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EVALUATION AND DEVELOPMENT OF DRAINAGE MANAGEMI SOUTH QANTARA SHARQ AREA-EGYPT

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ABSTRACT: Subsurface drainage methods were applied for disposing excess soil wat drainage methods, open and four covered drainage methods. Covered methods based on decreasing vertical soil water movement to above. The construction feature as it was appl study area for open drainage method, (OD) treatment, the four covered drainage method follows: the first, perforated plastic hose enveloped with gravels and polyethylene textile (second, perforated plastic hose enveloped with geo textile (CD_f), the third, perforated pl enveloped with gravels (CD_g) and the forth, only perforated plastic hose (CDs). The theory o drainage method depends on decreasing vertical movement of wastewater to abov Performance evaluation of the subsurface drainage was carried out in terms of two agricultur and comparing with the applied drainage method in the region. Chemical and Physical pro soil, irrigation and drainage water were measured during the agricultural seasons of 201 private farm in south Qantara Sharq area at North Sinai Governorate-Egypt. The meth evaluated taking into consideration crop-productivity, adding value costs of production unit, c of ground water level, and soil salinity. The results showed that the increment of crops p percentage were (7-9%, 13-15%, 16-19%, 23-26% and 20-22%) for winter and summer crop CDgt, CDf, CDg and CDs comparing with the applied drainage system in the study area, res Adding value costs of production unit were 28.8, 329.2, 91.3, 229.8 and 73.3 LE/ fad., whi water levels were 0.78, 1.18, 1.19, 1.24 and 1.21m under the same drained methods, respecti best results were achieved with the use of the drainage method CDg.

Key words: Subsurface drainage, construction, chemical and physical properties.

INTRODUTION

Drainage is considered one of the most important agriculture practice on both old and some new reclaimed desert area in Egypt. Sallam and Ismail (2012) decided that drainage impacts on the environment have given rise to a lot of concern, so in the future the design and operation of subsurface drainage systems should satisfy both agricultural and environmental objectives. Moreover, due to the high importance of subsurface drainage projects and its large scale in the national water strategy, it is valuable to perform an Environmental Impact Assessment (EIA) for these projects. *al.* (2016) developed a visual metho drainage system design, called visual assessment (VDA) design, which is information gathered from a soi assessment in combination with ba information on site and outfall conditi could be developed to approxin permeability of various soil horizons u conditions. Such information could the as a basis for site-specific drainag design that is accessible to all stakeho does not require laboratory or field mea of soil physical or hydrological p thereby preserving such expertise and e

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its usefulness to a wide number of practitioners. Moukhtar *et al.* (2012) considered that ~~Mole~~ mole drainage, on the specific soil type and done properly can help reduce waterlogging and salinity problems. They aimed to know some knowledge on effectiveness mole drains. Different experiments were done about mole drainage in Egyptian silty clay soil. The field trials area characterized as salt-affected clay soils with a permanent highly saline shallow groundwater table. Koch *et al.* (2012) estimated the proportions of tile flow on total stream flow at sub basin scale, to analyze the effect of the exclusion of tile drainage both on model performance.

The objectives of this work were to ~~:~~

~~1. I~~identify some characteristics of soil affecting the installation of drainage system under the study area conditions, ~~.~~

~~2. I~~installation of an appropriate subsurface drainage system according to the equations of design procedure and ~~.~~

~~3.~~ a~~A~~pplying engineering development for covered drainage technique using different filter types differs in the engineering dimensions around the tiles on the study area and evaluation the results.

MATERIALS AND METHODS

Materials

Studying area

About two ~~ha~~ hectares (ha), were used in the study period along two agricultural seasons from 2015 to 2017 in private farm at South Qantara Sharq area, North ~~of~~ Sinai, Egypt. The site of the experiment was located at latitude, (30^o: 54': 47.15" N) and longitude, (32^o: 23': 47.52" E), and the following contouring map in Fig. 1 illustrated the surface topographic of experimental site.

Laboratory, field devices and field equipment

Chemical and physical ~~analysis~~ analyses devices, leveling surveying devices, piezometer tubes, sounder devices, observation wells, double ring device and GPS were using before and during experiment.

Instruments

- Chemical analysis laboratory devices EC meters cations and anions analyses
- Physical laboratory soil mechanical devices such as, dry and wet sieves.
- Auger tools for taking soil samples.
- Soil hydraulic conductivity under condition (pumped borehole method).
- Observation wells and fitting.
- Rainfall gauge.
- Flow meters and fittings.

