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Developing Sprinkler for Seedling Trays Irrigation

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ABSTRACT

This research aimed to develop and evaluate of manual sprinkler for seedling trays irrigation in incubate greenhouses, chassis with wheel and two arms were developed to facilitate sprinkler pull and mechanical transmission by adding eccentric mechanism for sprinkler pump arm instead of manual one. This research also aimed to develop the irrigation water distribution system with multi - point holder and distributing regularly in two directions with increasing the number of irrigation nozzles. Preliminary experiments were carried out to ensure equal discharge of sprinkler nozzles on the same hose axis at factors : irrigation hose inclination angle on the horizontal level (0º, 5º, 10º, 15º and 20º) with Nk (Mini sprinkler and Fog sprinkler) nozzles at wheel : eccentric revolutions We (1:1, 1:2 and 1:4). Developed sprinkler experimented in one of the greenhouses for incubate vegetables seedling trays, at three different tested factors, two types of irrigation nozzles Nt (Mini sprinkler and Fog sprinkler), Wheel : eccentric revolutions (We) (1:1, 1:2 and 1:4), three levels of sprinkler irrigation hose arm height (H) from trays surface (13, 15 and 17) cm. The results showed that: the irrigation hose best inclination angle 10º gave regular discharge l/s. for two types of nozzles. In general, the rate of sprinkler nozzle irrigation discharge (6.3×10^{-2}) L/s. and water distribution is steadily increasing with increased We from 1:1 to 1:4 at irrigation hose arm height H = 13 cm.

Keywords: seedling trays – incubation greenhouses – irrigation sprinkler – irrigation nozzles – trays water distribution.

ITRODUCTION

Planting and taking care of seedling trays for some crops is an important and accurate operations that greatly affect the germination percentage and the final crop quantity. Irrigation of seedling trays (irrigation time, quantity and proper distribution of water) within the trays incubate process is an important in the care of the trays where irregular distribution of irrigation water and fewer amount lead to the death of seedlings on the other hand increase the rate of irrigation water leads to rot seeds and the emergence of fungi on the trays surface. Irrigation process of the seedlings trays in incubate greenhouses is done in the traditional manual way by workers using a spray hose or the use of manual sprinkler this leads to a large effort in trays irrigation process and thus irregular irrigation water distribution.

The main purpose of this research develop a manual sprinkler for greenhouses trays irrigation process by pulling it between seedlings trays paths instead of carrying it attached with eccentric mechanism operates the pump instead of the hand lever and increase the number of nozzles on sprinkler hose to irrigate more trays in less time.

Many studies had been carried out on the manufacture of seedling trays and the selection of materials suitable for their that do not interact with the soil or affected by irrigation water for example Kasirajan and Ngouajio 2012 elucidate traditionally, plastic was a commonly used material for making plug-trays. Lately, many biodegradable plug-trays have been seen on the market as a more environmentally friendly option in greenhouse and field production. From other hand a relevant study by Evans *et al*., 2010 showed the soil moisture affected seedling grown and would negatively impact trays strength/integrity, caution should be taken when handling wet trays, so that they could still hold the seedlings properly before transplanting, from other side they showed the importance of adding irrigation water amount to the trays made of biodegradable materials with sufficient quantity and not excess so as not to degrade the trays and the growth of algae and fungi on the seedling trays walls and the study focused on the absorption of water and its impact on the walls of the planting trays and the growth of seedlings at the same time. Schettini *et al*., 2013 studied the effect of increasing the rate of water for the tomato seedling trays and increasing the wetness of the trays for long periods has a negative role in changing the physiological characteristics and the size of the trays planting cells and also damage the environment of planting materials and seedlings. Jordá-Vilaplana *et al*., 2017 taked into consideration in the manufactured of seedling trays materials that not to absorb irrigation water due to the need to maintain the water standard stage and the use of a fertilizer environment in planting trays absorbs water to benefit seedlings. Zhang *et al*., 2017 studied the effect of irrigation water regularity, the accurate rate of irrigation water had a great role in preserving the agricultural environment of the seedlings from salting, which affects plant growth and combustion of roots. In onother study Devkota *et al*. 2015 showed the different irrigation frequencies, and unsuitable irrigation frequency will be harmful to the growth of crops. Kim *et al*. 2013 studied a precision seeding of plug trays requires single seeds to be picked from the hopper and individually placed in each cell, Singulation of seeds had been investigated extensively by researchers all over the world and a large number of precision seeding systems with design variations have been developed for different crops. Other studies showed that

