29 15 27

11 *Egypt. J. Hort.*, 3, No. 1. pp. 99-110 (1976)

Trickle Irrigation Trial on Pea in Conditions Typical of Qalyobeia, Egypt

M. N. El-Awady, G. W. Amerhom and M.S. Zaki

Faculty of Agriculture, Ain Shams University, and Higher Institute of Agriculture, Moshtohor, Egypt.

A SYSTEM was installed and operated to work on a very low pressure (about 40 cm head), thus reducing the plugging problem among other advantages.

Estimation of the water rate was based on evaporation from an open pan. The ratio of the water rate to evaporation was 0.7 for the best pea crop. The total water consumption was about 1000 m^3/feddan, giving a yield of 2.5 ton/feddan.

Due to the few advantages prospered by trickle irrigation, such as water and drainage saving and control of water with reduced labour, the method is gaining ground in a few parts of the world. In many instances, irrigation can play a key role in feeding an expanding population. For example, economists and engineers associated with the Asian Development Bank concluded that in many parts of Asia intensively developing irrigation would be much easier and more economical than developing new land (Rawlins and Raats 1975).

Among workers on the related subjects, Samny (1959) estimated the number of irrigations for pea by 15, at an average of 100 m^3/acre. Eid, Abd El-Samei, and Gibali (1966) estimated the balance between water requirements and river resources in Egypt by the aid of the Blaney and Criddle formula. They declared that the requirements for cropped area surpass the river supply, and recommended immediate minimization of water losses and efficient use of irrigation water. At any rate, the total consumptive use for vegetables in Middle Egypt was estimated at 1875 m^3/acre. With 55% estimated irrigation efficiency, the actual requirement is 3410 m^3/acre. In 1967, Difrawy estimated the best water duty for different crops and parts of Egypt, among which the beans need 1210 m^3/acre (closest crop to pea). Waly (1973) studied the effect of water regime on the growth and yield of onion and broad bean plants. He arrived at the fact that crop yield increased with the frequency of irrigation, and estimated the concsumptive use of broad beans in the range 1436 - 1520 m^3/feddan by means of Blaney and Criddle, Thornwaite, and Christiansen's Equations.

Due to the absence of deep percolation in trickling, the water requirement becomes dependent on evaporation and transpiration only. Consequently a few workers, such as Shmueli and Goldberg (1972) and Krupp (1973), base calculation of the water requirement on the amount of evaporation from an open pan, and the plant exposed-surface

Rawlins and Raats (1975) explained the philosophy of using high frequency irrigation (mainly trickler and sprinkler irrigations). Surface irrigation imposes two fundamental constraints on irrigation management :

(i) it depends on flow over the soil surface, which requires minimum depth of water simply to achieve coverage, and (ii) a fixed cost is associated with each application. Both of these constraints make it economically advantageous to decrease the number of irrigations by increasing the time required between them. As a consequence, the science of irrigation management has focused on decreasing irrigation frequency by storing as much water as possible in the soil profile during an irrigation and using as much of this as practical before next. The recent introduction of pressure irrigation (such as trickle irrigation) reverses the economic picture, making high frequency irrigation more feasible. From another view angle, crop yield is maximal only when water potential remains high trhroughout the life of the crop, due to the fact that growth decreases faster at higher water potential than does transpiration, thus crediting trickler irrigation with possible high-frequency irrigation

Wallace and Romney (1975) reviewed a few experiences with the trickle irrigation, among which Bernstein and Francois (1973) found that drip irrigation could out-produce the furrow and sprinkler irrigation by about 50%. In another experience Shmueli and Goldberg (1972), working on pepper plants irrigated by four different amounts of water based on evaporation from a class A pan, found that the amounts applied were 0.82, 0.95, 1.33, and 1.75 of the pan evaporation. Since annual total pan evaportion was 12.8 cm, the irrigation levels used were relatively low. An optimum curve was obtained for the relation between yield and water application, with a maximum yield resulting from use of the 1.33 factor.

Regarding the technique of trickling rate-control, Awady (1975) studied the relations between the trickle-tube rates of discharge and their lengths as well as other pertinent variables, namely : available head, and water physical properties. The boundary-layer concept was used. The head-loss parameter was correlated to the tube dimensionless-length parameter and Reynolds number for both laminar and turbulent boundary-layers.