Description of treatment~~s~~ compon

Traditional open drainage and fou experimental drainage methods with its were described as the following:

Open drainage system was applied area, main or first degree drain and (collector or second degree) were imp and designed by Egyptian Public Autl Drainage Project (EPADP), but the des third degree or tiles drains were left to the farm owners and through the themselves or by un technical worke owners may be establish~~ed~~ tiles or (open or covered) that were installed owners were created randomly and geometric or scientific basis. In the e site, main and sub main drainages wer and randomize traditional open drain~~s~~ control treatment (OD).

A local perforated polyethylene h locally manufactured for draina installation to serve as open third degre was manufactured from poly-ethylene on coils shape with 100 meters' lengt diameter, perforated to holes with 2 dimensions, the holes surrounded the intervals distances, about 40 × 20 mr and longitude then total numbers of meter length were approx. 300.

Covered drainage treatments we from the described hoses type above, adding different types of filters.

First covered drainage treatment hoses type enveloped with filter c from two layers, the first layer was gra 39 cm diameter. The type of gravel w from seven degree sieves with holes 5mm diameter -that corresponded with Karpo

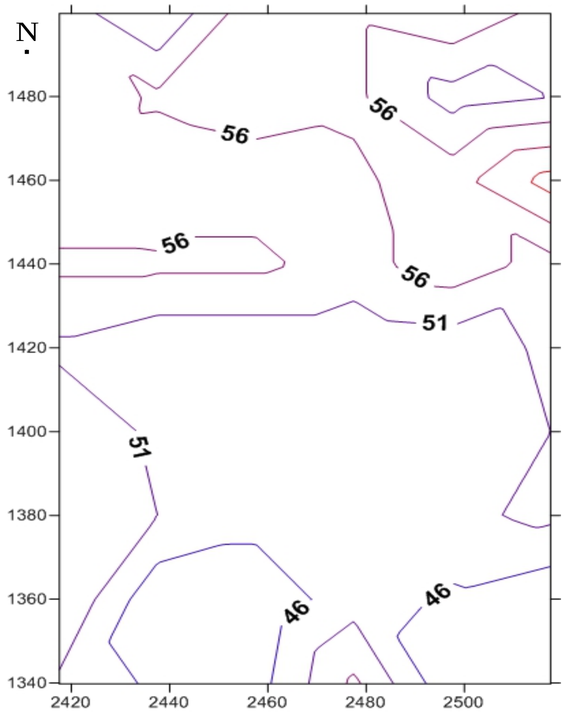


Fig. 1. Contouring map for study area

testes, this layer surrounded the hose directly the second layer was greenhouses shading textile ~~that~~ which enveloped the gravels and hose together, this filter was done and installed in the experimental site. This treatment denoted as (CD_{gt}), where: CD referred to covered drainage treatment and gt was filter type (gravel~~s~~ + textile), after installation the treatment in trench, it was filled with sand soil from the same soil site type.

Second covered drainage treatment was from the same hose type enveloped with filter that made from geo-textile fiber material, this material was manufactured from wastes of spinning and textile factories, the filter enveloped with the hose by industrial process at hoses factories and become ready to installed. This treatment was denoted as CD_f where: CD_f referred to covered drainage treatment with fiber filter, also the treatments' trench was filled with sand soil from the same soils' site t installation.

Third covered drainage treatment the same hose type but filter was m layer of the same type of gravel abo 39cm diameter surrounded the hose acc Karpoff (1955) testes also, this layer su the hose directly, this treatment was fo done in the experimental site and deno CD_g treatment it was covered drain gravel filter only. All the treatment's tr were filled with sand soil from the sa site type after installation.

Fourth covered drainage treatment the same hose type with no filter and t was fill with sand media, which was type of soil type that resulted from Tile process. This treatment was denoted (C

Excavator with 60 kW, Loader and Tractor with 90kW.

Five flow meters, one as 6 in. diameter for determining amounts of irrigation-water and four were 1 in. diameter for determining the drainage water amounts that resulted from treatments.

Seeds of winter crops (Egyptian clover "berseem" and wheat), and seeds of summer crops (corn and sorghum forage) were cultivated.

