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STUDY ON SUB-SURFACE IRRIGATION IN NEW LANDS

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ABSTRACT: A field experiment was carried out at the Egyptian Tank Factory 200 during seasons (2001 – 2002 and 2003) in sandy soil. To find the optimal lateral pipes spacing under sub-surface irrigation with field crops (maize and beans) planting on the same network. The data obtained showed, no significant difference in emergence, plant height and root depth for maize and beans crop at increased plant spacing from 0 to 25 cm, but found very significant difference when the plant spacing increased more to 50 cm from lateral pipes sub-surface irrigation . The water use efficiency gave highest value at treatment C (lateral spacing 100 cm) for maize and beans crops. Higher yield were obtained for treatments A and C. The cost of (maize and beans) production was affected by different spacing between laterals and distance between plant lateral pipes, causing different costs of network, water applied and farming operations, as the treatments A and C were more profitable than at other treatments.

Key words : Sub-surface irrigation, new land, water application efficiency.

INTRODUCTION

Sub-surface irrigation offers the additional advantages of less evaporation and less interference as they are located below, Schwanki *et al.* (1990). The soil reduced system performance is caused by plugging of system components for multiple years reducing annual cost, Camp *et al.* (1997). Steel *et al.* (1996) mentioned that sub-surface drip irrigation systems offer advantages over other types of irrigation systems, specially for crop production, including water savings, improved trafficability, and a drier canopy.Camp *et al.* (1989) found that surface drip irrigation spaced 1.5 m a part caused uneven crop growth during early-season drought following germination and plant establishment for corn planted in rows 0.76 m a part. This wide spacing led to reduce plant height and biomass, and a 10% reduction in grain yield in one of three years, Lamm *et al.* (1992). The 2.5 ft spacing in south west Kansas produced the highest average yield of all treatments, but was less economical than the 5.0-ft spacing due to its high tubing investment cost.Lamm *et al.* (1995) determined the optimum dripline spacing (installed at a depth of 40-45 cm) for corn production. The Garden city study evaluated 4 spacings (0.76, 1.52, 2.29, and 3.05m) with corn planted The standard 1.52 m dripline spacing was best when averaged over all years for both sites.

Sammis (1980) indicated sub-surface irrigation appears to offer the best method of supplying uniform soil moisture in the root zone to the plant.

Concerning the remained stored water before the next irrigation, it is clear that the soil contained water in the desired range of readily available water in the top 60, 80 and 15cm for depth 20 – 30 cm and surface trickle irrigation respectively. On contrast the remained stored water under depth 40 cm decreased to near welting percentage in the top layer.Camp *et al.*(1997) noted that sub-surface drip irrigation systems do not provide uniform soil wetting on or near the soil surface, especially in coarse-textured soils during extended drought. Schwanki *et al.* (1990) said that sub-surface irrigation is frequently used to increase water use efficiency . Significant deep percolation during the germination period is not desirable. Phene *et al.* (1991) revealed that the sub-surface drip irrigation systems can contribute in maximizing water use efficiency including negligible soil evaporation, percolation, and runoff. Lamm *et al.* (1995) found that sub-surface drip irrigation system can make significant improvements in water use efficiency by better managing.

Al- Henggeler (1997) found that investment in SDI systems was profitable largely due to increased yield. Prior to adoption of SDI. The irrigator's average cotton yield was 150% of the county average. The irrigator's average cotton yield improved to 190% of the county average after SDI adoption. Darvell *et al.* (1998) noted that sub-surface micro-irrigation (SMI) tubing costs make up 33 to 60% of total purchase and installation costs of system, depending on tubing spacing. Purchase and installation costs of SMI systems can be lowered by $ 290 /acre by increasing tubing spacing from 3 to 9 ft. Yields may be reduced due to less uniform placement of water in the crop root zone. Mattar (2002) found that sub-surface irrigation offers advantages in water and energy conservation.

Sub surface irrigation technology may be made profitable for multiple crops by finding optimum installation methods and lateral spacing that may be suitable . He also found that lateral spacing 100 cm under depth 30 cm had more economic net return than other treatments for production of multiple crops.

