Water Productivity of Cucumber and Tomato Crops as Affected by Different Cultural Substrates under Greenhouses Conditions at Bustan Area

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ABSTRACT

Greenhouses are considered as one of the feasible technologies for improving and propagating vegetables productivity per a unit of soil and water as well as for off-season productivity with higher net returns to the farmer. Two successive experiments were conducted at Abdel-Monem Reyad Village at El-Bustan area in 2005 and 2006 seasons to study the effects of using different agricultural media on water productivity of cucumber and tomato and the economics of their production. The objective of these experiments was to study the effect of polyethylene ditches (30X0.3X0.2 m ditch dug in the soil, coated with polyethylene film and filled with fertile compost), the polyethylene beds (close polyethylene film and contain fertile compost with the dimensions of 3.0X0.3X0.2 m. and punched for cucumber or tomato on 0.3m. and 0.5 m.) and the polyethylene bags (bags from polyethylene each with the capacity of 4 kg of fertile compost on applied water, vegetative parameters and economical factors of cucumber and tomato under greenhouse conditions. Also, to find a solution to avoid using chemicals for sterilizing seedlings bed such as methyl bromide in sterilizing the soil, which is costly and a source of environmental pollution.

Results revealed that:

- **There were some significant differences between the used treatments and the control on leaf area and dry matter parameters.**
- **Soil ditches Treatment had the highest significant yield for both cucumber and tomato crops.**
- **Applied water for both cucumber and tomato was measured and it increases with the vegetative growth increasing till the physiological maturity stage then decreased.**
- **Water productivity reached the highest value for polyethylene ditches treatment for cucumber and tomato greenhouse production.**
- **The net income for polyethylene ditches treatment reached 73.2 fold more than the traditional treatment for tomato, while, it reached 11.5 fold for cucumber.**

INTRODUCTION

Cucumber (*Cucumis sativus L.*) is one of the favorite vegetable crops in Egypt, which is used as salad or pickle, and become the main produces crops in greenhouse crop in Egypt, because of its high return. Also, tomato is considered profitable in off season production inside greenhouses. However, there are some problems facing cucumber and tomato production in greenhouses, such as soil born diseases, soil salinity and excessive low temperature in winter even under plastic cover (Etman, et.al.; 2002).

Neveen, et.al (2008) reported that substrate cultures proved their abilities to be alternative method to produce high yield, and quality as well, of carnation flowers in the absence of methyl bromide fumigator. Using different substrate cultures would save the environment from pollutants by methyl bromide and also, it could worm the roots in excessive cold winter in case of using compost which would be reflects on the yield and yield quality. From the other hand they appeared economically visible relative to the traditional methods.

There are highly needs for more information about water requirements for tomato and cucumber, and water productivity under the tested variables.

Irrigation scheduling using the climatic data is still generally used (Abu-Khalid, et.al.1988). In greenhouses, under Mediterranean climate the class A pans evaporation method as well as the radiation (FAO) and Priestly-Taylor methods are presumed to give reliable results of water requirements of protected crops (Graaf, et.al.,(1981), Doorebos and Pruntt,1984. and Abou Hadid,1993).

MATERIALS AND METHODS

Two experiments were carried out in 2005 and 2006 seasons at Abdel-Monem Ryad Village, El-Bustan area to study the effects of different cultural substrates on water productivity and economics of producing cucumber and tomato in greenhouses. The tested cultural substrates were polyethylene ditches, polyethylene beds, polyethylene bags and the farmer traditional method (soil fumigated with methyl bromide).

The polyethylene ditches were (spaces 30 X 0.3 X 0.2 m) ditch dug in the soil, coated with polyethylene film and filled with fertile compost. The polyethylene beds were close polyethylene film containing fertile compost with the dimensions of 3.0 X 0.3 X 0.2 m and punched for cucumber or tomato on 0.3m and 0.5 m, respectively. The polyethylene bags were bags from

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Received December3, 2008, Accepted December 29, 2008

polyethylene ach with the capacity of 4 kg of fertile compost. The bags were arranged according to the spacing of 0.3 m. for cucumber and 0.5 m. for tomato. The traditional (farmer practice or control) was the natural soil fumigated with methyl bromide.