Awady and Mostafa (1975) studied puddling and infiltration, as related to the rate of discharge in loamy soil. They expressed the spread of water in dimensionless form to give the rate in different directions surrounding the trickler point.

The objective of this work was to make use of the experiences gained to construct a trickler system and investigate its prospected advantages, with water requirement for pea as a trial case. The system used in this investigation, although experimental, is the first installed and operated in Egypt. A new technique was developed to depend on very low water pressure. Thus, among other advantages, tricklers of larger diameters could be used giving less plugging troubles. Tube tricklers used depend on their lengths in giving different rates of different rates of discharge necessary for different water treatments.

Material and Methods

The experiment design followed a randomized block system, having four block replicates, each including four water treatments and a control unit. Each treatment had 12 hills arranged in boxes of 3×4. Only two hills in the middle (along furrow) were taken for measurement, while the rest were left as a belt taking the same treatment. Each hill was intended to hold two mature plants. Spacing was 60 cm between furrows, and 40 cm between plants along the furrows. The total area was about 100 m^2 (Fig. 1).

The plot was located in the experimental farm of the Higher Institute of Agriculture at Moshtohor. Soil is mainly clay (Table 1)

Table (1) Mechanical Analysis of soil

Coarse sand	*Fine sand*	*Silt*	*Clay*	*Texture*
7.43%	16.8%	34.9%	40.9%	Clay

Chemical Analysis of Soil

(extraction 1:20, milli-equivalent in 100 gm soil)

Soluble salts	CO_3	HCO_3	*Cl*	*S*	*Ca*	*Mg*	*Na*	*K*
0.27	0.00	1.99	1.42	0.67	1.28	0.70	1.70	0.31

Climate of the area is typical of Qalyobeia, Egypt.

The trickle system was mainly composed of : (1) A relatively short main line, 1½″ D, galvanized pipe connected to a municipality water-supply, (2) The header included a valve, a flowmeter, a piezometric tube of about 40 cm height, thus limiting the available head to this height, and a tap to allow drainage of water from the system when it is out of use, and (3) Twelve laterals, each composed of five joints ½″ D. plastic tubes, 3 m long, joined together by means of plastic hoses, and with a blind end. Each tube joint carried eight trickler tubes. Only half of the lateral length was used for this experiment; the rest was used otherwise.

Trickler tubes were of the type described by Awady (1975), and were made of plastic tubes of about 1.3 mm I.D. The rate of discharge was made different from one treatment to another through different lengths of the trickle tubes. The lengths of 3, 4, 6, and 40 cm were used, Fig.2.

It is noteworthy that the system used a very low pressure (about 0.03 at., compared to 1-2 at. used in general practice). Thus taking the following advantages made possible :