The source of irrigation water was El Salam Canal which transports mixed water (fresh water from Nile River water at Damietta branch and agriculture drainage water) with mixing ratio1:1.

The main applied irrigation system in the study area was permanent sprinkler and the area divided by second degree of collector drainages (open drainage).

Methods

Drainage water salinity, level of water table, physical and chemical properties of soil and productivity of different crops were carved out, also the management of agricultural drainage were developed during the agricultural seasons of 2015-2016 and 2016-2017. Schematic diagram in Fig. 2 illustrate the design of experimental treatments.

Estimating soil hydraulic conduct above water table under un condition

Inverted auger-hole method was estimate soil conductivity for experim site; from soil surface to 50cm depth 50cm depth to water table surface, its approximately 50cm for two depths acc Sakla (2003),). K under unsaturated was calculated as following relationshi shape in Fig. 3 which illustrate the para the method.:

$$K=\frac{1.15r\left[\log_{10}\left(h_1+\frac{r}{2}\right)-\log_{10}\left(h_2+\frac{r}{2}\right)\right]}{(t_2-t_1)}$$

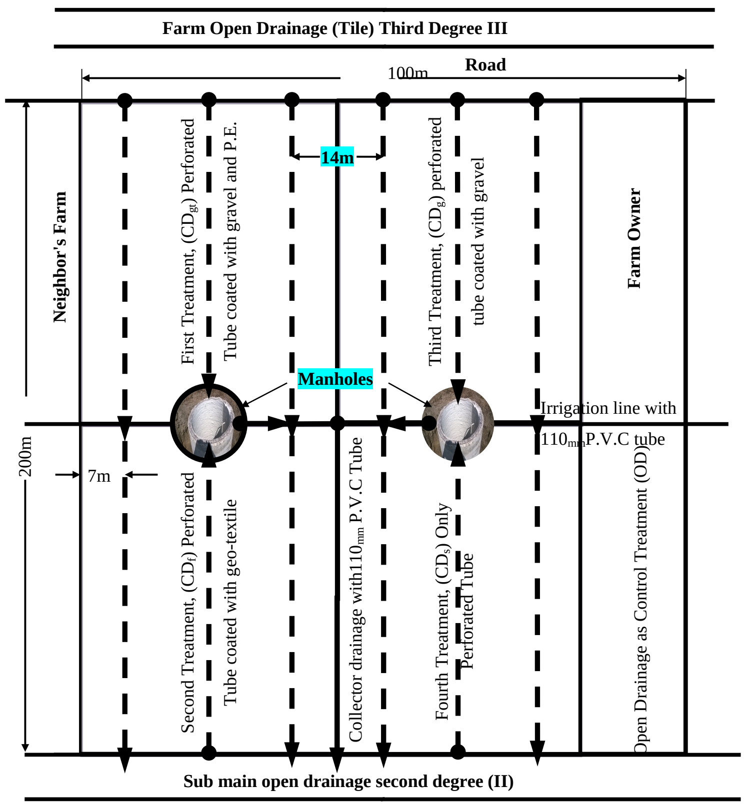
(or) K=1.15 r tanα

$$\frac{\left[\log_{10}\left(h_1+\frac{r}{2}\right)-\log_{10}\left(h_2+\frac{r}{2}\right)\right]}{(t_2-t_1)}$$

Where:

K-soil conductivity above water table (u case) – m/day.

r – radius of hole – cm.



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h_1– water high inside the hole at moment stop pumping - cm.

h_2 – water high inside the hole at the moment before next pumping - cm.

t_1 – time at the moment when water level high inside hole reached h_1 – min.

t_2 – time at the moment when water level high inside hole reached h_2 – min.

tan α (or)

Inclination the straight line that resulted from the relation between $\log_{10}$ (h + r/2) and time.

Identifying soil hydraulic conductivity under saturated conditions, zone which planned to establishing subsurface drainage-(K)

Pumped borehole method test was used to identify the parameter (K) which is the most important parameter of the drainage design equations hydraulic conductivity or coefficient of permeability was calculated by relationship of Zangar (1953).

$$K=\frac{Q}{C.L.r}\ ,\ L=\left(\frac{H^2-h^2}{H}\right)$$

Where:

K – hydraulic conductivity– m/day.

r – radius of the hole – cm.

Q– constant flow of pump (cubic cm/m

H, h-dimensions by meter as shown above and 4.