Trickle irrigation system was used for irrigation. The system consists of sub main PVC pipe 63 mm out-diameter and a sub-sub main for each greenhouse 40 mm out-diameter P.E. pipe. The drip lines had GR 2 l/h emitter spaced 0.5m. A fertilizer injector was connected to the system for fertigation and a flow meter to measure the applied water.

Cucumber (*Cucumis sativus L.*) hybrid seedlings Pasandra Varity were planted on 4/11/2005 and 5/11/2006 for the first and second seasons, respectively. Tomato (*Lycopersicon esculentum L.*) hybrid seedlings Thomspn variety, were transplanted on 10/11 and 20/11 for the first and second seasons, respectively.

The leaf area vegetative parameter was measured randomly in five plants from cucumber and tomato from each treatment, 75 days after transplanting and leaf thinning in tomato in the greenhouse (DAT). For dry matter content, of random fruits, samples from each fresh fruits were dried to determine the dry matter g/kg fresh fruits. The leaf area per plant was measured by taken five plants randomly from each treatment and the leaf area was determined as follows:

The leaves weighed freshly without petioles. Twenty random discs were taken from different detached leaf parts using a cork puncher and weighed. The leaf area per plant was calculated according to the following formula:

$$\text{Leaf area per plant} = \frac{\text{fresh Weight of leaves X area of 20 discs}}{\text{Fresh Weight of 20 discs}}$$

Dry matter content of fresh fruits (Cucumber and Tomato) were determined by weighing the fresh fruit and drying it in an oven at 70°C till a constant weight was attained, and then , the percentage of dry matter content was calculated after 75 DAT from the following formula:

$$\%\ \text{Dry matter} = \frac{\text{Dry weight}}{Freshweight} X100$$

Applied water was measured by flow meter, and water productivity in terms of kg fresh fruit weigt/m^3 applied water, was calculated according to the formula described by Jensen. (1983)., as follows:

$$\text{Water productivity} = \frac{\text{Cucumber or tomato fresh fruit weight (kg)}}{\text{Applied Water in (cubic meters)}}$$

The potential evapotranspiration was obtained from class A pan measurements as by the formula:

ETo = E pan X K pan

Where;

E pan = measured pan evaporation daily values in mm/day,

K pan = pan coefficient, values depend on relative humidity, wind speed and site conditions (bare or cultivated). A value of o.75 was used.

ETc = actual crop evapotranspiration and calculated by soil sampling before and after irrigation.

Kc = crop coefficient, it was calculated from the formula:

$$Kc = \frac{ETo}{ETc}$$

Soil and fertile compost samples were collected from the experimental site for physical and chemical analysis according to Page, (1984) and results are shown in Tables 1 and 2.

Table 1. Soil Physical and chemical analysis

A) The chemical analysis of soil samples for El-Bustan location.

Depth	E.C	pH	Soluble cations and anions (mequ//l)							
Cm.	Ds/m		Ca^{++}	Mg++	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO4^{--}
0 – 30	0.35	9.13	1.23	0.54	1.56	0.17	----	1.10	1.73	0.67
30-60	0..30	9.38	1.25	0.49	1.61	0.15	----	1.07	1.74	0.69

B) The physical soil properties for El-Bustan location.

Depth (cm.)	(Bulk density) g./cm^3	(PWP) %	(FC)%
0 – 15	1.65	6.80	15.61
15 - 30	1.67	6.78	15.39
30 - 45	170	5.99	11.01
45 – 60	1.74	5.97	10.99

C) Siol Texture and its fractions for El-Bustan location.

Depth cm.	Sand %	Silt %	Clay %	Texture Class

0:30	90.9	2.6	6.5	Sandy
30:60	91.0	1.8	7.2	Sandy

Table 2. Compost analysis

Element	Content of fertile compost	Element	Content of fertile compost
Total Phosphorous	0.68%	pH (1:10)	8.5
Total Potassium	0.65%	EC (1:10)	7.5 dSm^{-1}
Total N	1.5%	Fe	1700 ppm
Organic carbon	25.2%	Mn	220 ppm
Organic Matter	45%	Cu	1 ppm
		Zn	150 ppm
		Mg	700 ppm

The experimental design was randomized complete blokes design (RCBD) with three replicates.

Economic analysis

Economic analysis was based on the total income, variable costs and net revenue.