1. Direct supply of water by gravity from a storage tank without resort to pumps.

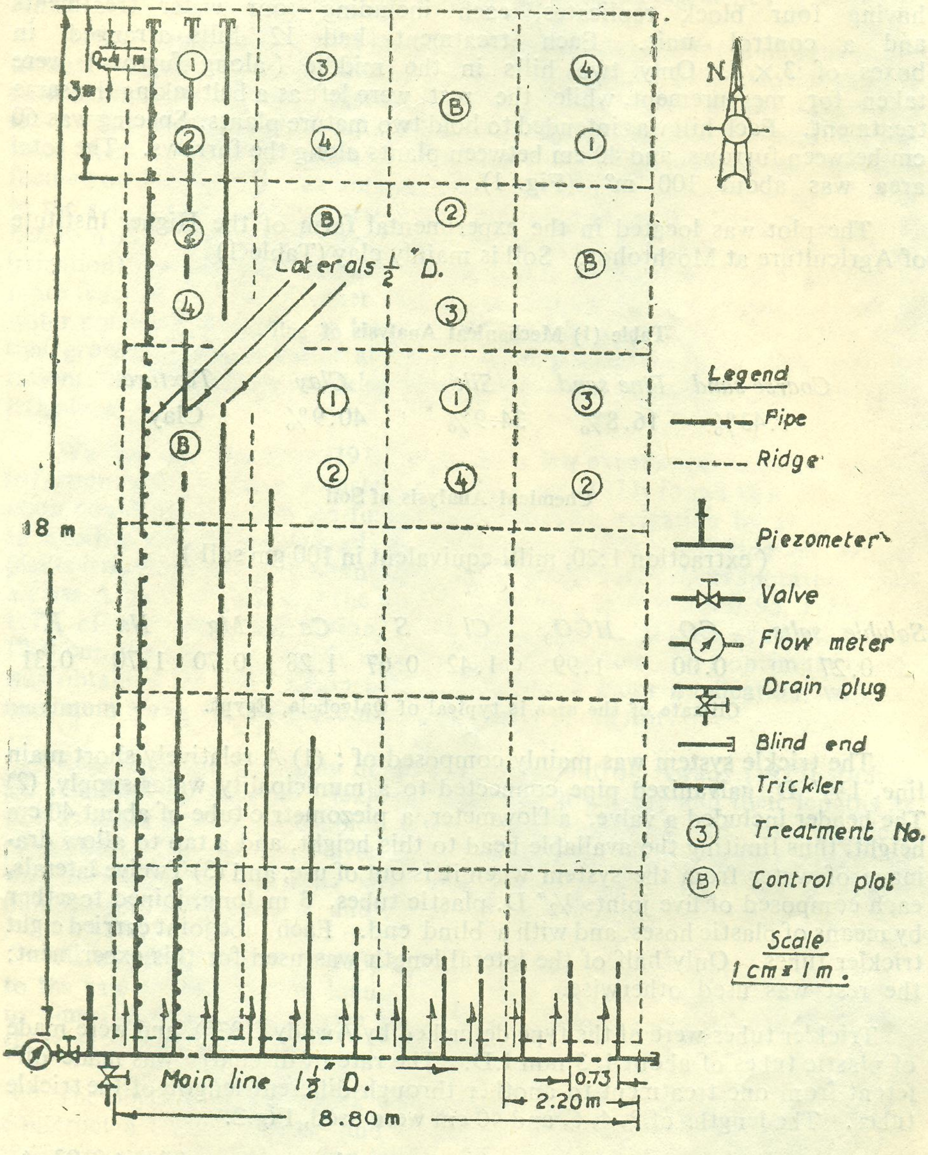

Fig. 1: System layout and experimental plots.

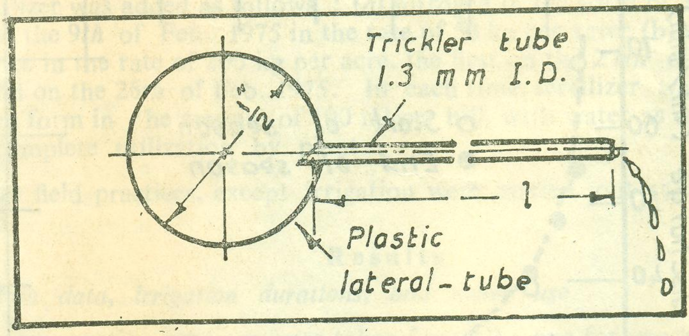

Fig. 2: Lateral-tube section and trickler.

2. Possible use of relatively large trickler diameters thus avoiding their plugging.

3. Reduction of the water rates, thus making the system more fit for small trees such as vegetables.

4. Reduction of strain on the joints and simplicity of construction and design.

Calibration of the tricklers was carried out by a stop watch and a graduated flask twice under the existing pressure : once in the start and another at the end of the experiment. In the first time, three tricklers were picked up at random from each replicate. In the second time, the two tricklers of the measurable hills were picked up. Calibration result is shown in Fig. 3. The average head was found 33.5 cm, measured from the vertical trajectory at each trickler hole.

Estimation of the daily water rate was based on evaporation from a free surface of an open pan (16 cm D. × 16 cm height) according to a method discussed in references such as Krupp (1973). Thus, the water requirement might be written in the following form (one trickler per plant hill)

$$q = \frac{1}{7} . h. A. r. f = i. t \qquad (1)$$

where "q" is the water rate in ml/day/trickler, "h" is the weekly evaporation in cm, "A" is the land area/plant (60×40 cm^2 in this case), "r" is the plant/land area ratio; was assumed to linearly vary with plant longevity (plant age 15 week, reaching a max of 100% of the land area), "f" is a factor varying from one treatment to another, and was finally calculated for the determination of the optimum water rate, "i" is the trickler rate in ml/min, and "t" is the daily application duration in minutes