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seedlings are usually grown in a seedbed under controlled climatic and conditions in a greenhouse. However, the water used for irrigation can be an important source of crop contamination, on the other hand the amount of water had an effect on the growth rate of seedlings Allende and Monaghan 2015 from other side few studies were carried out on the efficacy of spraying water directly on plants surface for controlling the seedling development. Iriti and Faoro 2009 this research was to determine if drizzle or new electrolyzed water applied as overhead sprinkler irrigation affects the photosynthesis rate, seedling development, the antioxidant status and the microbial load in the capsicum seed crop, in a commercial nursery under greenhouse. Moreno 2003 showed that, to increase irrigation efficiency in a group of homogeneous plants in a nursery (i.e. plants of the same species and of similar size), it is necessary to determine the dosage of water to be applied and the criteria for activating the irrigation system. The objective of this study is to develop sprinkler seedling irrigation to mention a good distribution of water on seedling trays and save effort of workers.

MATERIALS AND METHODS

Sprinkler main specifications, parts:

The main specifications of sprinkler before modifications tabulated as follow:

Model : manual	**Pump with push arm**
Main dimensions	47 × 35 × 12 cm.
Tank capacity	18 : 20 Liters
Minimum weight (empty tank)	5.8 Kg.
Maximum weight (tank full with water)	25 Kg.

It consists of 4 main parts as shown in fig (1):

(1) Tank.
(2) Manually operated pump.
(3) Arm extending under the labor left-hand to facilitate its operation.
(4) Handle hose with one spray nozzle.

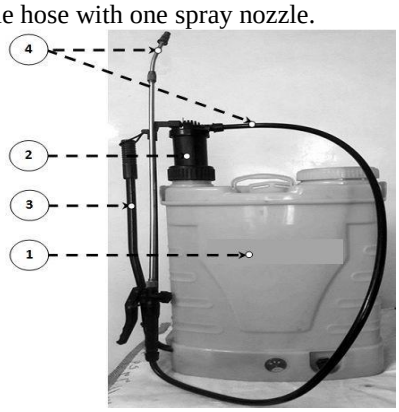


Fig 1. sprinkler main parts before modification

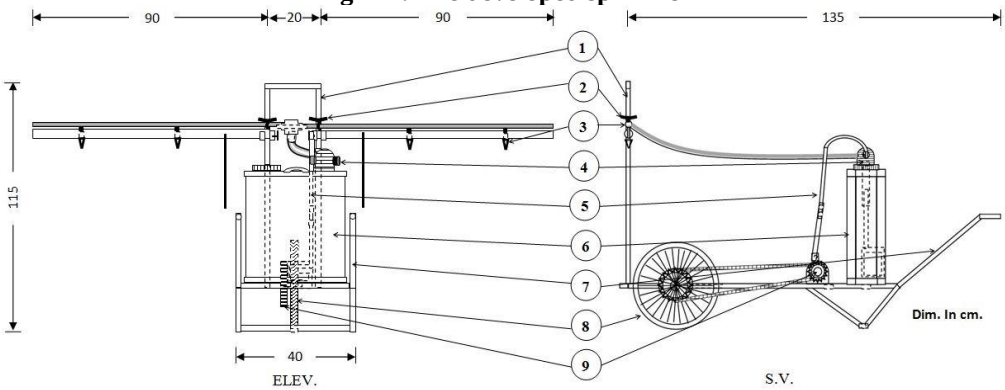
How manual sprinkler work before modification

As a result of the pump arm movement, hydraulic pressure is created on the surface of the fluid inside a tank which leads fluid to impulse through the sprayer hose with nozzle that sprayed liquid, spraying process and direction of the spray hose is done manually by the labor (the fluid exit and its direction are controlled manually).

