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Influence of Agri-Aquaculture and Seed Treatment Techniques on Sugar Beet Crop

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ABSTRACT

The current study aimed to investigate the influence of using different sources of irrigation (well "ground water" and agri-aquaculture) with some seed treatments techniques on amount of water applied, water use efficiency, yield and economic analysis of sugar beet crop. An experimental was design on split plot with 6 treatments and three replicates, where three seed treatments techniques i.e. control, soaking (24 h) and soaking (72 h). Drip irrigation was used and crops were planted in rows. Data indicated that the amounts of water applied were 2653, 2565 and 2489 m^3/fed. under control (C), soaking 24 h (S_1) and soaking 72 h (S_2). and amounts of water saving under different seed treatments (S_1, and S_2) compared with control treatment (C) were 88 and 264 m^3/fed., respectively. These results demonstrated that values of both root and sugar water use efficiencies were 7.54 and 1.29 kg/m^3 under well (W) treatment, while were 8.24 and 1.44 kg/m^3 under agri-aquaculture (A) treatment. The highest value of germination ratio was 94.06% under S_2 treatment, while the lowest value was 93.86% under C treatment. The maximum root yield among seed treatment techniques was recorded with S_2 treatment (20.18 ton/fed) followed significantly by soaking seeds 24 h (19.19 ton/fed) and followed by control treatment (19.76 ton/fed). The highest net return and the maximum value of water productivity were 8427 LE/fed and 3.53 LE/m^3 with used agri-aquaculture and soaking seed 72h, while the lowest value was 6144 LE/fed. and 2.32 LE/m^3 with well water and without treated seed.

Keywords: irrigation, agri-aquaculture, seed, sugar beet, net return

INTRODUCTION

The world's population is projected to reach 9.1 billion by the middle of this century, 34% higher than today. In order to respond to the expected demand, food production must increase by about 70 % by 2050 (World Summit on Food Security 2009).

Water resources are limited worldwide, and there is an urgent need to find and adopt new irrigation management strategies, agricultural land consumes more than 85% of water use worldwide (Zegbe *et al.,* 2006). Water for agriculture is critical to the future of global food security. However, the continued increase in demand for water by non-agricultural uses, such as urban and industrial uses, and greater concern for environmental quality have put the demand for irrigation water in a closer examination and threatened food security. (Fedoroff *et al.,* 2010). Irrigation practices is fundamental for crop production in areas of inadequate water supply, because water is often one of the primary factors in any crop production, thus its management plays a vital role in the agricultural strategy due to the limited water resources and at the same time the land reclamation. Irrigation development will play an important role in increasing production to meet increased food demand in future.

Agri-aquaculture is a viable and environment friendly option for increase of a farmer's income and net-return. Therefore, a farmer owning fish pond, water source and agricultural land at one location should go for agri-aquaculture for optimum utilization of resources, better income and ecologically sustainable development (Ray *et al.,* 2010). Most aquaculture activities are generally located in the Northern Nile Delta Region, with fish farms usually found clustered in the areas surrounding the four Delta Lakes (Maruit, Edko, Boruls and Manzala). The total land area used for this kind of aquaculture is (361,326 feddans / 151,757 ha) with an annual per hectare production of between 2.8 to 8 tones (Value-Chain Analysis of Egyptian Aquaculture, 2011). Recycling the drainage water of fish farming, rich with organic matter for agriculture use can improve soil quality and crops productivity (Elnwishy *et al.,* 2006), reduce the total costs since it decreases the fertilizers use, which demand became affected by the prices and the framer's education (Ebong and Ebong, 2006). Reuse drainage water of fish farming as a new resource for irrigation and rich with organic matter and it can improve soil quality and crops productivity, reduce the total costs of fertilizers by adding minimum doses from minerals fertilizers and reduce the pollution in soil. The potato yield and water use efficiency were 8 ton/fed and 2.9 kg/m^3 under drainage water of fish farms compared with 7.8 ton/fed and 2.9 kg/m^3 under traditional irrigation water (Abdelraouf and Hoballah, 2014).

Seed priming is a pre-sowing strategy for influencing seedling development by modulating pre-germination metabolic activity prior to emergence of the radicle and generally enhances germination rate and plant performance. Seed priming is soaking of seeds in a solution of any priming agent followed by drying of seeds that initiates germination related processes without radical emergence (McDonald, 2000).