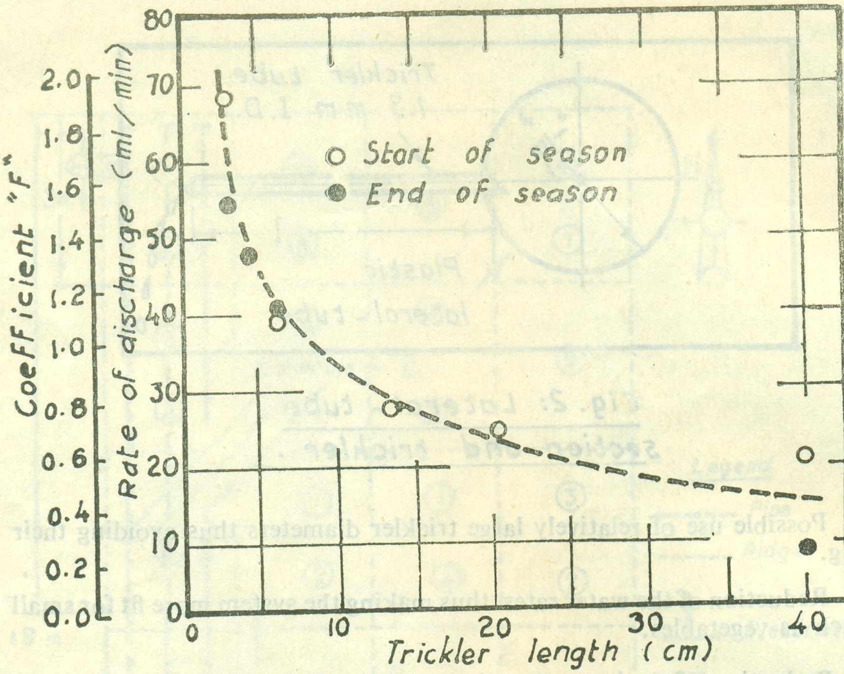

Fig. 3: Field calibration of tricklers.
(Av. head: 33.5 cm)

However, the following approximate relation was used to estimate the duration once a week, then the rate was given daily or combined for two or three days.

$$t = 0.5\ h.\ n \tag{2}$$

where "n" is the plant longevity in weeks, and "h" is the weekly evaporation in cm from pan in open sun. Comparison of equations "1" and "2" gives the values of "f" for different trickler rates and other pertinent factors,

$$f = 0.022\ i \tag{3}$$

"f" values as related to trickler rates of discharge and length are shown as a separate scale in Fig. 3.

However, irriagtion was stopped in rainy days when soil was observed wet in consequence.

The control plots were manually irrigated by a bucket of 10 liter capacity. The foreman was given the authority of determining the suitable irrigation quantity by observation once a week.

Pea seeds (*Pisum sativum* L.) cultivar (Lincoln) were sown on the 20 *th* of Dec. 1974 in hills 40 cm apart and were thinned to two plants per hill. Peas were harvested twice for green seed production. The first harvest was carried out on the 24 *th* of Mar 1975, while the second was carried out on the 10 *th* of Apr 1975.

Fertilizer was added as follows : (*a*) nitrogen in the form of ammonium nitrate on the 9*th* of Feb. 1975 in the rate of 50 kg per acre; (b) superphosphate twice in the rate of 200 kg per acre, the first on the 27*th* of Jan. and the second on the 26*th* of Feb. 1975. In each time, fertilizer was added in a solution form in the amount of 100 ml per hill, with water as a solvent to ensure complete utilization by plant.

Other field practices, except irrigation were carried out as is normally practised.

Results

Evaporation data, irrigation durations, and water use

Two evaporation readings were taken for "h" : one for pan in sun, and another in shade. Fig.4 shows the data.