The developed sprinkler

The development was carried out on a manual sprinkler at the local workshop in Mansoura city by developed and added new parts to manual sprinkler as shown in fig 2 (A and B):

Fig 2-A. The developed sprinkler



1- Chassis.
2- T shape water trap.
3- Hose with irrigation nozzles.
4- Operated pump.
5- Articulated (pump- eccentric) link.
6- Tank.
7- Two puller arms.
8- Wheel.
9- Eccentric mechanism.

Fig. 2-B. A schematic diagram of developed sprinkler main parts

The experiments done in one of the greenhouses for incubate tomato and cucumber seedlings trays at Qatna village – Belqas – Dakahlia Governorate in march / 2019.

Initial studies and theoretical considerations:

To design the developed sprinkler and estimate its parameters, the following informations were identified as follow:

Seedling tray

Material : plastic & foum

Number of transplant cells : 209

Tray main dimensions : 50 × 30 × 3 cm.

Greenhouses of incubate seedlings

Material : polyethylene & burlap

Main dimensions:(length 40 & width 3.5:4 & height 2:3) m.

Seedling trays are distributed inside greenhouses in three rows (90, 150 and 90 cm), including two pathways (50 cm width) for trays care and service process, fig (3) shows divided trays placement inside incubate greenhouses.

Fig 3. seedling trays inside incubate greenhouse

Theoretical considerations and developed sprinkler specifications: Generally mean of labor forward speed (1 ± 0.06 m/s) manually equal 2 stroke (7 cm.) of pump piston as shown in fig (4-A), wheel diameter is 65 cm. (perimeter = 3.14 × 65 = 204 cm) attached with (20 teeth gear) previously it is clear that, one roll of sprinkler wheel = two labor step at 2 sec. Chassis attached with eccentric mechanism with = 7 cm. diameter and take its movement from sprinkler wheel by attached with 3 gears (5, 10 and 20 teeth) and chain to multiply the movement of the pump piston in relation to the labor forward speed to duplicate the amount of irrigation water in two directions. Sprinkler pump connected with eccentric mechanism by articulated arm as shown in fig (4-B).

Fig. 4-A. Length of pump piston.

- Sprayer hose holder: the irrigation hose is mounted on a multi-point vertical column to control the height of the irrigation nozzles above the seedling trays surface.

- Sprayer hose with spray nozzles: divided for two hoses (90 cm. length) enabled for irrigation two sides (3 seedling trays of each side).

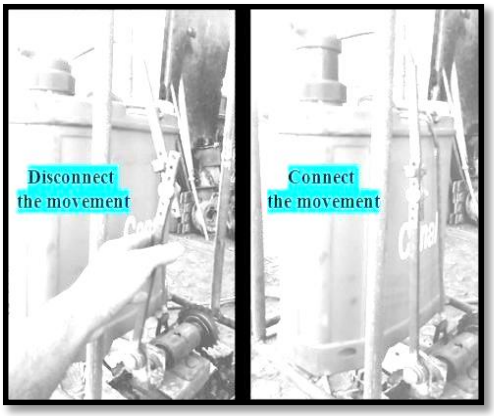


Fig. 4-B. Connected arm between pump and eccentric.