Total income = Total yield X unit price.

Variable coasts = sum (all production coasts)

Net revenue = Total income – Variable coasts.

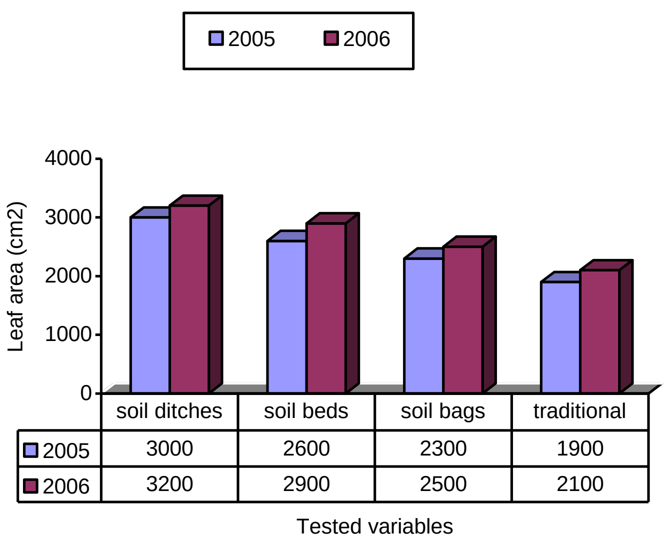
Statistical analysis:

Obtained data were analyzed using the software CoHort (1986) statistical package. The average values of the replicates of each treatment were interpreted using the analysis of variance (ANOVA). The Duncan's multiple range tests for comparisons between means according to Steel and Torrie (1980).

RESULTS AND DISCUSSION

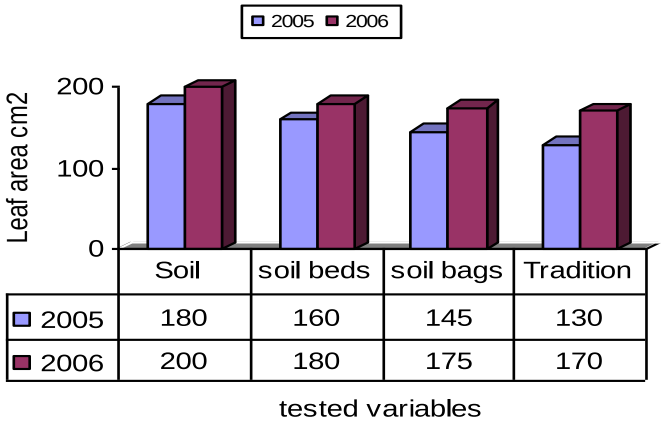
Vegetative growth:

Leaf area and fruit dry matter content are two important parameters reflect the response of crop vegetative growth and obtained yield of both cucumber and tomato. Figures 1and 2 illustrate the leaf area (cm^2) for cucumber and tomato as affected by the four treatments, respectively. The figures show that there are significant increases in the leaf area at the tested variables in the two growing seasons (2005 and 2006) as compared to the farmer traditional treatment (control). The treatment (soil ditches) had the highest values of leaf area for both cucumber and tomato in the two growing seasons. These values were 3000, 3200, 180 and 200 (cm^2) for cucumber 2005, cucumber 2006, tomato 2005 and tomato 2006, respectively. Figures 3 and 4 presented the obtained results for fruits dry matter (g/kg) for cucumber and tomato in the two growing seasons 2005 and 2006, respectively. For cucumber (Table 3) there was no significant increase in dry matter for fruits at the two growing seasons 2005 and 2006. But, for tomato (Table 4) there was significant increase between soil ditches & soil beds and traditional treatment, a significant increase between soil bags and the control treatment in the two growing seasons.The obtained data were in agreement with Etman, et.al.2001, Tawfik, et.al.2004 and Neveen,et al., (2008).