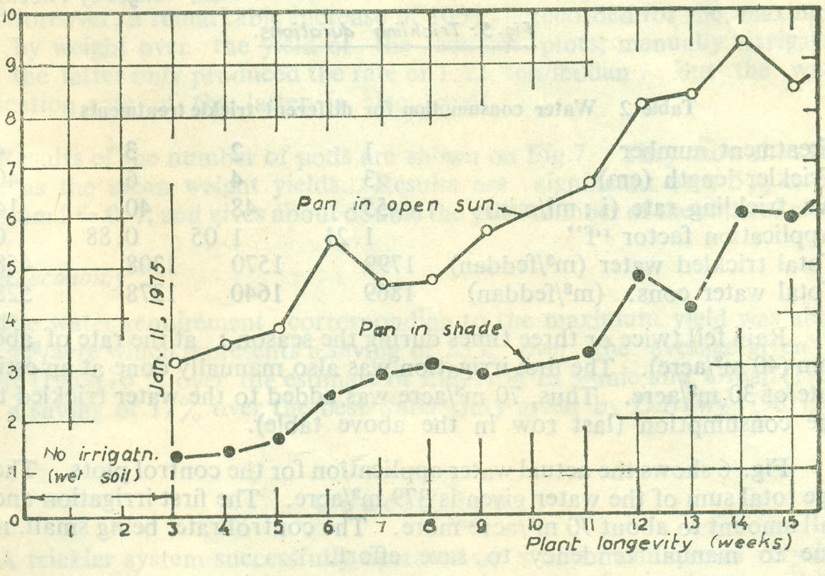

Fig. 4: Evaporation data.

Daily durations of irrigation "t" are also shown according to Eq. 2 in Fig. 5. Actual weekly durations were sometimes less than those estimated from the equation, due to rain.

The total amounts of water consumption "u" during the season were calculated according to the following relation

$$u_i = 0.123 \ i \sum_n t_n \qquad (4)$$

where "u_i" is in m^3/acre for the trickler rate "i" for any treatment in ml/min, and "t_n" is the daily actual time duration in minutes at the longevity "n" of plant in weeks. Table 1 summarizes the water consumption thus computed, provided that $\sum_{n=1}^{15} t_n$ was found = 266 min (from data of Fig. 5).

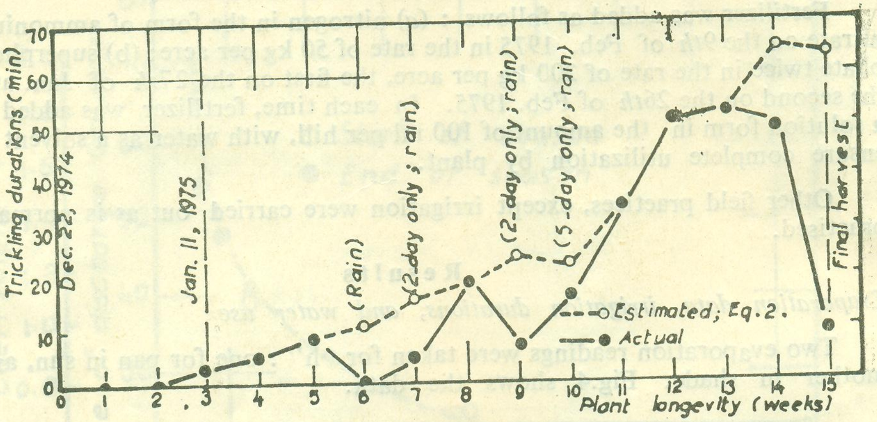

Fig. 5: Trickling durations.

Table 2 Water consumption for different trickle treatments

Treatment number	1	2	3	4
Trickler length (cm)	3	4	6	40
Av. trickling rate (i : ml/min)	55	48	40	14
Application factor "f"	1.21	1.05	0.88	0.31
Total trickled water (m^3/feddan)	1799	1570	1308	458
Total water cons. (m^3/feddan)	1869	1640	1378	528

Rain fell twice or three times during the season ; at the rate of about 10 mm (40 m^3/acre). The first irrigation was also manually done at an estimated rate of 30 m^3/acre. Thus, 70 m^3/acre was added to the water trickled to give the consumption (last row in the above table).

Fig. 6 shows the actual water application for the control plots. The average total sum of the water given is 379 m^3/acre. The first irrigation and rainfall amount to about 70 m^3/acre more. The control rate, being small, may be due to manual tendency to save effort.

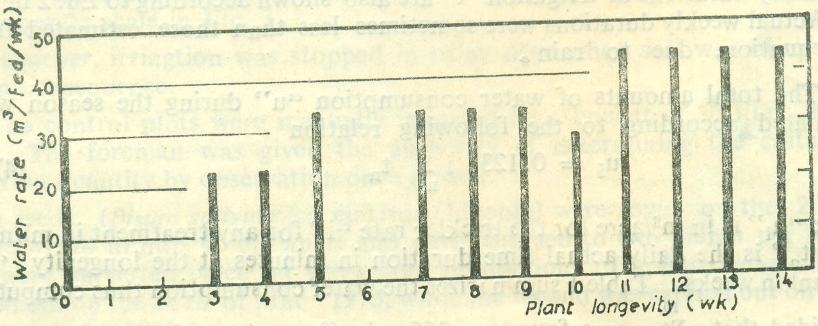

Fig. 6: Control-plots irrigation.