By drawing irrigation cone as shown in fig (5), the considerations for irrigation nozzles distribution on sprinkler hose and height of irrigation hose with irrigation nozzles above seedling trays determined as follow:

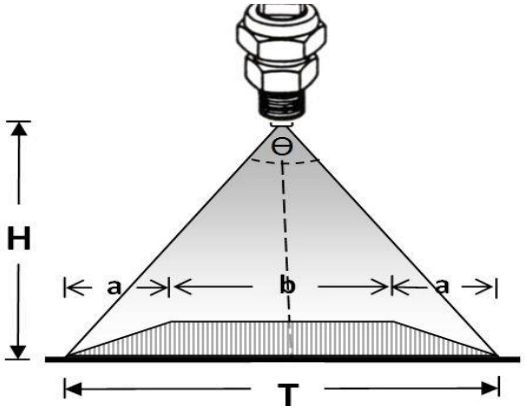


Fig. 5. Irrigation cone parameters

$$T = 2\,H \quad \tan\left(\frac{\theta}{2}\right) \qquad \text{------ (1)}$$

$$\tan\left(\frac{\theta}{2}\right) = (a + b/2) / H \qquad \text{------ (2)}$$

Where:

H = Height of irrigation cone (irrigation nozzles from trays surface).

T = Maximum width of irrigation cone (water distribution distance above trays surface).

b = Minimum width of irrigation cone.

a = Horizontal distance of the irrigation cone slope.

Θ = Angle of irrigation cone (60º for normal pressure to 75º for high pressure) .

number of nozzles on one irrigation hose (2 nozzles) for irrigate 3 trays (90 cm width) of each side thus T = 45 cm at irrigation cone angle 60º, from the previous, H = 22.5 × 0.58 = 13 cm.

The experimental variables :-

There were three experimental factors under study to assess the performance of developed sprinkler as follow :

1) Wheel : eccentric revolutions We (1:1, 1:2 and 1:4).
2) Two types of irrigation nozzles Nt (Mini sprinkler and Fog sprinkler)
3) Three levels of sprinkler irrigation hose arm height H from trays surface (13, 15 and 17) cm.

Preliminary experiments were carried out on different irrigation hose inclination angle on the horizontal level (0º, 5º, 10º, 15º and 20º) with Nk (Mini sprinkler and

Fog sprinkler) nozzles at wheel : eccentric revolutions We (1:1, 1:2 and 1:4). to ensure equal discharge of sprinkler nozzles on the same hose axis by using tank to collect water from each nozzle at previous experimental variables.

The nozzle discharge was calculated using equation (3)

$$Q = V/T \quad \text{------ (3)}$$

Where:

Q = Discharge L/s.
V = Collected water L.
T = Time of collecting water s.

The experimental measurements:-

- Discharge (*l*/s) with water lateral distribution curves :

Total sprinkler nozzles discharge (L/s) was calculated for different experimental variables under study at both sprinkler operating sides, sprinkler was run with empty seedling trays to facilitate the collection of water from trays cells and make calculations of water discharge (L/s) and drawn the water discharge distributions curve for every 30 cm width with longitudinal distance 1m. (1 second of experimental time), from the results data of preliminary experiments an irrigation hose inclination angle has been selected at 10º for all experimental procedures as will be explained.

RESULTS AND DISCUSSION

Results of preliminary experiments (the nozzle discharge L/s)

The values of the two nozzles discharge on the same irrigation hose with different inclination angles for the irrigation arm on horizontal level are histogramed as shown in fig 6 (A throw F), it seen in the fig 6 (A throw F) the regular discharge (6.3×10^{-2} L/s.) for mini sprinkler obtained with We = 1:2 at irrigation hose inclination angle 10º. On the other hand, the fog sprinkler discharge was more regular with Wheel : eccentric revolutions We = 1:4 at irrigation hose inclination angle 10º. From the results illustrated, the use of spraying arm without inclination angle obtained irregular discharge (L/s) for two sprinkler kinds with all Wheel : eccentric revolutions (We) rates under study. At inclination angle 10º discharge will be more regular for two sprinkler nozzles on the same irrigation hose to increase the amount of water arrived to the second nozzle this leads by extension to regularity of two nozzles discharge (L/s).