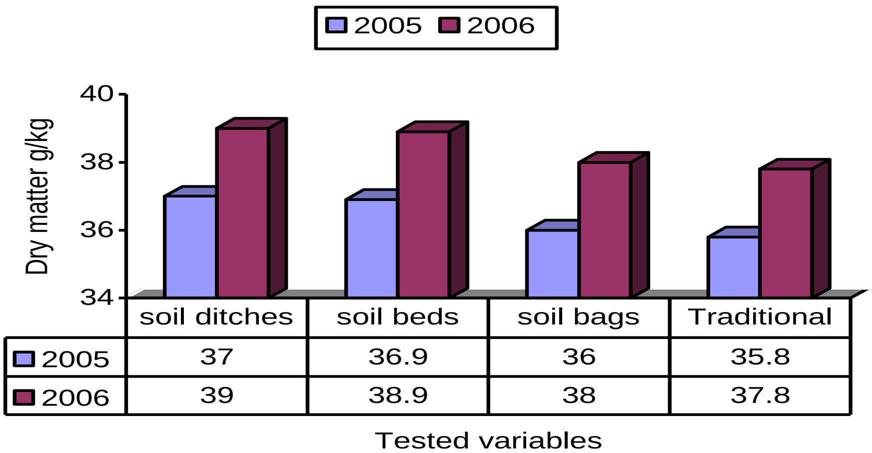
LSD 0.05 (2005) = 339.435
LSD 0.05 (2006) = 339.435

Figure 1. The effect of tested variables on cucumber leaf area (cm^2) DAT



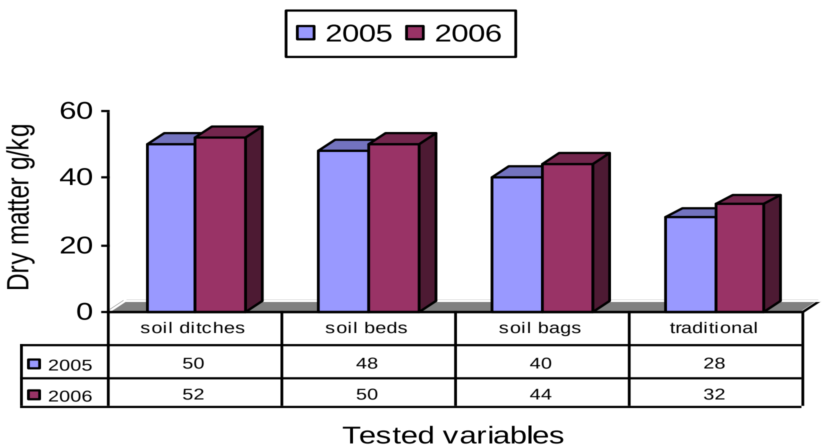
LSD 0.05 (2005) = 18.824
LSD 0.05 (2006) = 26.627

Figure 2. The effect of tested variables on leaf area (cm^2) for tomato 75 DAT and after leaf thinning



LSD 0.05 (2005) = 1.331
LSD 0.05 (2006) = 1.310

Figure 3. The effect of tested variables on dry matter in cucumber fruit (g/kg)



LSD 0.05 (2005) =5.879
LSD 0.05 (2006) = 5.242

Figure 4. The effect of tested variables on fruit dry matter in tomato g/kg

2 Fresh fruit yield

a) Cucumber yield

Results in Table 3 shows the yield of cucumber, applied water and water productivity in the two growing seasons (2005 and 2006) as affected by the tested variables. Results indicated that there are highly significant increases on the yield of cucumber among the polyethylene ditches, polyethylene beds, polyethylene bags and the farmer traditional method (soil fumigated with methyl bromide).

The measured applied water varies among the treatments because the wetted areas varied in polyethylene ditches, polyethylene beds, polyethylene bags and the farmer traditional method and their values were 194.4, 216, 156.9 and 297 m^3/season, respectively for 2005 season. The same trend was observed for 2006 season.

Water productivity in (kg) fresh cucumber fruits per applied water in cubic meters was higher in the treatments polyethylene ditches, polyethylene beds, polyethylene bags than the control. These values were 23.66, 14.81, 19.79 and 10.10 for polyethylene ditches, polyethylene beds, polyethylene bags and control, respectively for 2005 season. The same trend was observed for 2006 season.

b) Tomato yield:

Table 4 shows the yield of Tomato, applied water and water productivity in the (2005 and 2006) growing seasons as affected by the tested variables. Results proved that there were highly significant differences on tomato yield among the polyethylene ditches, polyethylene beds, polyethylene bags and the farmer traditional control method (soil fumigated with methyl bromide).