Pod yields

The average yield was evaluated for each treatment by adding the yield of four replicates each having two hills with about four plants. Result is shown in Fig. 7. Analysis of variance with the F-test on the weights of pods for the different treatments and replicates, showed a little insignificance over 5% level. But when the point of origin was included (zero yield for zero water rate), the variation showed significance even over 1% level.

The figure shows that the maximum yield was about 140 g/hill or at the rate of 2.5 ton/acre, at a value of "f" = 0.7, and at a total water rate of 982 m^3/ feddan. However, the value of f = 0.7 might be considered superfluous since strong weed growth was observed.

Moreover, a remarkable increase of 100% is recorded for the maximum yield by weight over the yield of the control plots, manually irrigated, since the latter only produced the rate of 1.25 ton/feddan. But the water application rate of the latter is also small.

Results of the number of pods are shown on Fig.7. They show the same trend as the mean weight yields. Results are significant over 5% level; optimum f = 0.7, and gives about double the yield number of the control plots.

Water economy

The water requirement corresponding to the maximum yield was about 1000 m^3/acre which represents a saving of 33% over the average given by Samny (1959) 70 % over the estimate of Eid, Abd El Samie and Gibali (1966) and a saving of 17% over the best water duty given by Difrawy (1967).

Conclusion

A trickler system successfully operated on a new technique of very low pressure (about 40 cm head), with the main advantage of using larger tricklers resulting in less plugging troubles, in addition to other simplifications in the system.

Estimation of the daily water can be based on evaporation from open pan, plant spacing, longevity, and a varibable coefficient "f", (according to Eq.1). "f" was varied by means of calibrated trickle tube lengths between 0.31 and 1.21. The optimum yield was found to correspond to "f = 0.7 to 0.8".

Maximum pod yield was 2.5 ton/acre at a total water requirement of about 1000 m^3/acre including rain and initial irrigation with a saving of 17 - 70% over requirements based on other sources. Further work on the subject is undertaken.