- Mini sprinkler **- Fog sprinkler**

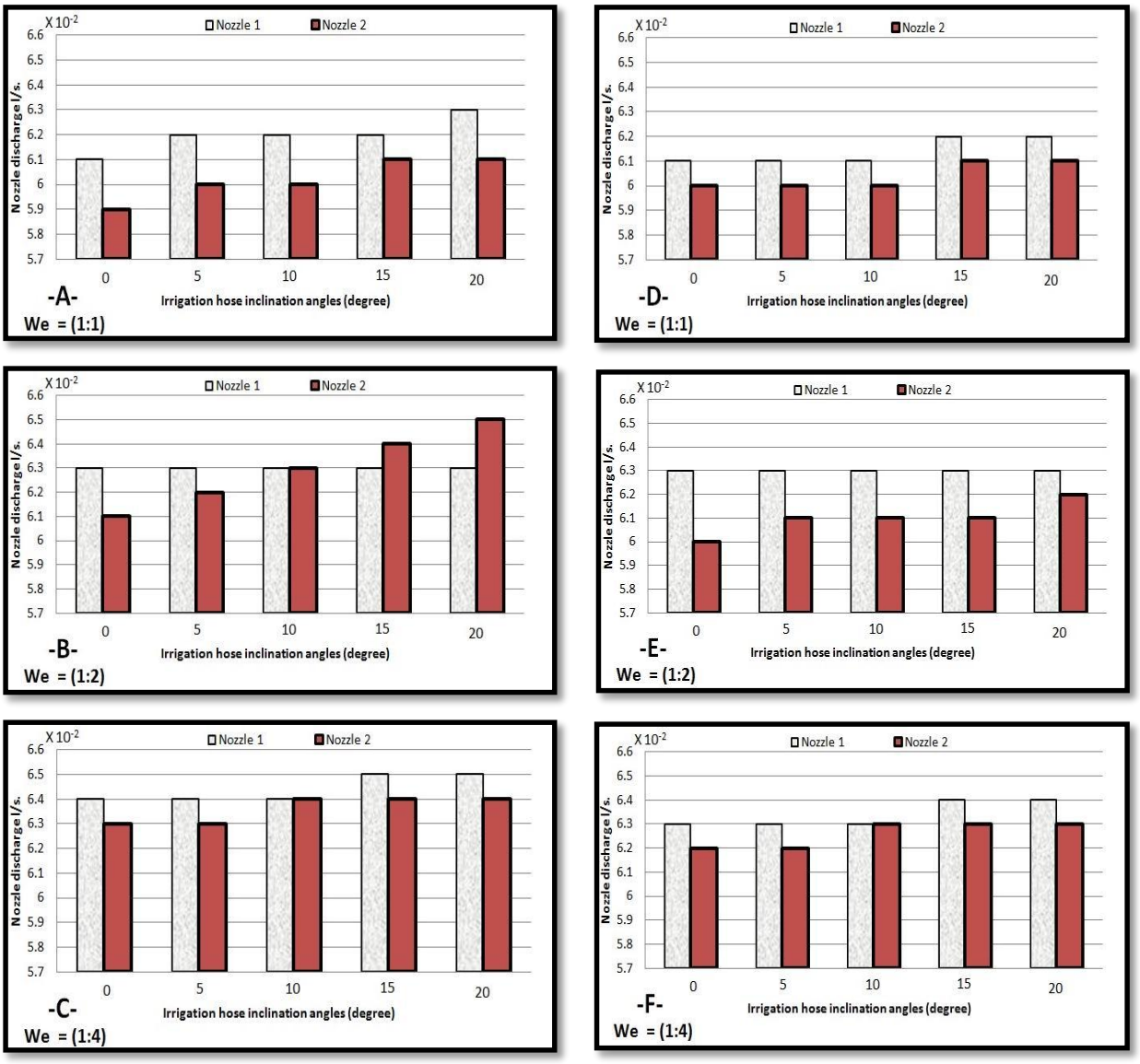


Fig. 6. A throw F. Discharge L/s. for two types of irrigation nozzles at preliminary experiments

Discharge (L/s) with water lateral distribution curves

The nozzles discharge L/s was recorded and water lateral distribution curves were drawn as shown in figs 7 (A throw F).