C– coefficient depend on the dimensic hole and identified form the followi (Fig. 5).

S – coefficient depend on the dimensic hole and determined from the shown Fig. 6.

Estimation the fluctuating of wate

Observation wells were established the water table frequencies before, du after field experiment. Also, to know of ground or soil water under e: treatments.

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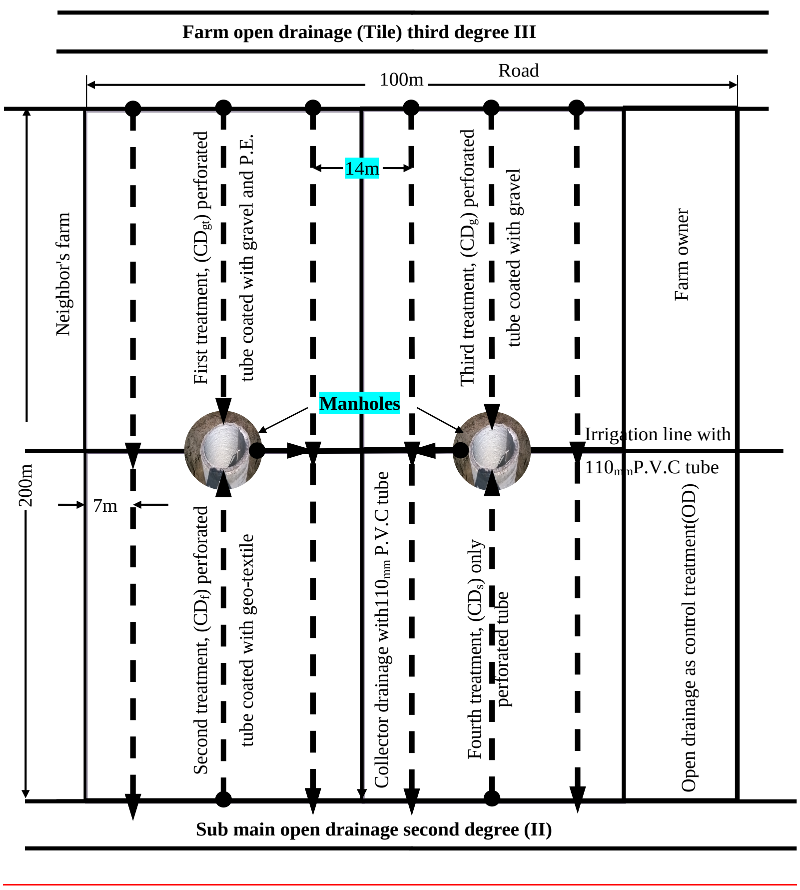

Fig. 2. Schematic diagram of study treatments (Scale 1:500)

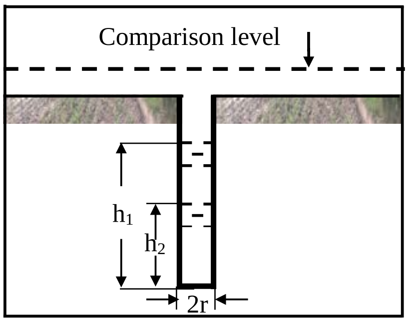

Fig. 3. Estimating soil hydraulic conductivity above water table

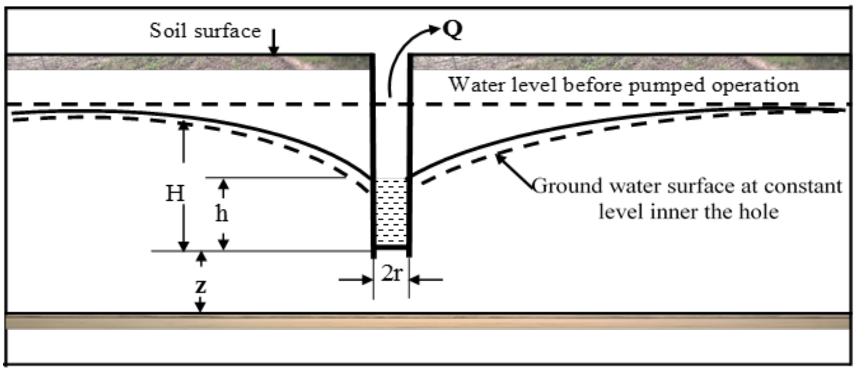

Fig. 4. Schematic diagram illustrate the pumped borehole method for measured conductivity (K) under saturated conditions