The aim of the present study is to find the optimal laterals pipe placements under sub-surface irrigation suitable to multiple crops in sandy soil at Egyptian Tank Factory200 for years period (2001 to 2003) with field crops (maize and beans) planted on the same network.

MATERIALS AND METHODS

The objectives of this study is to find the optimal laterals pipe placements under sub-surface irrigation suitable for multiple crops.

Experiments were conducted in sandy soil at Egyptian Tank Factory 200 for years periods (four season) (2001, 2002, and 2002, 2003).

Components of the sub – surface irrigation network:

Main pipe: p. v. c of 160 mm diameter pipes was used to convey the water from the water source to the pump station

Control head: The control head is located at the source of the water supply, and it includes the pumping station (electrical pump) fertilizer and chemical injection equipment, filtering. Equipment (Screen filter), valves, water–measuring devices pressure regulator, pressure gauges flowmeter, automatic valve (operating according to the volume of discharge), air valve and non return valve.

Main lines: p. v. c pipes (63 mm in diameter) are used to convey the water from the main pipe to sub main line.

Sub main lines: p. v. c pipes (50 *mm* in diameter).

Laterals pipe (porous pipe):

14 mm with outer diameter porous pipe irrigation laterals are used. Source laterals which emit water by seepage through tiny pores along the wall pipe have microscopic openings, porous pipe is an extruded membrane made from recycled rubber tires and fresh polyethylene that is being promoted for use in micro irrigation also, widely known as leaky pipe

Leaching line (flushing line) 25 mm P . E . tube is used to convey the water, from network to exit and keep the pressure distribution thorough the net work.

Methods:

Treatments were as follows

A- Lateral spacing 75 cm .

B- Lateral spacing 100 cm E R

C- Lateral spacing 100 cm A F

D- Lateral spacing 125 cm .

E- Lateral spacing 150 cm E R

F- Lateral spacing150 cm AF. where :

E R= sub–surface lateral pipe under every row.

A F= sub–surface lateral pipe under alternate furrows.

All treatments were evaluated at 30 cm depth of sub–surface soil to planting maize and beans.

The objectives of this study were:

1. Study effect of plant distance from lateral on yield and yield components. The plant distances were (0 , 25 , 50 and 75cm) from l ateral pipe .
2. Study of effect the specing between laterals to select the optimum lateral placement and suitable for multiple crops.
3. Effect of lateral placement on irrigation efficiency and water requirements
4. Study of the economical analysis for maize and beans production under sub–surface irrigation treatments.

Measurements

Field water capacity

It is the amount of water available from soil for plant when water moves out of the microspores and replaced by air.

Moisture contents at field capacity for the different soils were determined by the method described by Peters (1965). The field capacity was 7.98% soil moisture content by weight .

Wilting point (W P)

The soil moisture content at this stage (W P) does not give enough water to plants. The moisture contents at the permanent wilting point for the different soil layers (0 – 30, 30 – 60, 60 –90 cm) were determined using a pressure membrane apparatus according to Statakman and Vander Hast (1962), and was found to be 4.2% in the average.

Water use efficiency

Water use efficiency (WUE) has been used to describe the relationship between seed yield and the total amount of water used. Water use efficiency is determined according to the following equation:

$$\text{Water use efficiency} = \frac{\text{Seed yield (kg / fed)}}{\text{Total applied water (m}^3\text{ / fed)}}$$

Water application efficiency

Water application efficiency was calculated according to following equation :

$$Ea = \frac{Dau}{Da} \times 100$$

Ea : Water application efficiency %

Dau: Water available in the root zone, determined 2h after irrigation according to measured root depth over the vegetation periode .

Da: The amount of total water applied to the field.

Measurments on Yield and Yield Components

Plant height

Plant height was measured from the ground to the end of stem. Measurements of plant height were taken 15 days to the end of season for maize and beans planting. Samples of each of ten plants were selected randomly from every treatment and measured by a tape. The average height was calaulated

Root depth

Root depth was measured from the soil surface to the end of primary root. These measurments were carried out on random samples of three plants in each treatment, every 15 days to the end of the season.