From previous data, the highest uniformity of irrigation water distribution was obtained on seedling trays with nozzles Mini type by using developed sprinkler at wheel : eccentric revolutions We = 1:4 and sprinkler irrigation hose arm height H = 13 cm with 12.6 l/s. discharge value. The nozzles Fog type had highest uniformity of irrigation water distribution at wheel : eccentric revolutions We = 1:2 and sprinkler irrigation hose arm height H = 13 cm with 12.5 L/s. discharge value, this due to irregularity of water pressure by increasing We which leads to more water atomization and good distribution.

- **Mini sprinkler** - **Fog sprinkler**

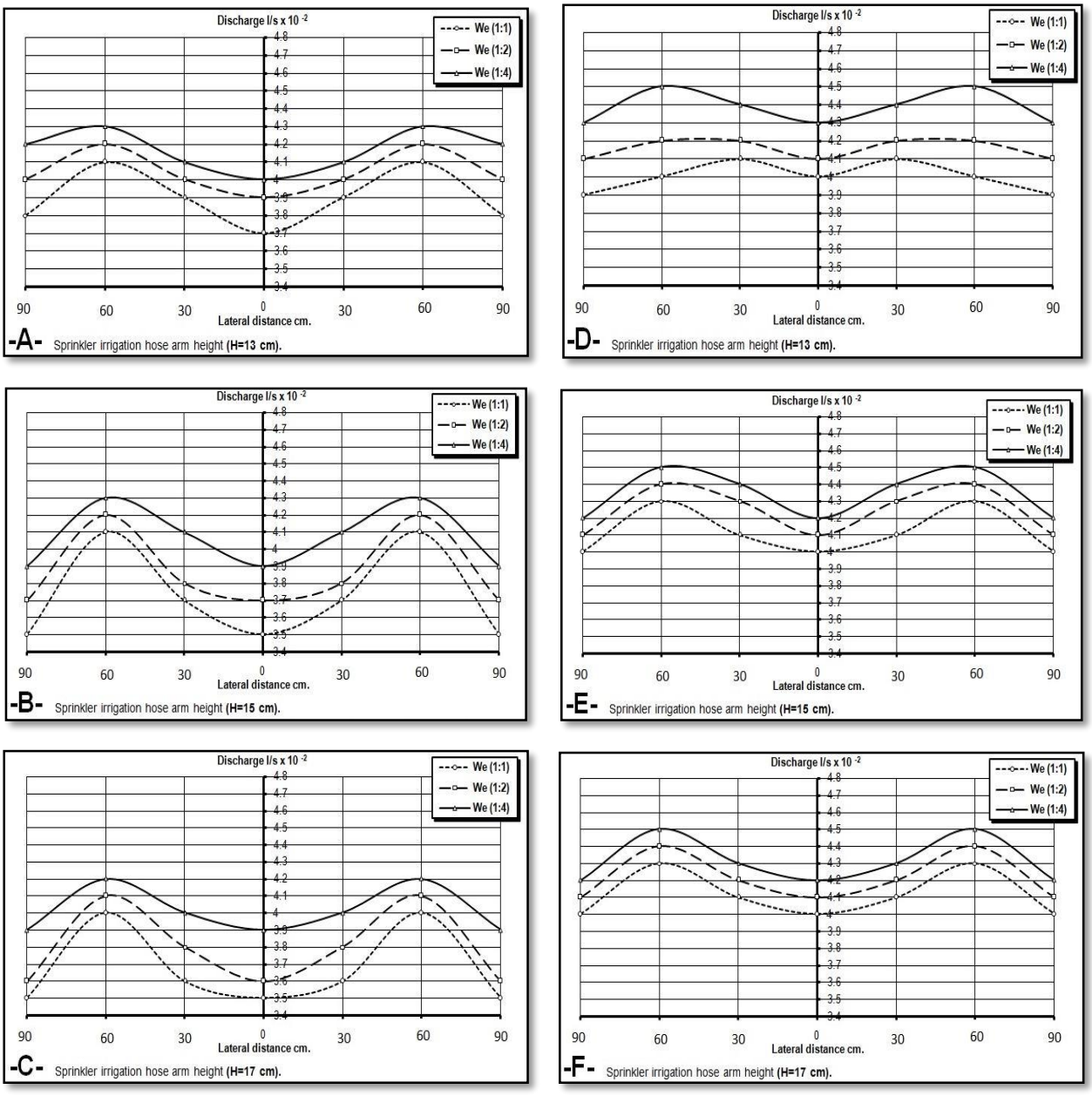


Fig. 7. A throw F. Discharge l/s. and water lateral distribution for experimental factors under study.

CONCLUSION

This study contributed to the irrigation process for seedling trays by developing a manual sprinkler to suite irrigation process easily and more accuracy in water discharge quantity and uniformity of irrigation water distribution. The sprinkler was developed by adding a chassis equipped with a traction wheel and transmission eccentric mechanism for mechanical operation of the pump and increase the number of nozzles with irrigation water distribution in two directions. From the results of the experiment, from the obtained results of this research we can say that, the use of the developed sprinkler in the irrigation process of seedlings trays led to the regular rate of water discharge quantity (6.3×10^{-2} L/s) for one nozzle with regular water distribution on trays surface at irrigation hose height H = 13 cm with inclination angle on the horizontal

level 10º and wheel : eccentric revolutions We = 1:4 for both types of irrigation nozzles Nk (Mini sprinkler and Fog sprinkler). From the above it is recommended to use the developed sprinkler in seedling trays irrigation process.