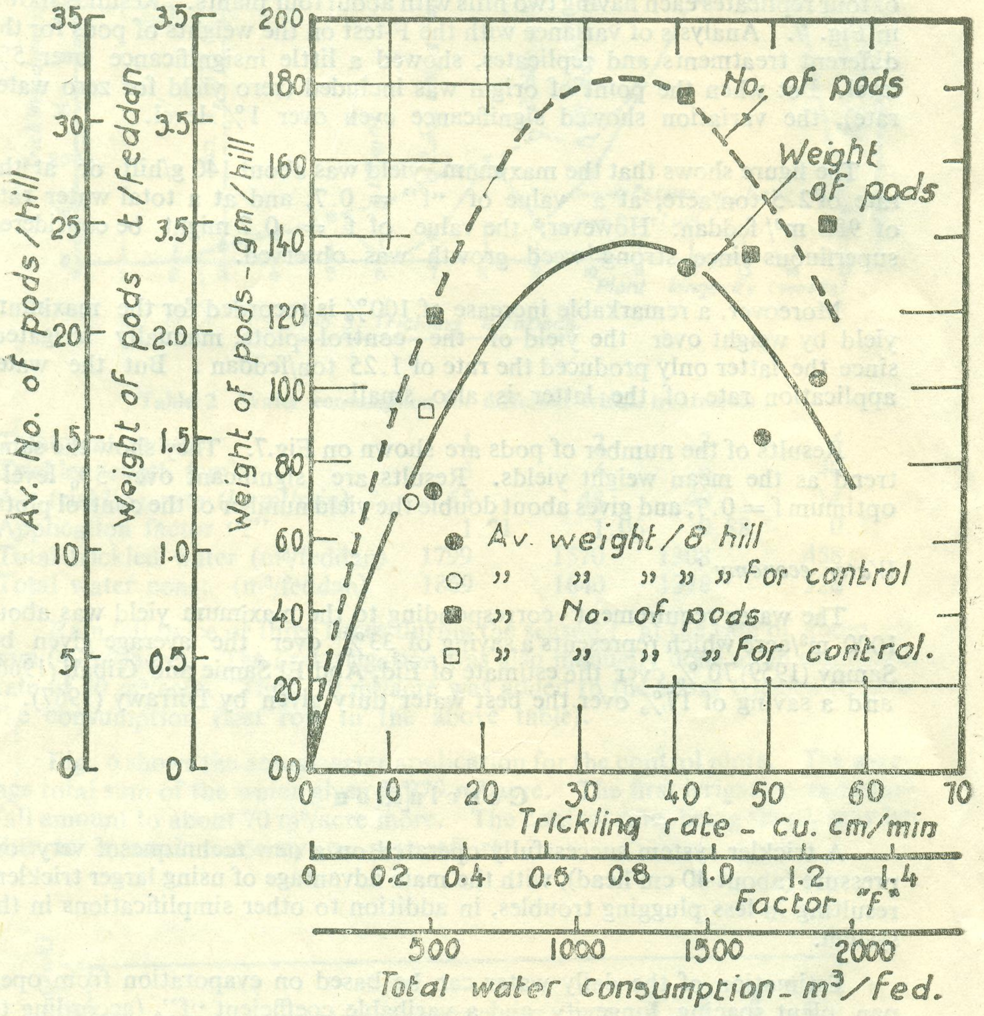

Fig. 7: Yield as related to water consumption and "F" values.

References

Awady, M.N. El (1975) Head loss in the entrance of trickle tubes, *Proc. Congress of Silver Jubilee of the Soil Science Socity of Egypt. Cairo* (in press)

Awady, M.N. El and Mostafa, M. (1975) Infiltration of water from tricklers into loamy soil *Proc. of the Silver Jubilee of the Soil Sience Sciety of Egypt, Cairo.* (in press)

Bernstein, L. and Francois, L.E. (1973) Comparison of drip, furrow and sprinkler irrigation, *Soil Sci.* **115**, 73.

Difrawy M.H. El, (1967) "*Consumptive use of water*", Ministry of Irrigation, Egypt.

Eid, M.T., Abd El-Samie, M. and El-Gibali, A. (1966) Preliminary estimated balance between irrigation requirements and river resources in U.A.R., *Agric. Res. Rev.*, Min. Agric., Cairo.

Krupp, D. (1973) "*Drip irrigrtion systems*", Controlled water emissions systems co., El-Cajon, Cal., U.S.A.

Morsy, M.A. and Nour El-Din, N.A. (1975) "*Agricultural Experiments*", Alam El Kotob, Cairo (Arabic).

Rawlins, S.L. and Raats, P.A. (1975) Prospects for high frequency irrigation, *Science* **188**, 604.

Samny, S.A. El (1959) Projects of sprinkler irrigation, *Engineers Magazine*, Cairo (Arabic).

Shmueli, M. and Goldberg, D. (1972) Response of trickle irrigated pepper in an arid zone to various water regimes, *Hort. Science* **7**, 241.

Wallace, A. and Romney, E.M. (1975) Feasibility and alternate procedures for decontaminated and post treatment management of pu-contaminated areas in Nevada, Unpublished repot.

Waly, M.A. (1973) *Water requirement of some vegetable crops*, Ph. D. Thesis. Fac. Agric., Ain Shams Univ.

(*Received* 26/5/1975
in revised form 9/12/1975)

تجربة الرى بالتنقيط على البسلة فى ظروف محافظة القليوبية

محمد نبيل العوضى وآخرين

كلية الزراعة جامعة عين شمس ـ شبرا الخيمة

تم انشاء وتشغيل جهاز للرى بالتنقيط ليعمل على ضغط منخفض جدا (بضاغط ٤٠ سم تقريبا) ، وبالتالى أمكن تخفيف مشكلة انسداد الفوهات بالاضافة الى مميزات أخرى .

وقد استند تقدير معدل المياه على معدل التبخر من وعاء مكشوف أما نسبة معدل اضافة المياه الى معدل التبخر فقد وجدت ٧و٠ لأحسن محصول بسلة ، حيث بلغ الاستهلاك الكلى للماء نحوا من ١٠٠٠ متر مكعب للفدان وبلغ المحصول ٥ر٢ طن للفدان .