Number of branches per beans plant

The total number of branches per plant, as an average of ten plants, was chosen randomly from each treatment .

Number of pods per beans plant

The number of pods was recorded before harvesting a sample of ten plants chosen randomly from each treatment, and the average number of branches was calculated.

Yield

At harvesting of maize and beans, yield of seeds mass was determined in kg/fed. for each treatments.

RESULTS AND DISCUSSION

Study of the Optimum Planning of Lateral Pipes for Maize Planting

Effect of lateral pipes planting on maize growth parameter

Seed emergence ratio

Figure 1 indicated that increasing the lateral spacing and plant distance from lateral, the maize emergence ratio decreased. This trend was true in each of the three sampling data (9, 12 and 15 days after planting) in both growing seasons. Also it was found that the maximum average values of the maize emergence ratio were 96.31,95.87 and 94.66% with plant distances from lateral 0 and 25 cm at lateral spacing of pipes 75and 100 cm respectively.

Plant height

Figure 2 indicates no significant effect in plant height with plant distance from lateral 25 cm, but very significant effect in plant height with plant distance from lateral 50 and 75 cm. It was found that by increasing plant distance from lateral from 0, 25, 50 and 75 cm plant height decreased from 211.92, 201.71, 85.19 and 64.33 respectively.

Root depth

Figure 3 indicates no significant effect in root depth with plant distance from lateral 25 cm but very significant effect in plant root depth with plant distances from lateral 50 and 75 cm. It was found that by increasing plant distance from lateral from 0 and 25 cm, root depth increased from 180.12 and 182.92 cm respectively. It was found that by increasing plant distance from lateral from 25, 50 and 75 cm, root depth decreased from 182.92, 90.55 and 65.24 cm respectively.

Maize yield components

Figure 4 indicated that by increasing the plant distance from lateral, the yield components decrease. No significant difference in yield components was noticed with plant distances 0 and 25 cm from lateral, but increasing the plant distance from (0, 25) to 50 and 75 cm from lateral gave very significant difference in all yield components.

Maize yield

the obtained data form Table 1 show that there are significant diffenreces between treatments in maize yield. There are higher significant was recorded between

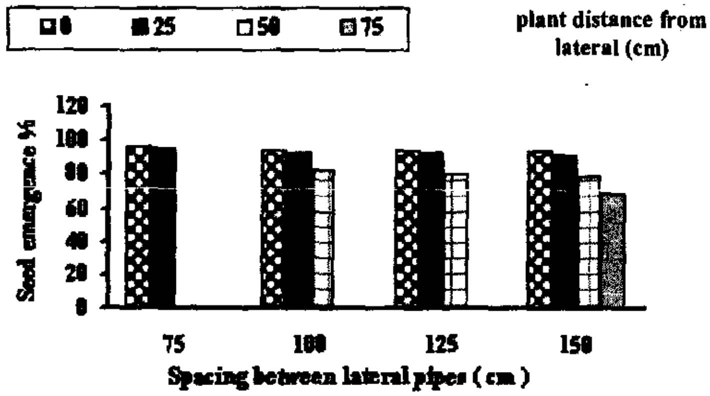

Fig. 1 : Effect lateral spacing and plant distance from lateral on maize mergence ratio aftar 15 days