Maralian Habib 2010*,* evaluate the effect of pre-sowing seed treated by soaking in water and two concentrates of hydrochloric acid (0.03 and 0.3 N HCl) at three different times (2, 4 and 6 hr) and showed that both the type and time of treatment could improve rate of germination. Soaking 6 hr with diluted acid (0.03 N) or with water, improved significantly the mean time of germination comparison with untreated seeds.

Eskandari and Kazemi 2011, studied the effect of hydropriming (soaking seeds in water 8, 12 and 16 hours duration) and halo priming (solutions of 1.5% KNO and 0.8% NaCl) on seedling cowpea and showed that hydropriming significantly improved germination rate and seedling dry weights. Seedling emergence rate was also enhanced by priming seeds with water, suggesting that hydropriming is a simple, low cost and environmentally friendly technique for improving seed and seedling vigor of cowpea.

Ikuomola *et al. 2013*, investigated the effect of soaking period (6, 12, 24 h and 72 h in water) on soybeans and found that soaking for 6 to72 h produced beske with varied yield and protein ranging from 10.71-25.42% and 18.21- 23.88%, respectively.

Moosavi *et al. 2014*, soaked seed of soybean in water at different time (hydro-priming 8, 12, 16 and 20 hours) and found that there is a significant difference at percent level between hydro-priming durations on germination percentage, number of pods per plant and yield.

The sugar industry depends on sugar cane and sugar beet crops to produce sugar, Where the latter contributes more than 30% of world production of sugar, and 50% locally in Egypt with a total production of 0.99 million tons of sugar which indicates the strategic importance of this crop (Sugar Crops Council Report - December 2013). Sugar beet crop is one of the most important sugar crops throughout most countries in the world. This crop can be grown under wide range of climates, soils and environmental conditions such as drought and salinity stress. In Egypt, sugar beet crop takes much concern for its growth, production, quality, fertilization and soil and water management under the local environmental conditions.

Therefore, nowadays in Egypt still no clear strategy for using non-traditional sources of irrigation, plus it could be useful to overcome fertilizer prices. There are many new sources of non-traditional irrigation. One of these sources using drainage water of fish farms, which rich with organic matter and nitrogen fertilizer. Using such source of irrigation will increase water saving, crop productivity and decreasing fertilizer cost for which led to maximize water use efficiency.

The aim of this work is to investigate the influence of different sources of irrigation with some seed treatments techniques on the amount of water applied, water use efficiency, yield and economic analysis of sugar beet crop in Egypt.

MATERIALS AND METHODS

Experimental site

Two field experiments were carried out at the Research Farm, Wadi El-Natroon Research Station for water management research institute, NWRC, during the two winter seasons of 2015/2016 and 2016/2017.

The experimental site has the following characteristics: (longitude 30° 13' 0 E°, latitude 30° 25' 0 N and altitude 25.5 m). The average mean temperature is 38.3 C° in the hottest month (July) and 19.3 C° in the coldest month (Jan.). Annual mean relative humidity is 70%. The soil texture was sandy soil with an average bulk density of 1.56 gm/m^3, field capacity 9.1% and 5.9% wilting point. The irrigation water source was artesian well with 7.14 pH. Soil moisture content was measured in each treatment by dielectric sensor Delta Devices model Profile Prob-PR2 (England) at 30 cm deep.

The sugar beet crop was sown manually in 1Oct., variety was Multigerm pleno and seeds were sown at rate of 4 kg/fed. on 0.25 m planting space and 0.6 m between rows with two seeds per hill. The seedling was thinned to one plant per hill after 35 days.

Prior to sowing, normal agricultural practices and fertilizer rate for grown sugar beet were followed as recommended for Sugar Crops Research Institute, Agriculture Research Center.

Experimental design and treatments

The experiment was set up in split plot design with 6 treatments and three replicates Fig. (1), each plot consisted of three rows. The plot area was 25 x 1.8 m. Drip irrigation system was used in the experimental, consist of pump, control unit, main line, sub main line and laterals. The dripper types were GR with 4 lit/hr discharge and 25 cm between dipper to another.

