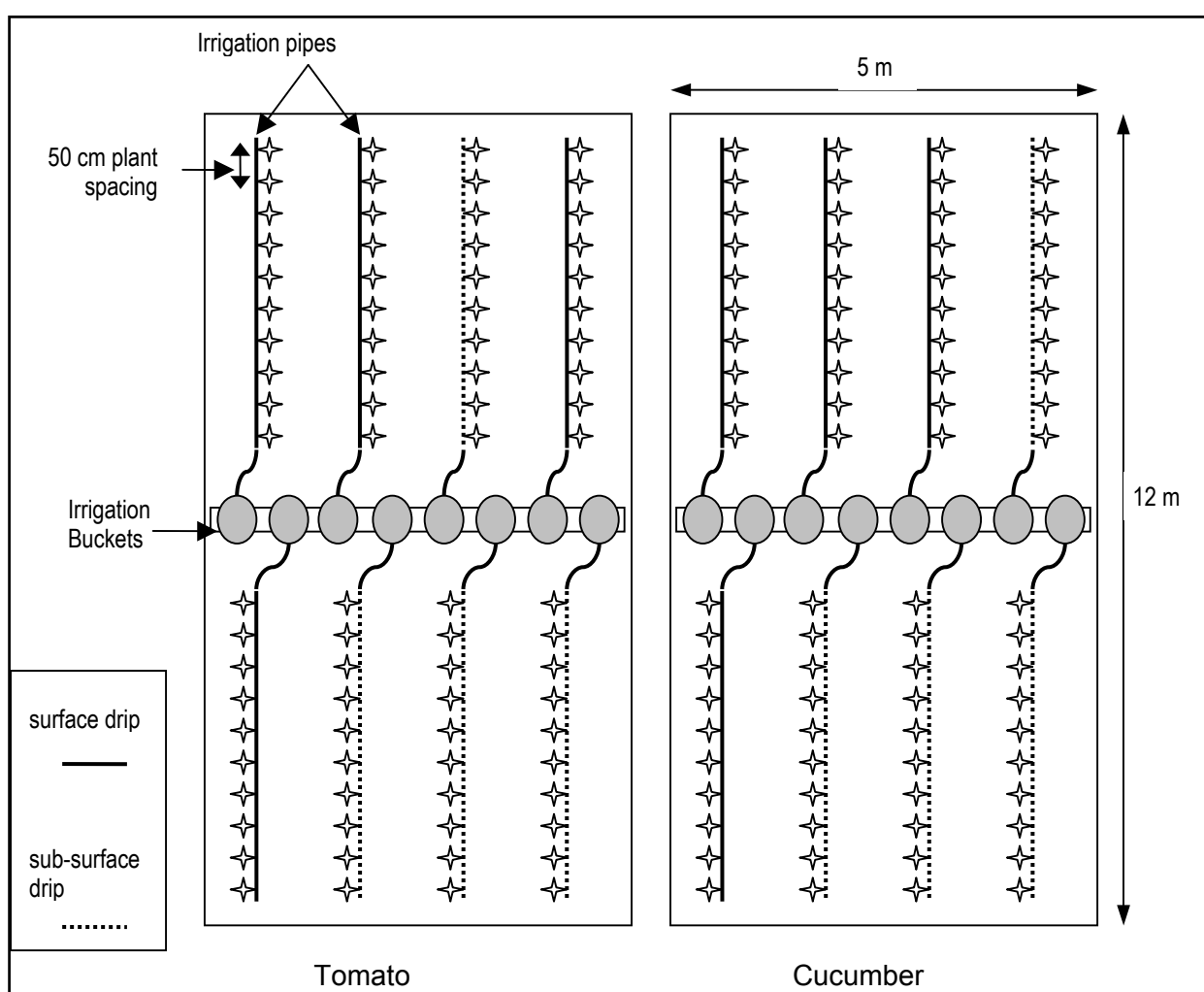


Figure 1. Layout of drip irrigation blocks and treatments

Cucumber seedlings were transplanted on May 31 and final harvest was done on August 9th, 2005, hence a total growing period of 70 days. During this period the total amount of applied for drip irrigation was 280 L per row of 10 to 11 plants. Similarly, for tomato, transplanting of seedlings was done on June 2 and final harvest was completed on September 6, 2005, resulting in a growing period of 96 days. The total irrigation water applied during this time was 384 L per row, which varied from 8 to 11 plants.



Plate 1. Drip-irrigation plot setup for tomato crop



Plate 2. Cucumber crop growth and plot setup



Plate 3. Sub-surface installation of drip-irrigation pipe.

RESULTS AND DISCUSSION

The yields of vegetable crops grown using drip irrigation with a minimum of water (8 L/48h) were comparable with those reported in previous studies (Adhikari et al., 2005). For both cucumber and tomato, yields were observed to be higher for the surface drip irrigation treatment as opposed to subsurface drip (Table 1 and Figure 2). One-way analyses of variance (ANOVA done using SPSS) done for each crop separately showed no significant difference in the yields according to drip irrigation method (i.e., surface or subsurface). However, when a general linear model (factorial) analysis of variance was done on the combined (cucumber and tomato) data set, a significant difference due to drip method was seen as reflected by the F-test value of 296, which was significant at the 5% level of probability ($P = 0.037$).