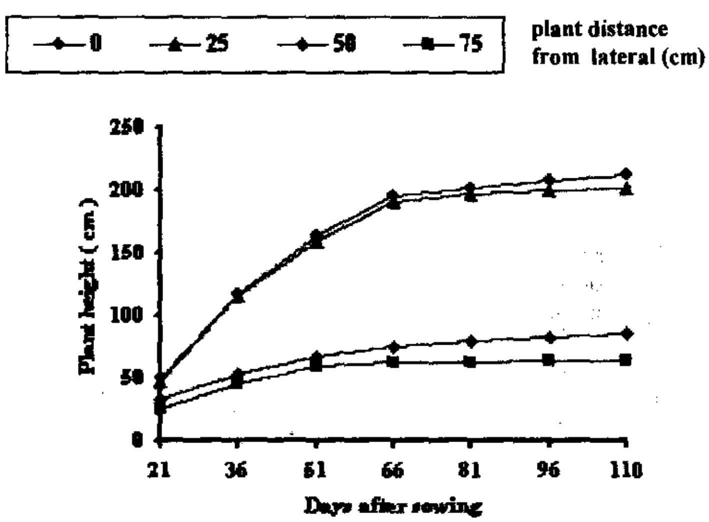

Fig. 2: Effect of plant distance from lateral on maize plant height

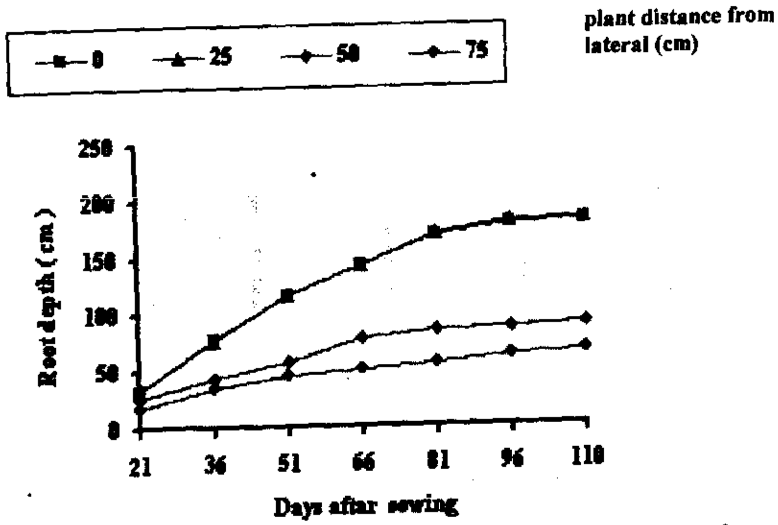

Fig. 3: Effect of plant distance from lateral on maize root dept

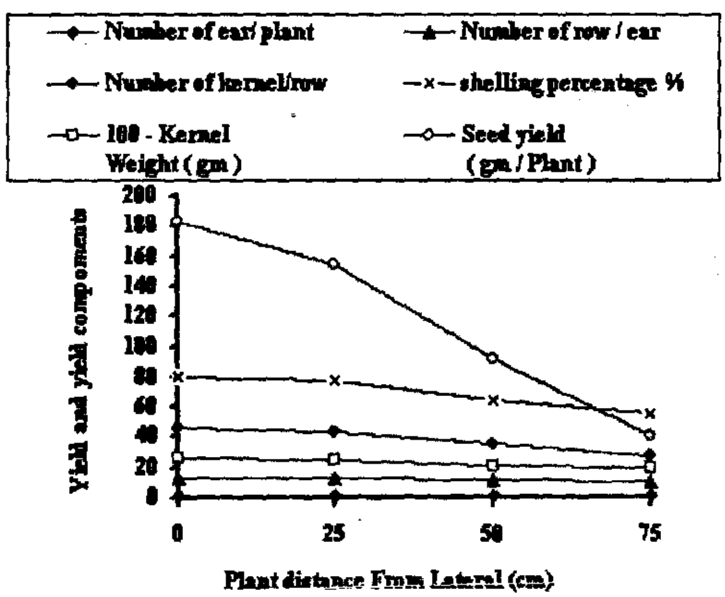

Fig. 4: Effect of plant distance from lateral on maize yield and yiled compoments

treatment A and C comparing to treaments E and F.

The maximum value of maize yield was found to be 5289.26 kg/fed at treatment A.Meanwhile, lower yields were found to be 3499.42, 3552.87 and 4065.14 kg/fed at trearments F, E and D respectively. This was due to the insufficient upward and horizontal movements of water to reach the root zone. Also, the available water and fertilizer were very limited to such plants.

Applied water

Table 2 for the water applied for all treatments before sowing (8 June) till havesting in (28 September) was calculated for months of June, July, August and September. The data indicated that:

The highest value of total applied water used was 2289.52 m^3/fed for treatment A, followed by 1653.7 and 1647.27 m^3 / fed for treatments B and C. Meanwhile, the lowest value of total applied water were 1361.22 and 1377.36 m^3/fed for treatments E and F.