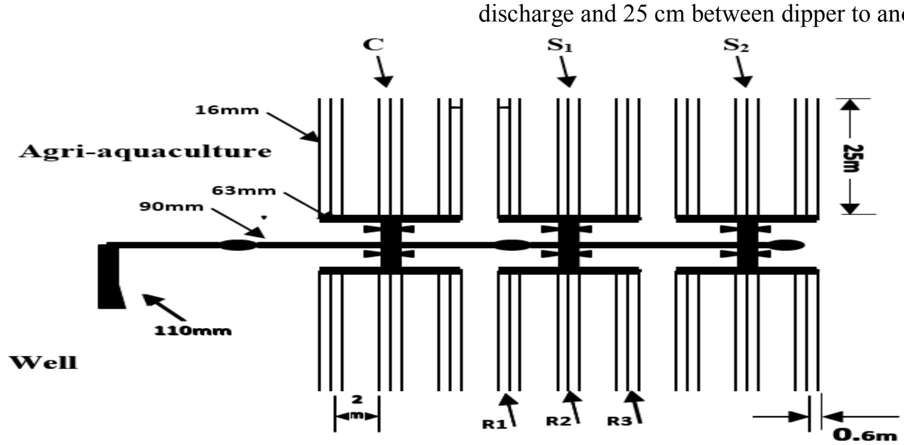

Fig. 1. Layout of the experiment.

The main plot of the experiment was types of irrigation sources, while the sub plot was the seed treatments techniques (soaking seed in water). The sources of irrigation treatments were:

1- Well (ground water) "W" (EC, 1200 ppm)
2- Aquaculture effluent "A" (fish farms with EC, 2500 ppm).

The seed treatments techniques were:

1- (C) Control (direct planting).
2- (S_1) Soaking for 24 hours before planting.
3- (S_2) Soaking for 72 hours before planting.

Data recorded

- Germination ratio.

The germination ratio (G_r) was determined by using the following formula:

$$G_r = \frac{N_p}{N_s} \times 100$$

Where:

N_p = Number of sugar plants within a length of 10 m.

N_s = Number of sugar seeds delivered within the same length.

- Crop characteristics

- Roots: Measurements of root length (cm) and diameter (cm).
- Yield quality: Sucrose, Extractable white sugar and juice purity percentage were measured.
- Yield parameters: Root yield and white sugar yield (ton/fed)

- Amount of Water Applied

The depth of irrigation was calculated according to the equation given by Israelsen and Hansen (1962).

$$D_{aiw} = \frac{F.C. - \theta 1}{100} \ X \ Bd \ X \ d$$

Where:

D_{aiw} : Depth of irrigation water applied. (mm)

F.C. : Soil moisture content at field capacity by weight. (%)

Θ_1 : Soil moisture content before irrigation by weight. (%)

Bd : Bulk density. (gm/cm^3)

d : Soil depth. (mm)

- Water Use Efficiencies (WUE)

WUE was calculated according to Jensen (1983) formula as follows:

$$WUE_{Root} = \frac{Root\ yield\ (kg/fed)}{Amount\ of\ water\ applied\ (m^3/fed)} \ kg/m^3$$

$$WUE_{Sugar} = \frac{Sugar\ yield\ (kg/fed)}{Amount\ of\ water\ applied\ (m^3/fed)} \ kg/m^3$$

- Economic Analysis

The prices in-puts and out-puts were calculated for different treatments for sugar beet crop during the experiments in the area. Concerning costs of irrigation in whole season for different treatments was calculated on the basis of rent of water.

- **Total production costs (LE/fed.)** was calculated with the following equation:

Total production costs (LE/fed.) = Irrigation system costs (fixed and running cost) + cost of cultivation (Preparation of soil, different agriculture practices, price of seed, labors and harvesting)

- **Total return (LE/fed)**: was calculated with the following equation:

Total return = Price (LE/ton) × Grain yield (ton/fed)

- **Net return**: was calculated with the following equation:

Net return = Total return - Total costs

- **Water productivity, (WP, LE/m^3)**: was calculated by using the following formula:

$$Water\ productivity = \frac{\text{Net return (LE/fed.)}}{\text{Amount of water applied (m}^3\text{/fed)}} \ \text{LE/m}^3$$

- Statistical Analysis.

Data were subjected to analysis of the least significance difference (LSD) at 5% level of probability was used to compare treatment means when F-test was significant.