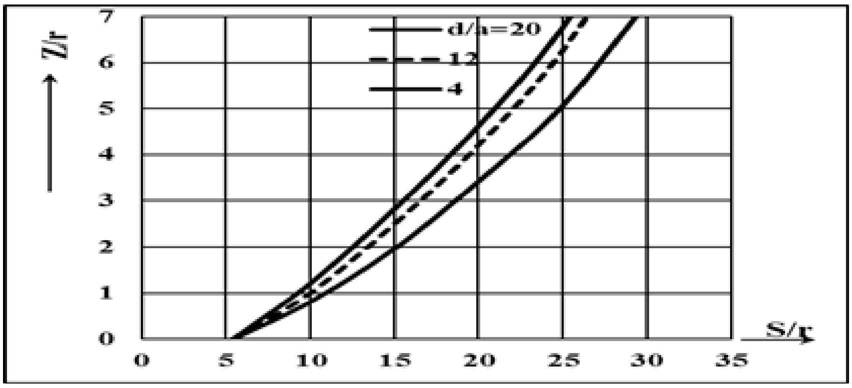

Fig. 5. value of function S.

Fig. 6. Value of coefficient C.

Irrigation and drainage water electrical conductivity (EC)

EC was measured before, after installation and during the successive seasons from both drainage treatments and irrigation water source.

Estimating irrigation and drainage water

Five flow meters were used, one for estimated added water and the other for estimated amounts of drainage water. Also precipitation water was determined.

Water balance in root zone

After estimating the amounts of added irrigation water, the water balance in root zone equation was applied as follows, according to Sakla (2003)

$$I + P + G = E + L$$

Where:

I – the amount of irrigated water that permeate the soil pores.

P –precipitation water that permeated soil pores.

G – amount of water that raised with capillary property to root zone.

E – water consumed by (evapotranspiration).

L– amount of gravity water that percolated under root zone or deep percolation.

Then drainage rate or drainage duty was determined by the following position equation:

$$D_f = \frac{(P + S).I}{2400F}$$

Where:

D_f - drainage rate by mm/hr.

P– percentage of losses water by deep p faraway root zone as percentage from water.

S- filtered water from irrigation ne percentage from irrigation water.

I – amount of irrigation water –mm.

F – period between irrigations.

Also the distances between ti identified according to the (Hooghoudt) equation by (EPADP),

$$L^2 = \frac{8K \cdot d_e \cdot h}{q}$$

Where:

L - latitude spacing between tiles, m.

d_e–equivalent depth of hard pan under drai

h– level (height) of water table at the distance between two tiles from the w inside the tile, m.

q–equivalent depth of water to be dis drainage with fixed rate, (m/day).

Characteristics of Crops

Consumptive use of water-U

The amounts applied during each event were appropriate to the crop' stage_ ~~plants~~ according to the metho described by Allen *et al.* (1998).

Germination, growth vegetative st crops yield

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Germination percentage, growth vegetative and crop yield were estimated for all type of crops within all treatments by the following relation:

Germination (%) =

$$\frac{\text{Number of plant per area unit}}{\text{Number of planting seeds per area unit}} \times 100$$

Vegetative g

~~G~~rowth ~~vegetative~~ was estimated by comparing the weight of biomass for all crops within all treatments compared with control treatment, the same thing for crop yield.

Performance evaluation of drainage treatments

- Amount of drainage water of each were measured by flow meters and with drainage duty for each treatment
- Ground water depth was meas observation wells on three locations treatment, (at beginning-middle-end).
- According to the efficiency of drainage water for each treatment was recorded along the experimen follow the changes of (EC).
- Within estimating the amount of water for each treatment, the Effi removed stored water (ERSW) out of zone was estimated according to the relation.