Water use efficiency

The data shown in Table 3 indicated that the highest WUE value of 2.92 kg/m^3 under treatment C was due to the correspondening decrease in water applied, but the minimum value of WUE was 2.31 kg/m^3 at treatment A. The decreasing was due to the corresponddening increase in water applied.

Study of the Optimum Planning of Lateral Pipes for Beans Planting

Effect of lateral pipes planting on beans growth parameter

Seed emergence ratio

Figure 5 indicated increasing the lateral spacing and plant distance from lateral. The beans emergence ratio decreased. This trend was true in each of the three sampling data (9, 12 and 15 days after planting) in both growing seasons. Also, it was found that the maximum average values of the beans emergence ratio were 95.91, 94.35 and 94.15% with plant distances from lateral 0 and 25 cm at lateral spacings of pipes 75 and 100 cm respectively.

No significant difference was found in beans emergence ratio at increased plant distance from 0 to 25 cm . Very significant difference was found when the plant distance increased from 0 to 50 and 75 cm .

Plant height

Figure 6 shows the effect of plant distance from lateral on beans plant height. It is obvious that by increasing the plant distance from lateral, the beans plant height tends to decrease for all sampling dates (21, 36, 51, 66, 81, 96, 111, 126, 141 and 156) days after planting in both

Table 1: Effect of different treatments on yield of maize crop

Treatment	A	B	C	D	E	F
Seed yield (kg / fed)	5289.26	4191.57	4817.27	4065.14	3552.87	3499.42

Table 2: Total applied water during growing season of maize crop

Data	Applied water m^3 / fed					
	A	B	C	D	E	F
June	629.71	456.33	455.21	430.99	373.16	375.35
July	582.35	424.62	420.53	417.67	357.25	369.27
August	655.82	475.51	475.41	431.49	387.49	388.43
September	421.64	297.24	296.12	262.22	243.32	244.31
Total	2289.52	1653.7	1647.27	1492.37	1361.22	1377.36

Table 3: Water use efficiency for treatments under subsurface irrigation of maize planting

Treatment	A	B	C	D	E	F
Water use efficiency (kg / m^3)	2.31	2.53	2.92	2.72	2.61	2.54

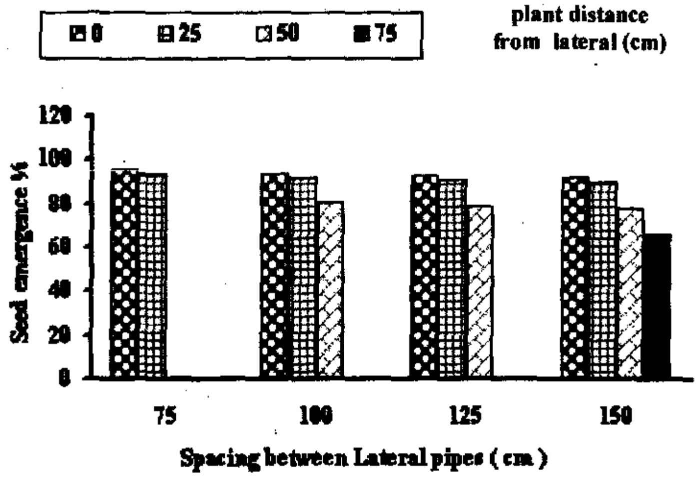

Fig. 5: Effect lateral spacing and plant distance from lateral on beans emergence ratio after 15 days