RESULTS AND DISCUSSION

Amount of Water Applied

Results in fig. (2) showed that the average of the amount of irrigation water applied (m^3/fed) during of the two growing seasons of sugar beet crop were 2653, 2565 and 2389 m^3/fed under control (C), soaking 24 h (S_1) and soaking 72 h (S_2), respectively. Seed treatments S_1 and S_2 reduce the amount of water applied by about 3.3 and 9.95% compared to C treatments. That may be due to reduce the sugar beet growing season as result of soaking.

The water saving under different seed treatments (S_1 and S_2) compared to control treatment (C) were 88 and 264 m^3/fed., respectively.

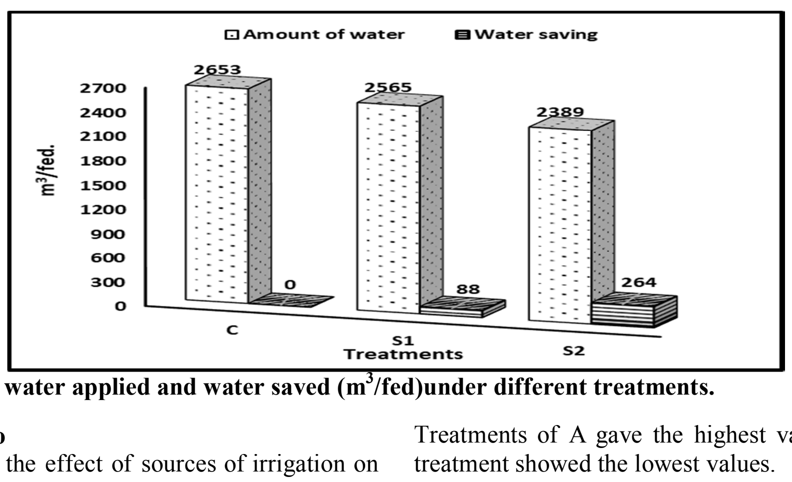

Fig. 2. Amount of water applied and water saved (m^3/fed)under different treatments.

Germination ratio

Concerning the effect of sources of irrigation on germination ratio after 10 days from planting as shown in Table (1), there are significant differences among these treatments as compared with control plants. Treatments of A gave the highest values. Whereas, W treatment showed the lowest values.

As the effect of seed treatments, the highest value of germination ratio was 94.35% under S_2 treatment, while the lowest value was 93.53% under C treatment. These results are in agreement with obtained by Maralian Habib 2010.

The interactions between the two studied factors declared that significant effect was obtained. The highest values of germination percentage after 10 days from planting was obtained from the interactions of A x S_2. While the lowest value of germination percentage was obtained from the interactions of W x C.

Table 1. Germination ratio, root length and diameter, sucrose, juice purity and extractable white sugar percentage under different treatments.

Treatments	Germination ratio %	Length cm	Diameter cm	Sucrose %	Juice purity %	Extractable white sugar %
Irrigation Water						
W	93.86	39.32	13.00	19.75	85.06	17.05
A	94.06	42.48	14.28	20.08	85.89	17.43
F test	*	NS	*	*	*	*
LSD	7.6	-	11.4	13.36	3.8	13.89
Seed treatments						
C	93.53	37.68	13.98	19.73	85.33	17.03
S_1	94.01	42.27	13.68	19.89	85.58	17.26
S_2	94.35	42.75	13.28	20.13	85.52	17.42
F test	*	*	*	NS	*	*
LSD	4.28	2.68	1.26	NS	3.14	1.25
Interaction effects						
W C	93.40	35.72	13.81	19.61	84.14	16.76
W S_1	93.90	40.79	13.08	19.75	85.22	17.11
W S_2	94.28	41.44	12.12	19.90	85.83	17.29
A C	93.67	39.63	14.15	19.85	86.53	17.31
A S_1	94.11	43.76	14.27	20.04	85.94	17.42
A S_2	94.41	44.06	14.43	20.36	85.22	17.56
F test	*	NS	NS	*	NS	*
LSD	3.91	-	-	1.196	-	1.14

*** Significant at 5%**

Crop characteristics

Root length and diameter

Data on root study are summarized in Table1. As the effect of, different sources of irrigation water showed significant impact on root diameter but no significant on root length. Significantly higher root dimeter of 14.28 cm was recorded when irrigation with A treatment. Minimum root dimeter of 13 cm was recorded when irrigation with W treatments.

