

# The effect of upper-limit of soil water content on tomato and cucumber

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## Abstract

This study was conducted to determine the optimum upper limit of soil water content (SWC) for tomato and cucumber from early stages after transplanting. Five different upper limits of SWC were tested at the lowest limit of 60% of field capacity (FC) for tomato and of 75% for cucumber. Stem growth, root viability, yield and fruit concentrations of vitamin C and total soluble solids were significantly affected by the treatment. The highest yield and best fruit quality was obtained at 85% of FC for tomato and at 90% for cucumber. This suggests that irrigating to FC does not necessarily result in higher yields and better fruit quality.

**Key word:** Upper-limit, soil water content, yield, fruit quality, tomato, cucumber

## Introduction

Water supplies are limited worldwide (Postel, 1998). Therefore, it is necessary to explore efficient irrigation methods. Soil water content (SWC) is one of the important parameter used most often by small farmers in China (Blanke *et al.*, 2007) for determining irrigation requirements. Field capacity (FC) is viewed as an upper limit when irrigating based on SWC. But 80% of FC was better for lettuce compared to 98% (Dunkel, 1968). Maize yield decreased when SWC exceeded 90% of FC (Gao *et al.*, 2006). Better results for watering below FC could be because of higher soil aeration (Sidorova *et al.*, 1988).

The objective of this research was to explore the optimal upper-limit of soil water content for tomato and cucumber. We measured plant stem diameter, root viability, yield, and quality of fruit. The experiment was carried out in a greenhouse to minimise the adverse effects that frequently changing weather may have on plant responses.

## Materials and methods

The experiment was conducted at the Horticulture Crop Test Unit, North West A&F University, Yangling (latitude 34°21' N, longitude 108°10' E), China, from February to June 2005. Seedlings of fresh market 'Qinfen' tomato and 'Jingchun 2' cucumber were transplanted with plant and row spacing of 0.40 × 0.55 m on 28 March 2005 in two greenhouses. The soil was clay loam.

Irrigation was applied according to:

$$m=10 \times r \times h \times \beta_f (\beta_U - \beta_L) \frac{1}{\eta \times p} \quad (\text{Wang } et al., 2000) \quad [1]$$

Where  $m$ =irrigation amount (mm),  $r$  =bulk density ( $\text{g cm}^{-3}$ ),  $h$ = the depth of wetting front (cm),  $\eta$ =efficacy of irrigation water use,  $\beta_f$ =field capacity (%),  $\beta_U$ =upper-limit of SWC (%),  $\beta_L$ = lower-limit of SWC (%),  $p$  =water density ( $\text{g cm}^{-3}$ ). The values of these parameters are shown in Table 1.

There were five treatments with three replicates in a completely randomized block design. The five irrigation treatments started 18 days after transplanting and continued for 35 days. At each irrigation, 102.4, 76.8, 64.0, 51.2, 25.6 mm of water were applied to the five treatments for tomato and 38.1, 30.4, 22.8, 15.2, 7.6 mm for cucumber following Equation 1. There were 9, 10, 14, 14 for tomato and 4, 5, 6, 7 and 9 irrigations for cucumber, respectively. Furrow irrigation under plastic mulch was used every other row.

The soil moisture meter HH2 connected to an ML2x soil moisture sensor (Delta-T Devices Ltd., Cambridge, England) was used to measure soil moisture every other day at 10 a.m. at a soil depth of 20 cm. Three plants were tagged in each plot and diameter of the main stem, 5 cm from ground, was measured twice using a ruler accurate to 0.001cm (50-75, Shanghai Cany Precision Instrument Co. Ltd., China), at the beginning and the end of the experiment. Root viability was measured by the reduction of triphenyl tetrazolium chloride (TTC) method (Gao, 2000). Concentration of soluble solids was measured by the Anthracene Ketone method and that of vitamin C by Molybdenum bluesness colorimetric method (Gao, 2000). Root samples were collected at the end of irrigation treatments. Fruit samples were randomly chosen at peak harvest. The data were analysed using the DPS procedure of Statistical Analysis System software. Treatment means were separated by t-test at  $P \leq 0.05$ .

## Results and discussion

Stem diameter growth over 30 days, root viability, yield and vitamin C content and total soluble solids in fruit were significantly affected by irrigation treatments (Table 2). For tomato, the lowest values of these parameters were for the 70% treatment while the highest values were shared by the 85 and 90% treatment except for the root viability which was highest for the latter. In cucumber, the lowest values of these parameters was shown in the 80 or 100% of FC treatment and the highest were for the 90%. More irrigation water did not result in higher yield. The reason for the yield drop

Table 1. Soil parameters and treatment levels of irrigation water applied as % of soil field capacity (the parameters are explained in the text)

Experiment	$r$ (g cm <sup>-3</sup> )	$h$ (cm)	$\eta$ (%)	$P$ (g cm <sup>-3</sup> )	$\beta_f$ (%)	$\beta_L$ (%)	$\beta_U$ (%)				
							T1	T2	T3	T4	T5
Tomato	1.2	60	90	1	32	60	70	80	85	90	100
Cucumber	1.37	40	90	1	25	75	80	85	90	95	100

Table 2. Effect of irrigation treatment (in terms of soil water as a percentage of field capacity (FC)) on stem diameter increase over 30 days (SDI), root viability (RV), yield, percentage yield increase compared to 100% of FC (PYI), vitamin C content (VC) and total soluble solids (TSS) in fruit

Treatment (% of FC)	SDI (cm)	RV (g kg <sup>-1</sup> h <sup>-1</sup> )	Yield (kg ha <sup>-1</sup> )	PYI (%)	VC (mg kg <sup>-1</sup> )	TSS (g kg <sup>-1</sup> )
Tomato						
60-70	0.423c	0.9935c	55532.5c	-0.49	257.2c	45.2c
60-80	0.550b	1.0041bc	58540.4b	4.90	299.7b	47.3b
60-85	0.610a	1.0982bc	62812.5a	12.55	339.6a	53.4a
60-90	0.609ab	1.4888a	61352.5a	9.94	328.4a	50.7a
60-100	0.574b	1.2723b	55807.5b	0	271.1b	46.2b
Cucumber						
75-80	0.141c	0.5504c	79479.17c	-1.06	236.4c	20.9c
75-85	0.163b	0.8074b	88020.83b	9.57	248.1b	28.5b
75-90	0.185a	1.0756a	95104.17a	18.39	276.2a	37.4a
75-95	0.167b	1.0253a	90083.33b	12.14	252.6b	31.2b
75-100	0.134c	0.5194c	80333.33c	0	239.6c	29.2b

Means followed by different letters are significantly different at  $P < 0.05$  using Tukey's Studentised range test.

at 100% of FC may be inadequate oxygen concentration in the root zone (Bhattarai *et al.*, 2004.), and this can be explained by the values of root viability (Table 2).

It is a very popular management technique in China that the growth point on main stem is cut when tomato plant have the fourth or fifth inflorescence in soil culture style. So, water management was a key technique to change the growth centre from vegetation to reproduction for tomato to reduce the abortion at the early stage after transplanting (Zhang, 2001). Although, this experiment had been carried for only 30 days at the early stage after transplanting, it was very important for changing the growth centre and total yield of tomato; it can represent all growth stages of cucumber in this experiment, because the cucumbers were harvested during the treatment. Also, soil water content below field capacity may be more advantageous in regulating the relationship between underground and above ground plant growth at early stage. This needs to be explored further.

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