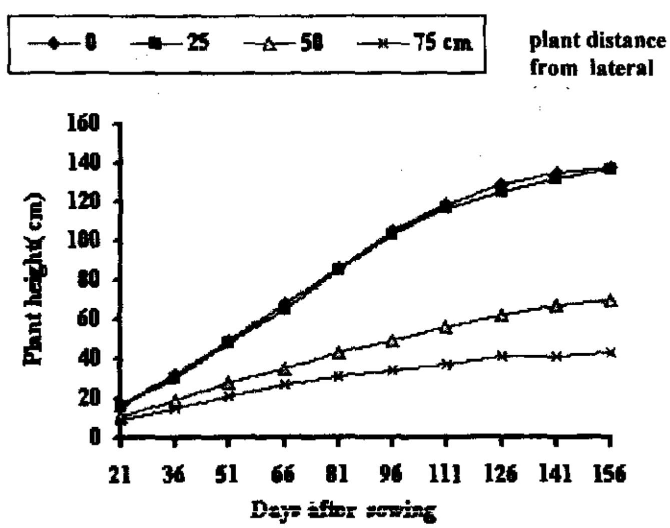

Fig. 6: Effect of plant distance from lateral on beans plant height

growing seasons. The results indicate no significant effect in plant height with plant distance from lateral 25 cm.

Root depth

Figure 7 shows the effect of plant distance from lateral on beans root depth .The results indicate no significant effect in root depth with plant distance from lateral 25 cm but very significant effect in plant root depth with plant distances from lateral 50 and 75 cm .

BeansYield components

Figure 8 shows that by increasing the plant distance from lateral, the yield components decrease. No significant difference in yield components was noticed with plant distances 0 and 25 cm from lateral, but increasing the plant distance from (0 , 25) to 50 and 75 cm from lateral gave very significant difference in all yield components.

Beans yield

Table 4 shows that the beans yield. Significantly increased for treatments A and C comparing to treatments B and E.

The maximum value of beans yield was found to be 3638.88 kg/fed at treatment A. Meanwhile, lower yields were found to be 1921.88, 2287.52, 2389.7 and 2513.46 kg/fed at trearments E, B, F and D respectively .

This was due to the insufficient upward and horizontal movements of water to reach the root zone. Also, the available water and fertilizer were very limited to such plants.

Applied water

Applied water during beans growing seasons is presented in Table 5 which indicated that in February, more water was applied for all treatments . The values of water applied were found to be 390.27 , 296.64 , 294.71 , 234.75 and 203.83 m^3/fed for treatments A , B , C , D , E and F respectively

The highest values of total applied water used were 2015.61 m^3/fed for treatment A ,followed by 1512.83 and 1501.65 m^3/fed for treatments B and C. Meanwhile the lowest value of total applied water was 1209.33, 1018.47 and 1016.72 m^3/fed for treatments E and F.

Water use efficiency

The data shown in Table 6 indicated that the highest WUE value 2.37 kg/m^3 under treatment C, due to the corresponding decrease in water applied, but the minimum value of WUE was 1.51 kg/m^3 at treatment B. The decreasing due tothe corresponding increase in water applied.