Table 3. Fresh fruit of cucumber, applied water and water productivity for the 2005 and 2006 growing seasons

Treatment	2005 season		
	Ton/greenhouse	**Applied water (m^3/season)**	**Water productivity (Kg fresh fruit/m^3)**
Polyethylene ditches,	4.6 a	194.4	23.66
polyethylene beds,	3.2 b	216	14.81
polyethylene bags	3.1 b	156.6	19.79
farmer traditional	3.0 c	297	10.10
Treatment	**2006 season**		
	Ton/greenhouse	**Applied water (m^3/season)**	**Water productivity (Kg fresh fruit/m^3)**
polyethylene ditches,	4.2 a	188.6	22.27
polyethylene beds,	3.5 b	207.5	16.87
polyethylene bags	3.3 b	150.9	21.37
farmer traditional	3.0 c	270	11.11

Greenhouse area is 270 m^2.

Table 4. Fresh fruit yield of tomato, applied water and water productivity for the 2005 and 2006 growing seasons

Treatment	2005 season		
	Ton/greenhouse	**Applied water (m^3/season)**	**Water productivity (Kg fresh fruit/m^3)**
polyethylene ditches,	3.49 a	291.6	11.96
polyethylene beds,	2.9 a	324	8.95
polyethylene bags	2.64 b	236	11.2
farmer traditional	2.3 b	447	5.15
Treatment	**2006 season**		
	Ton/greenhouse	**Applied water (m^3/season)**	**Water productivity (Kg fresh fruit/m^3)**
polyethylene ditches,	3.62 a	283.5	12.77
polyethylene beds,	3.1 a	310.5	9.98
polyethylene bags	2.62 b	225	11.64
farmer traditional	2.72 b	405	6.72

Greenhouse area is 270 m^2.

The measured applied water varies among the treatments because of the wetted areas varied in polyethylene ditches, polyethylene beds, polyethylene bags and the farmer traditional method and its values were 291.6, 324, 236 and 447, respectively in 2005 season and the same trend was observed in 2006 season.

Water productivity in kg fresh cucumber fruits per applied water in cubic meters was higher in the treatments polyethylene ditches, polyethylene beds, polyethylene bags than the value of control treatment. These values reached 11.96, 8.95, 11.2 and 5.15 for polyethylene ditches, polyethylene beds, polyethylene bags and the control, respectively in 2005 season. The same trend was observed in 2006 season.

3 Water consumptive use, reference evapotranspiration and crop coefficient:

Monthly water consumptive use (ETc), reference evapotranspiration (ETo) and crop coefficient (Kc) for cucumber are presented in Table 5, where the same data are presented for tomato in Table 6. Results showed that values of water consumption by both cucumber and tomato increased from the vegetation stage to flowering and to yield formation stage, they decreased at ripening stage. The total water consumptive use for cucumber was 84.4 and 81.8 m^3/greenhouse for 2005 and 2006 growing seasons, respectively. For tomato, the total water consumptive use was 135.2 and 131.4 m^3/greenhouse for 2005 and 2006 seasons, respectively. ETo values represents the evaporation through the growing seasons. The average crop coefficient of cucumber under greenhouse conditions was 0.343 and for tomato it was 0.462. The Kc values increased from the initial state to the vegetative, flowering and then decreased with ripening stage for the two growing crops.

3 Economic analysis:

Tables 7 and 8 present average variable coasts, total income and net revenue for cucumber and tomato under greenhouse conditions and different cultural substrate. From Tables 7 and 8 data showed that:

- The highest average net income was achieved from polyethylene ditches treatment for both cucumber and tomato.
- The lowest average net revenue was for the traditional method (farmer practice).
- The net revenue for polyethylene ditches treatment has increase with 73% than the traditional one.

Table 5. Water consumptive use for cucumber under greenhouse condition, ETo and Kc

Months	2005		
	ETo m^3/greenhouse	ETc m^3/greenhouse	Kc
Nov.	18.58	4.645	0.25
Dec.	62.59	30.889	0.49
Jan.	68.90	37.566	0.54
Feb.	25.16	11.322	0.45
Months	**2006**		
	ETo m^3/greenhouse	**ETc m3/greenhouse**	**Kc**
Nov.	18.66	4.536	0.24
Dec.	60.58	29.995	0.50
Jan.	66.726	36.39	0.55
Feb.	24.435	10.93	0.45

Greenhouse area is 270 m^2.