Table 1. Yield of cucumber and tomato under surface-drip and sub-surface-drip irrigation method

	Cucumber		Tomato	
	Sub-surface	Surface	Sub-surface	Surface
Rep 1	17.85	10.90	6.10	12.95
Rep 2	10.60	18.05	7.70	9.75
Rep 4	14.70	13.80	8.85	7.50
Rep 5	15.15	26.30	7.90	14.15
Means	14.58	17.26	7.64	11.09
Std. Dev.	2.99	6.70	1.14	3.03

Table 2. Plant stands in each row of cucumber and tomato

	Cucumber		Tomato	
	Sub-surface	Surface	Sub-surface	Surface
Rep 1	10	10	8	11
Rep 2	11	11	8	10
Rep 4	10	10	9	10
Rep 5	11	10	8	11
Means	10.50	10.25	8.25	10.50
Std. Dev.	0.58	0.50	0.50	0.58

The number of plants in each row were found to be significantly different for the tomato crop (Table 2). According to the one-way ANOVA test for tomato plant numbers, sub-surface drip irrigation method had significantly lower plant stand than surface drip method as indicated by the F-test value (34.7; P = 0.001).

Yield was not highly correlated with plant number when analysis was done for the combined (cucumber and tomato) data set as seen in Figure 3. Although an exponential fit gave a slightly better fit for the yield vs. plant number data, the correlation was weak. On the other hand, when correlations were done for crops separately, a significant yield vs. plant number correlation was seen for tomato (Figure 4) as indicated by the R² value of 0.72.

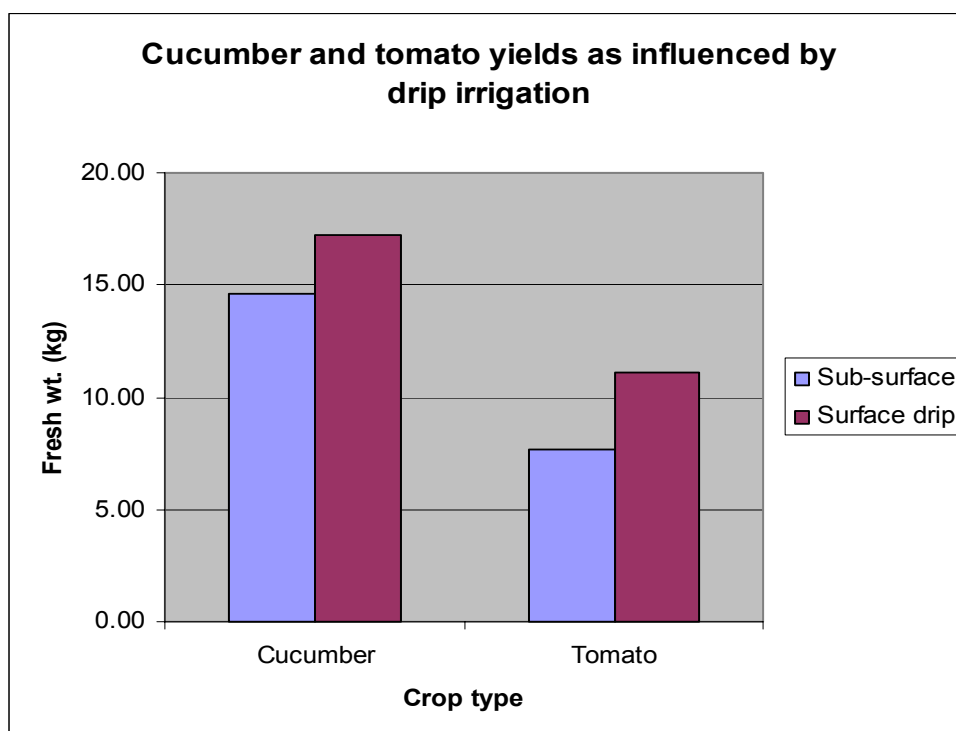


Figure 2. Mean yields of cucumber and tomato according to drip irrigation method.