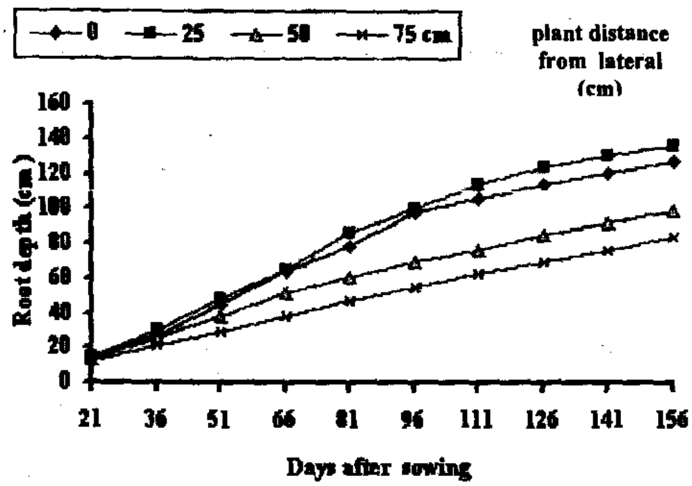

Fig. 7: Effect of plant distance from lateral on beans root depth

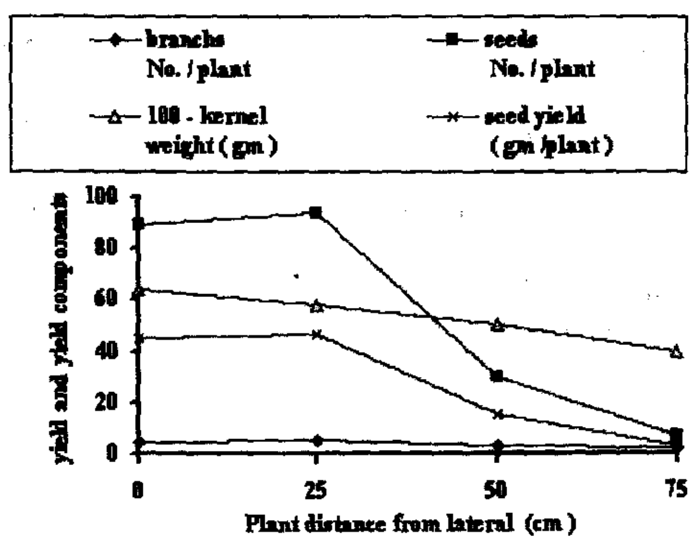

Fig. 8: Effect of plant distance from lateral on beans yield and yield components

Table 4: Effect of different treatments on yield of beans crop

Treatment	A	B	C	D	E	F
Seed yield (kg / fed)	3638.88	2287.52	3565.69	2513.46	1921.88	2389.7

Table 5: Total applied water during growing season of beans crop

Data	Applied water m3 / fed					
	A	B	C	D	E	F
November	353.92	265.42	264.88	217.16	189.51	188.55
December	371.33	278.83	276.26	229.53	196.29	196.62
January	385.15	292.55	292.22	231.48	199.66	199.54
February	390.27	296.64	294.71	234.75	204.75	203.83
March	387.43	280.28	279.06	224.62	189.34	188.94
April	127.51	99.11	94.52	71.79	38.92	39.24
Total	2015.61	1512.83	1501.65	1209.33	1018.47	1016.72

Table 6: Water use efficiency for treatments under sub-surface irrigation of beans planting

Treatment	A	B	C	D	E	F
Water use efficiency (kg / m3)	1.80	1.51	2.37	2.07	1.88	2.35

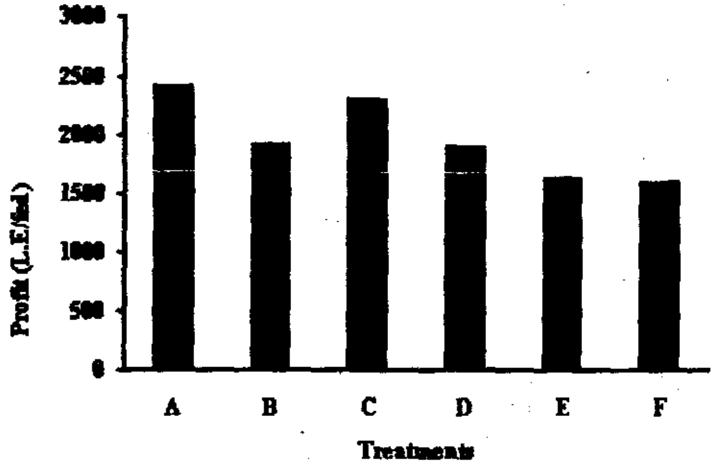

Fig. 9: Economical analysis for maize production under sub-surface irrigation treatements

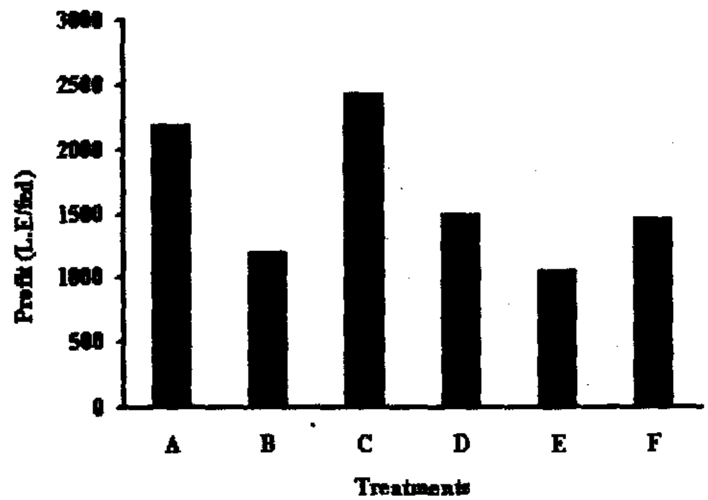

Fig. 10: Economical analysis for beans production under sub-surface irrigation treatements