Table 1. Fixed cost (Fc), for experiment area

No.	Item	Unit	Amount	Unit cost	Total cost (LE)
1	Total rent of Excavator's hour for digging	Hour	27.5	80 LE/h.	2200
2	Total rent of Loader's hour for embankment,	Hour	10	120 LE/h.	1200
3	Total rent of Tractor's hour for Leveling,	Hour	10	60 LE/h.	600
4	Total laborer's hours	Hour	135	12 LE/h.	1620
5	Total lengths meters of perforated plastic hoses,	Meter	900	4.5 LE/m	4050
6	Total meters of perforated plastic hose enveloped with geotextile filter,	Meter	300	6.25 LE/m	1875
7	Total amount of gravel's filter,	Cubic meter	78	120 LE/m^3	9360
8	Total square meters polyethylene textile	Square meter	625	4 LE/m^2	2500
9	Total lengths of Manhole with 1m internal diameters	Meter	6	310 LE/m	1860
10	Total length of Poly Venial Chloride (PVC) collector's pipe with 110mm diameter	Meter	168	15.6 LE/m	2620.8
11	Flow meters with 6 inches for measured irrigation water	Number	1	3000 LE/unit	3000
12	Flow meters for measured drained water	Number	4	625 LE/unit	2500
Total Fixed cost, LE (Fc), (for experimental area 2ha)				33385.8	

$$\text{ERSW} = \frac{\text{acual removed water}}{\text{water drainage duty}} \times 100$$

According to the efficiency of removing drainage water, problems and its reasons were identified for each treatment.

Cost Analysis

Experimental treatments costs, whic fixed costs (construction, martials and In and variable costs (repair, maintenance a The methodology of estimating draina costs was estimated by end of 2015 y inflation rate percent 10.4 According to Price Indices (General Agency fo Mobilization and Statistics-Egypt, 2015

$$\frac{\text{Power. requirement (kW)}}{\text{Installation (m/hr.)}}$$

Variable costs (Vc)

Repair and maintenance costs as laborer annual day and some maintenance fitting materials = 100 LE.

Total costs (Tc)

Total costs (Tc) = total fixed costs + total variable costs. (Ritzema *et al.*, 2008)

Energy requirements

Estimation of total energy required for each treatment in installation was achieved using the following equation:

Requirement (kW.hr./m)=

Average soil conductivity along soil profile at three depths

The following shape in Fig. 7 showed the low of soil conductivity of the third layer because of the low of soil permeability, which resulted from small soil porosity and the type of soil which was loam soil.

Chemical analysis of soil at each treatment

Routine chemical analysis of soil solution was conducted for each treatment, because the change of chemical analysis was considered another indicator of removing excess water like the drainage water salinity. The following shapes in Figs. 8 and 9 illustrate the differences between treatments for decreasing salt in soil profile.

Fig. 88 showed increments of soil salinity along soil profile (before experiment starting) for all treatment, the range was 2-12 ds/m, that's because of accumalated soil water and its salt content, also there is no way for disposing of this water. Fig. 9 showed the decrements of soil salinty (after experiment starting) along soil profile, the range was 1.5-8 ds/m, because of the efficiency of the drainage treatments in removing exceed water.

Comment [HH1]: Put the percentages

Comment [HH2]: Put the percentages

Efficiency of treatments for soil water removal

From the results above, each treatment was exposed the same conditions, all agricultural practices were the same on all treatm the following dissection, in Fig. 10 illu efficiency of each treatment. All treatm exposed to the same amount of gravi but Fig. 10, illustrate the differences treatments of removing drainage water.

RESULTS AND DISCUSSION

The obtained results will be discus the following items:

Measurement of Experimental So

Mechanical analysis of soil sites

Mechanical ~~analysis~~ analys experimental soil site samples were for seventeen sites with three depths profile, from zero -0.25 m, 0.25-1 m m, respectively. The mechanical specif soil profile for samples, the texture was from zero level to 0.25 m depth, from was sand and from 1-1.5m was loam.

Fig. 10 showed the differences of e between treatments of removing draina for open drainage treatment (OD), on from its drainage duty was remove because of the differences of top irregularity slopes and depths of imp layer, also open drainage wasn't hav and specified track for soil water move covered drainage, the results show efficiency of removing water that exc 100% percentage from drainage duty treatments, this excess removal w resulted in the treatments quantities water in drainage zoon added wit water. Furthermore, the filters create soil water movement directly under im layer.

Estimation the fluctuating of wate

The results from observation wel and after established covered drainage also during period between before directly irrigation were as the followin The observation wells readings were the center of each treatment, Fig. 11 differences drop of soil water, that resu the efficiency of treatments for removing water amounts, that recorded by drainage flow meter.