Regarding seed treatment techniques, the results showed that significant impact on root length and diameter. The highest root length of 42.75 was observed at S_2 and highest diameter 13.98 cm among the seed treatment techniques C treatments. Similar effects of increasing root length in seeds soaked for 48 h were also observed in sorghum crop under aerated conditions (Tiryaki and Buyukcingil, 2009).

The interactions between the two studied factors declared that no significant effect was obtained.

Yield quality

The yield quality included sucrose, juice purity and extractable white sugar. concerning the effect sources of irrigation water showed significant impact on yield quality. It is obvious from the data presented in Table 1 that source of irrigation water A resulted in higher value of sucrose, juice purity and extractable white sugar percentage, whereas minimum value was recorded by W treatment.

Concerning seed treatments, the data showed significant impact on juice purity and extractable white sugar percentage, while no significant on sucrose percentage. The highest value of sucrose percentage was 20.13% under S_2 treatment, while the lowest value was 19.73% under C treatment.

The interactions between types of irrigation water and seed treatments were significant on sucrose and extractable white sugar percentage, while not significant in Juice purity percentage.

Yield production

One of the main objectives of this study is to examine the changes in the root yield production using different seed treatments technique and different sources of irrigation as important water saving options.

Data pertaining to yield are presented in Table 2. Regarding types irrigation water, data revealed that there was not significant between A and W treatments. The results of this table revealed that root and sugar yield (20.84 and 3.63 ton/fed) was better at A treatment than another treatment tested. These results are in agreement with those obtained by Abdelraouf *and* Hoballah, 2014.

It was apparent that seed treatments techniques was influenced significantly. The lowest root and sugar yield was noticed with O seed treatments. The maximum root yield among seed treatment techniques was recorded with S_2 treatment (20.18 ton/fed) followed significantly by soaking seeds 24 h (19.91 ton/fed) followed by control treatment (19.76 ton/fed). The same trend was followed in case of sugar yield also. Similar finding is reported by many researchers namely Yari *et al.* 2011 and Ikuomola *et al.* 2013.

It was apparent that sources of irrigation and seed treatments techniques effected significantly on root and sugar yield. The maximum root and sugar yield were recorded with A × S_2 treatments and the minimum with W × C treatment.

Table 2. Yield and water use efficiency under different treatments.

Treatments	Root yield ton/fed	Sugar yield ton/fed	WUEroot Kg/m^3	WUEsugar Kg/m^3
Irrigation Water				
W	19.07	3.26	7.54	1.29
A	20.84	3.63	8.24	1.44
F test	NS	NS	NS	*
LSD	-	-	-	1.94
Seed treatments				
C	19.76	3.35	7.45	1.26
S_1	19.91	3.44	7.76	1.34
S_2	20.18	3.56	8.45	1.49
F test	*	*	*	*
LSD	4.37	0.73	1.9	0.376
Interaction effects				
W C	18.91	3.16	7.13	1.19
W S_1	18.99	3.26	7.40	1.27
W S_2	19.30	3.36	8.08	1.41
A C	20.60	3.53	7.76	1.33
A S_1	20.84	3.61	8.12	1.41
A S_2	21.07	3.75	8.82	1.57
F test	*	*	*	*
LSD	3.99	0.66	1.75	0.343

Water use efficiency

Water use efficiency of root and sugar as affected significantly by different treatments presented in Table (2). The average values of both root and sugar water use efficiencies were 7.54 and 1.29 kg/m^3, respectively under W treatments, while 8.24 and 1.44 kg/m^3, respectively under A treatment. As the effect of seed treatments techniques, there were significant effect on water use efficiency.

The interactions between types of irrigation water and seed treatments were significant in water use efficiency of root and sugar.

Economic analysis

The presented data in Table (3) showed the economic analysis under different treatments. It could be noticed that using agri-aquaculture caused reduce the cost of production while increase the net return and net profit under all treatments. This may be because agri-aquaculture is rich in organic matter and nitrogen fertilizers, which reduces the use of fertilizers. Similar result was reported by Ray *et al.,* 2010, Elnwishy *et al.,* 2006 and Ebong and Ebong, 2006.