Economic Study

Maize production economics under SSI

Economical input of new technology of maize production under using subsurface irrigation, is shown Figure 9 It is shown that the treatments A and C gave more profit than other treatments .The profitable of treatments A and C were 20.5, 5.0, 21.5, 32.5 and 33.9% compared with treatments B, C, D, E and F respectively.

Beans production economics under SSI

Economical input of new technology (profit) at beans production under subsurface irrigation is shown in Figure 10 The treatments C and A gave more profit than other treatments . The profit of treatment C increased by 0.9 , 37.4 , 31.2 , 47.4 and 34.6% over treatments A , B , D , E and F respectively .

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دراســة على الــري تحت ســطح التــربة فــى الأراضي الجــديدة

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. أجريت الدراسة على محصولى الذرة الشامية والفول البلدي فى تربة رملية بمصــنع ٢٠٠ الحربي خلال عامى (٢٠٠١ – ٢٠٠٣)، حيث تم دفن خراطيم الرشح على مسافات متفاوتــة مــع ثبات عمق الدفن وهو ٣٠ سم. وتمت الزراعة فى سطور على مســافة ٥٠ ســم بــين النباتــات للمحصولين. وقد تمت المفاضلة بين ٦ معاملات هى A , B , C , D , E , F و التــى اســتهدفت تأثير اختلاف المسافة ٧٥ ، ١٠٠ ، ١٢٥ ، ١٥٠سم بين خراطيم الرشح على إنتاجية المحاصــيل وكفاءة الرى والاحتياجات المائية وكذلك تأثير بعد النبات عن خرطوم الرشح (صــفر ، ٢٥، ٥٠، ٧٥سم) على المحصول ومكوناته.

ويمكن تلخيص أهم النتائج كما يلى:

زادت كل من نسبة الإنبات وارتفاع النبات فى المحصولين عندما قلت المسافة بين الخراطيم وكذلك المسافة بين النبات والخرطوم.

سجلت المعاملة A (٧٥ سم بين الخراطيم و ٢٥ سم بين النبات والخرطوم) أعلــى نسبة انبات وأطول ارتفاع للنبات.أ ما عمق الجذور فتلاحظ أن أكبر عمق عنــدما زرعــت النباتات على مسافة ٢٥ سم من الخرطوم فى المحصولين فى حين أقل عمق عندما كانــت المسافة ٧٥ سم.

أظهرت النتائج أن مكونات المحصول تأثرت ببعد النبات عن خرطوم الرشــح ففــى الذرة الشاميه، أعطى البعد صفر (النبات فوق الخرطوم مباشرة) أعلى قيمة لعــدد الكيــزان وعدد السطور وعدد الحبوب ونسبة التفريط ووزن ١٠٠ حبة، أما فى الفول البلــدى، فقــد أعطى البعد ٢٥ سم للنبات عن خرطوم الرشح أعلى قيم لمكونات المحصول مــن الفــروع وعدد البذور فى حين سجل البعد ٧٥ سم أقل قيم لتلك المكونات.

. أما الإنتاجية الكلية للفدان من البذور فقد تأثرت باختلاف المســافة بــين خــراطيم الرشح، حيث كانت أعلى إنتاجية لفدان الذرة الشامية والفول البلدى عند المعاملة A وأقــل إنتاجية كانت عند المعاملة E , F على الترتيب. كما أوضحت الدراســة أن أعلــى كفــاءة لاستخدام مياه الرى فى المحصولين كانت عند المعاملة C (المسافة بين خــراطيم الرشــح ١٠٠سم والنباتات تبعد عن الخراطيم ٢٥سم بالتناوب). فى حين أن أقل كفــاءة لاســتخدام مياه الرى كانت عند المعاملة B, A لكل من الذرة والفول على الترتيب.