Table 6. water consumption use for tomato under greenhouse conditions (ETc), ETo and Kc

Months	2005		
	ETo m^3/greenhouse	ETc m^3/greenhouse	Kc
Nov.	17.5	7.00	0.4
Dec.	70.1	35.05	0.5
Jan.	87.5	56.88	0.65
Feb.	68.5	30.83	0.45
March	16.7	5.46	0.31
Months	**2006**		
	ETo m^3/greenhouse	**ETc m^3/greenhouse**	**Kc**
Nov.	17.0	6.8	0.4
Dec.	68.0	34.0	0.5
Jan.	85.0	55.3	0.65
Feb.	67.0	30.2	0.45
March	16.5	5.1	0.31

Greenhouse area is 270 m^2.

Table7. The total income, variable coasts and net income for cucumber 9average of the two seasons in L.E

Treatment	(Total income). (L.E.)	(Variable coasts). (L.E.)	Average net revenue (L.E)
polyethylene ditches,	2482.5	1276.2	1206.3
polyethylene beds,	1660	1480.2	179.8
polyethylene bags farmer	1734.75	1258.2	476.55
traditional	1613.25	1505.7	107.55

Table 8. The total income, variable coasts and net income for tomato average of the two seasons in L.E

Treatment	(Total income). (L.E.)	(Variable coasts). (L.E.)	Average net revenue (L.E)
polyethylene ditches,	2593.1	813.2	1779.9
polyethylene beds,	1652.2	1001.5	650.7
polyethylene bags farmer	1817.89	800.2	1017.8
traditional	1446.3	1200	246.3

Greenhouse area is 270 m^2.

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الملخص العربي

الإنتاجية المائية لمحصولى الخيار والطماطم المنزرعة تحت ظرف البيوت البلاستيكية وتحت بيئات زراعية مختلفة بمنطقة البستان

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أجريت تجربتان حقليتان بالبيوت البلاستيكية بمنطقة البستان قرية عبد المنعم رياض عامى 2005 و2006 لدراسة تأثير استخدام بدائل للتربة الأصلية لزراعة الخيار والطماطم من أجل تجنب التعقيم ببروميد الميثيل (معاملة المزارع) لما لها من أثرعلى تلوث للبيئة ولإرتفاع تكلفتها وعدم إتمامها بنجاح لدى المزارعين ودراسة إقتصاديات هذه البدائل.

وقد جاءت النتائج بالتالى:

1. أوضحت القياسات الخضريه (المساحة الورقية) على مدى عامى الدراسة 2005 و 2006 أن هناك فروقاً معنوية قوية بين المعاملات تحت الدراسة وطريقة المزارع التقليدية وكانت أحسنهم على التوالى معاملة الخنادق بالبلاستك ثم الوسائد البلاستيكية ثم الأكياس البلاسيكية وأخيراً معاملة المزارع التقليديه وذلك لمحصولى الخيار والطماطم المنزرعة داخل البيوت البلاستيكية.
2. أوضحت كذلك النتائج أن المادة الجافة فى الثمار الطازجة للخيار ليس لها فروقاً معنوية فى موسمى النمو 2005 و 2006 بينما مع محصول الطماطم كانت هناك فروق معنويه بين المادة الجافة بالثمار الطازجة وعاملات التجربة.
3. بالنسبة للمحصول الطازج من كل من الخيار والطماطم أوضحت النتائج أن هناك فروق معنوية قوية بين معاملات الدراسة ومعاملة المزارع .
4. وجد أن الإستهلاك المائى لمحصولى الخيار والطماطم يزداد من أطوار النمو الخضرى الى الإزهاروالإثمار ثم يقل فى مرحلة النضج.
5. كفاءة إستخدام لمياه (الإنتاجية المائية) وصلت لأعلى قيمة لها فى معاملة الخنادق البلاستيكية.
6. أوضح الجانب الإقتصادى تفوق معاملة الخنادق من حيث صافى العائد المحصولى بالإضافة لتفوق هذة المعاملة أيضاً من حيث نظافة البيئة من بروميد الميثيل والحصول على أعلى محصول مع تقليل التكاليف المتغيرة.