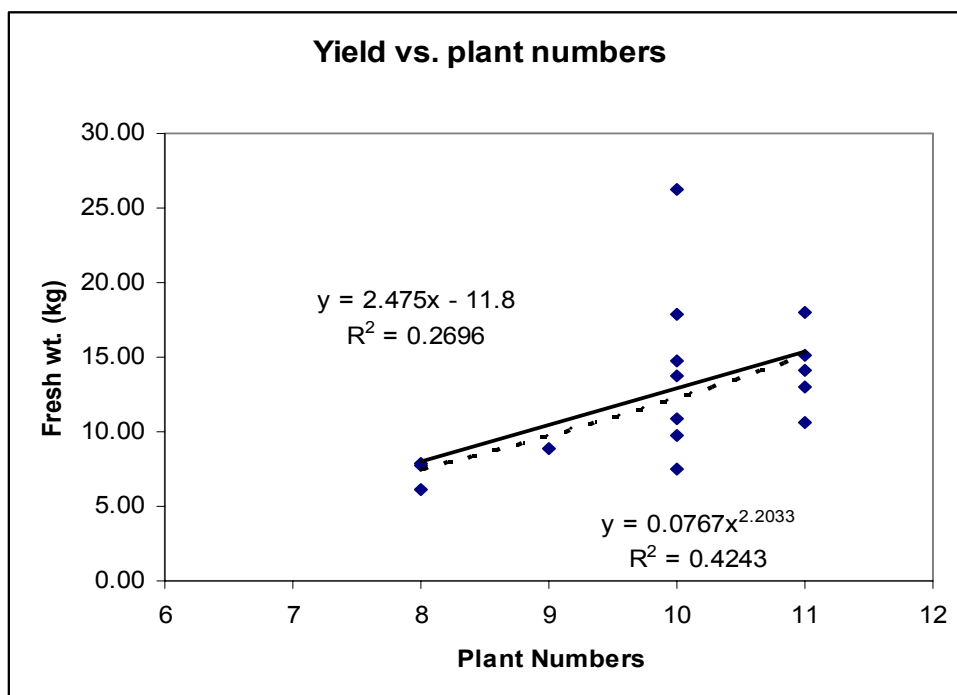


Figure 3. Regression fit of crop yield versus plant numbers for cucumber and tomato combined.

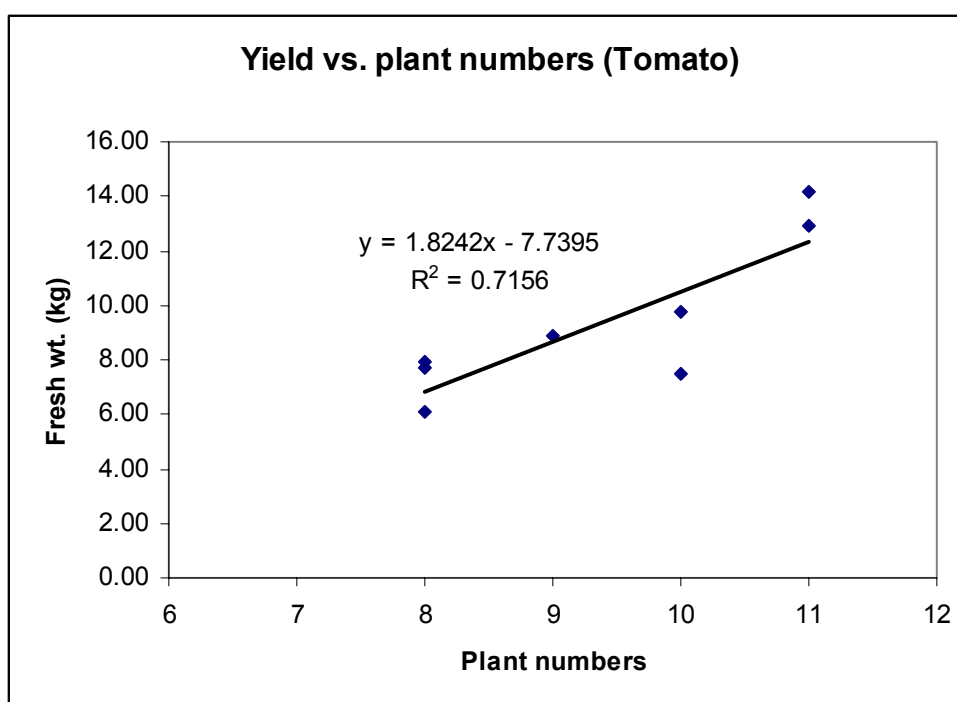


Figure 4. Regression and correlation of yield versus plant numbers for tomato crop.

It was hypothesized that sub-surface drip irrigation method would improve the water use-efficiency of cucumber or tomato crops by minimizing the evaporative loss and delivering water directly to the root zone. However, the results of this preliminary study were contrary

to the anticipated outcome. The reason for lower yields in the case of sub-surface irrigation was thought to be two-fold. The first reason was clogging of pores by algae which grew in the irrigation buckets and flowed into the irrigation pipes. And second, insufficient water delivery during the early stages of crop growth, after transplanting, led to poor establishment and low plant numbers, especially in tomato.

Additional study is needed with closer monitoring to assess soil moisture status and water delivery rate. Means to reduce clogging of irrigation pipes should be explored and could be achieved by changing the water storage container and delivery system. Maintenance of the same plant stand within each row/treatment is also crucial.

CONCLUSIONS

The preliminary study indicated that surface drip irrigation method gave overall better crop establishment and hence higher yields than did sub-surface drip method. Clogging of openings in the irrigation pipe by algae that grew in the water was presumed to be the main reason for the reduced yields in sub-surface drip method. None-the-less, drip irrigation may be a feasible option for vegetable crop production under water limiting conditions. Further research under more controlled conditions is need to determine the true effect of drip method on yield of vegetable crops.

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