Effect of Drainage Treatment Types on Some Crop Indicators

Winter and summer cultivated crops affected by different drainage treatments were illustrate by the following results:

Fig. 12 illustrated some crop indictors, germination percentage, vegetative growth and crop yield, the increment percentages for the three crop indicators were (7-9%, 13-15%, 16-19%, 23-26% and 20-22%) for winter and summer crops for OD, CD_{gt}, CD_f, CD_g and CD_s comparing with the applied drainage system in the study area, the increments of crop indicators resulted from the improvement of soil properties, that accord by the effect of drainage treatments which created suitable conditions for productions, such as preventing wate soil salinity and good aeration in root z

Crop costs evaluation

Costs analyses illustrate that, total fi of drainage network as an experime and the applicability in farms, were treatment 865, 9875, 2740, 6895, and for traditional open drainage (contr second, third and fourth covered draina (CD_{gt}), (CD_f), (CD_g) and (CD_s), res Where variable costs were 562, 20, 2 20LE per year. Also total costs for o meter were 2.9, 32.9, 9.1, 23, and 7. traditional open drainage (OD), first third and fourth covered drainage (CD (CD_g) and (CD_s), respectively as shown in

Soil depth

Fig. ~~7~~7. Values of exprimental soil conductivity at deffirent depths

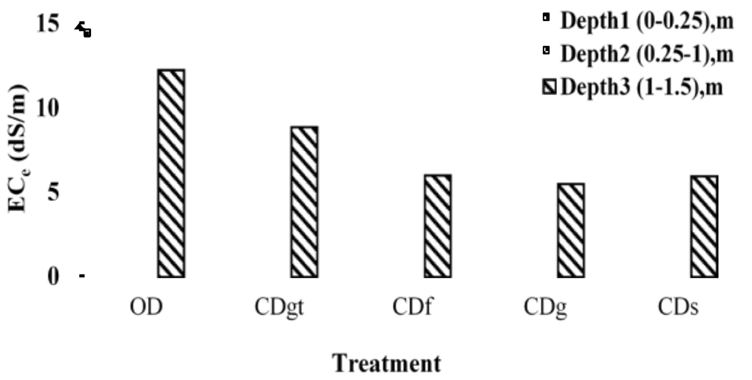

Fig. ~~8~~8. Soil salinity before experiment start

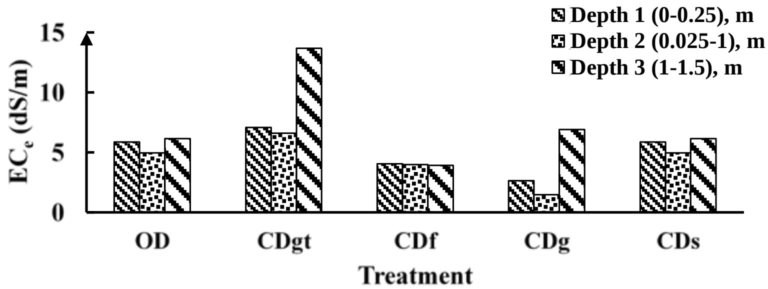

Fig. 9. Effect of experiment treatments on soil salinity before experiment end

Efficiency (%)

Fig. 10. Efficiency of removing drainage water by treatments

Fig. 11. Average monthly water levels on the center of each treatment

Germination percentage Vegetative growth Crop yield

Fig. 12. Impact of drainage treatments on some crop indicators measurements

Fig. 13. Total costs construction of drainage treatments

Assumed default age of drainage network fifteen years, then costs of each treatment per year were 57.67, 658.3, 182.67, 459.67 and 147.67 LE for traditional open drainage and the four covered drainage treatments, respectively.

Drainages costs were contributed v 329.2, 91.3, 229.8 and 73.8 LE per one summer crop, (one crop) for traditic drainage and the four covered drainage t respectively, shape in Fig. 14 illustr construction costs of drainage treatmen

Costs per productivity unit for open drainage (OD) was compared with covered drainage treatments, with fixed other production costs for all treatments and adding drainage costs for all treatment also, we found that the increment of drainage costs between traditional open drainage and covered drainage was offset by the increment of unit production. Although construction costs of covered drainage were more than open drainage but the costs of unit production were less, also there were variable costs of open drainage (repair and maintenance) will increase the total costs of unit production by long-term.

Effect of drainage methods on energy requirement

Energy consumption was distributed on the following practices, digging practices, embankment practices, gravel putting and leveling practices adding laborer. Total power consumption was 3763.75 kW for summation of total lengths also the following shape in illustrate the energy requirement treatment.