It could be concluded that the highest net return and the maximum values of water productivity were 8427 LE/fed and 3.53 LE/m^3 with used agri-aquaculture and soaking seed 72 h, while the lowest values were 6144 LE/fed and 2.32 LE/m^3 with well water and without treated seed. That is may be due to reduce the fertilizer cost and reduce the sugar beet growing season to save water. These results are in agreement with those obtained by Abdelraouf and Hoballah, 2014.

Table 3. Economic analysis under different treatments.

Source of irrigation water	Seed treatments	Total cost (LE/fed)	Total return (LE/fed)	Net return (LE/fed)	WP (LE/m^3)
	C	3410	9554	6144	2.32
Well	S1	3395	9661	6266	2.44
	S2	3366	9889	6523	2.73
	C	2660	10532	7872	2.97
Agri-aquaculture	S1	2645	10751	8106	3.16
	S2	2616	11043	8427	3.53

CONCLUSION

The present study indicated that the germination rate and yield parameters and net-return of sugar beet plants was highly enhanced by using agri-aquaculture than ground water resource. Soaking seed 72 h not only increased germination rate and yield of sugar beet but also enhanced sugar and root use efficiency and total return. Agri-aquaculture rich with N fertilizers. It could be reduced pollution in soil during the plant growing season, promoted higher fertilizer use effectiveness and improved plant productivity.

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تاثير استخدام مياه الاستزراع السمكى وتكنولوجيا معاملة البذور على محصول بنجر السكر

محمد عنتر محمد مرسى

معهد بحوث ادارة المياه – المركز القومى لبحوث المياه

تعتبر الادارة الجيدة لمصادر المياه في الزراعه لكى حقق اكبر استفادة ممكنة من المياه المتاحة للاستخدام. ويوجد حلول كثيره من شأنها مساعدة المستهلكين على زيادة كفاءة الطاقة وترشيد استخدام المياه وزيادة كفاءة عملية الري وزيادة الدخل المزرعى. ونظراً لما تعانى مصر من ندرة في مورد المياه ومع التوسع في إنشاء المزارع السمكية للحصول على البروتين الحيواني اللازم والتى تعتمد فى الأساس على المياه مما يعد إهداراً لمورد المياه إذا لم يتم استخدامها في زراعة المحاصيل الزراعية للاستفادة بها مرة أخرى بالإضافة إلى الاستفادة مما بها من مخلفات الأسماك كسماد حيوي لمواجهة ارتفاع أسعار الأسمدة الكيماوية وبالتالى زيادة تكاليف إنتاج المحاصيل وانخفاض العائد الزراعى. أجريت هذه الدراسه بمزرعة معهد بحوث ادارة المياه بوادى النطرون – محافظة البحيرة واستهدفت تاثير استخدا نوعين من مصادر المياه (الاستزراع السمكى – مياه جوفيه) مع بعض المعاملات على البذور على كلا من الإنتاجية وكمية مياه الرى المضافه وأيضا على العائد الاقتصادى بنجر السكر. ومن أهم النتائج التى توصلت اليها الدراسة: 1- كمية مياه الرى المضافة تحت معاملات بدون نقع ، نقع البذور 24 ساعة ونقع البذور 72 ساعه كانت 2653 ، 2565 ، 2489 م^3/فدان على التوالى.2- نقع البذور ادى الى ترشيد المياه بالمقارنة بدون نقع بحوالى 88 ، 264م^3/فدان لكلا من 24 ، 72 ساعة على التوالى. 3- كانت قيم كفاءة استخدام المياه لكلا من محصولى الجذور و السكر 7.54 ، 1.29 كجم/م^3 تحت المياه الجوفيه بينما كانت 8.24 ، 1.44 كجم/م^3 تحت مياه الاستزراع السمكى.4- اتضح ان اعلى قيمة لمحصول الجذور 20.18 طن/فدان تحت استخدام النقع لمدة 72 ساعه يليها النقع لمدة 24 ساعة بانتاجية 19.19 طن/فدان.5- اعلى قيم لصافى العائد والعائد من وحدة المياه 8427 جنيه/فدان و 3.53 جنيه/م^3 تحت استخدام مياه الاستزراع السمكى مع النقع لمدة 72 ساعه. عموما : توصي الدراسة باستخدام مياه الاستزراع السمكى فى الرى مع نقع البذور لمدة 72 ساعة للحصول على اعلى عائد وصافى عائد واعلى عائد من وحدة المياه بالاضافة الى تقليل التكاليف.