Conclusion

1- Increasing soil conductivity at drain depth was the best method of brea reducing the vertical movement of to above at root zone or soil surface.

2- Perforated covered drainage enveloped with gravels is recommen used for drainage excess water as it highest scale down of ground water.

3- Perforated covered drainage tile that with gravels give the best results 1.5‰, 14m distances between Tile a length.

4- Thickness of enveloped gravel average diameter, and hose diameter

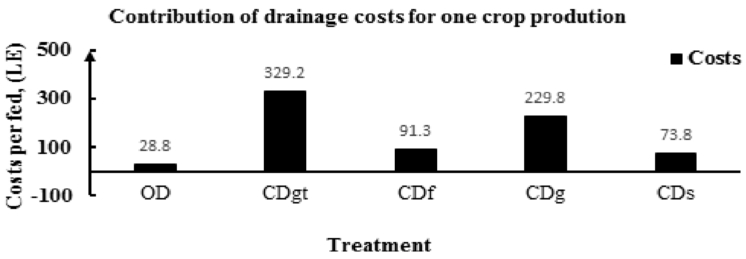

Fig. 14. Contribution of drainage costs for one crop production

Energy requirement (kW.hr/m)

Fig. 15. Effect of drainage method on energy requirement, kW.hr/m

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وتطـــويــــر إدارة الصــــــرف بمنطقـــــة جنــــوب القنطـــرة شــــــرق – مصــــــــــــر

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- قسم الهندسة الزراعية - كلية الزراعة - جامعة الزقازيق - مصر

ن طريقتين للصرف تحت السطحي (الباطني) للتخلص من الماء الأرضي الزائد: صرف مكشوف واربعة طرق
عتمدت طريقة الصرف المغطي علي خفض الحركة الرأسية للماء الأرضي لأعلي، وكانت الخصائص الإنشائية
رف المكشوف (معاملة الـ OD) كما هو مطبق بمنطقة الدراسة، أما طرق الصرف المغطي فكانت كما يلي:
ولي (CD_{gt}) عبارة عن خراطيم بلاستيكية مثقبة من البولي إثيلين وغلفت بالحصي ثم بنسيج البولي إثيلين.
انية (CD_f) خراطيم بلاستيكية مثقبة من البولي إثيلين وغلفت باللباد (الفيبر)، المعاملة الثالثة(CD_g) خراطيم
ثقبة من البولي إثيلين وغلفت بالحصى، المعاملة الرابعة (CD_s)خراطيم بلاستيكية مثقبة فقط، اعتمدت نظرية
ف المغطي علي خفض الحركة الراسية لمياه الصرف للطبقات الأعلى، تم تنفيذ وتقييم أداء نظام الصرف تحت
لال عامين وتم مقارنة النتائج بنظام الصرف المطبق بالمنطقة، وتم قياس الخواص الفيزيائية والكيميائية للتربة
والصرف خلال مواسم زراعية ٢٠١٥-٢٠١٦ ، ٢٠١٦-٢٠١٧ بمزرعة خاصة بمنطقة جنوب القنطرة شرق
مال سيناء – جمهورية مصر العربية، تم تقييم طرق الصرف من حيث إنتاجية المحاصيل، قيمة التكلفة المضافة
تجة، منسوب الماء الأرضي، خفض ملوحة ماء التربة، أظهرت النتائج أن هناك زيادة في إنتاجية المحاصيل
صيفية بلغت ٧-٩%، ١٣-١٥% ، ١٦-١٩% ، ٢٣-٢٦% ، ٢٠-٢٢%، بالنسبة لمعاملة الصرف المكشوف
عاملات الصرف المغطي (CD_{gt}) (CD_f) (CD_g) (CD_s) على الترتيب وذلك مقارنة بطريقة الصرف
طقة الدراسة ، في حين كانت التكلفة المضافة لوحدة الإنتاج ٦٨.٥٤ ،٧٨٣.٥ ، ٢١٧.٣ ، ٥٧٦.٩ ، ١٧٤.٥
ا لنفس المعاملات علي الترتيب بينما بلغ منسوب الماء الأرضي ٠.٧٨ ، ١.١٨ ، ١.٢٤ ، ١.٢١ مترا لنفس
بقة أيضاً، وحققت معاملة الصرف المغطي (CD_g) أفضل النتائج

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