REFERENCES

Allende A. and Monaghan J. (2015) Irrigation water quality for leafy crops: a perspective of risks and potential solutions. Int. J. Env. Res. Public Health. 12, 7457–7477.

Devkota M.; Gupta R.K.; Martius C.; Lamers J.P.A.; Devkota K.P.; Sayre K.D. and Vlek P.L.G. (2015) Soil salinity management on raised beds with different furrow irrigation modes in salt-affected lands. Agric. Water Manag. 152, 243–250.

Evans, M.R.; Taylor M. and Kuehny J. (2010). Physical properties of biocontainers for greenhouse crops production. HortTech 20 (3), 549–555.

Iriti M. and Faoro F. (2009) Chemical diversity and defence metabolism: how plants cope with pathogens and ozone pollution. Int. J. Mol. Sci. 10, 3371–3399.

Jordá-Vilaplana A.; Carbonell-Verdú A.; Samper M.D. and Garcia-Sanogurera, D., (2017). Development and characterization of a new natural fiber reinforced thermoplastic (NFRP) with Cortaderia selloana (Pampa grass) short fibers. Composites Sci.and Tech. 145, 1–9.

Kasirajan, S. and Ngouajio, M. (2012). Polyethylene and biodegradable mulches for agricultural applications: a review. Agron. Sustain. Dev. 32, 501–529.

Kim D. E.; Chang Y. S.; Kim S. H. and Lee G. I. (2013). Development of vacuum nozzle seeder for cucuribitaceous seeds (I)—design factors for vacuum seeding large sized seeds. Journal of the Korean Society for Agricultural Machinery, 28(6), 525–530.

Moreno J. F. (2003). El riego a la demanda en cultivos hidropo´ nicos. [The irrigation taking into consideration water needs in hydroponics]. Horticultura, 168, 42–45.

Schettini E.; Santagata G.; Malinconico M.; Immirzi B.; Mugnozza G.S. and Vox G. (2013) Recycled wastes of tomato and hemp fibre for biodegradable pots. Resour. Conserv. Recycl. 70, 9–19.

Zhang H.M.; Xiong Y.W.; Huang G.H. and Huang Q.Z. (2017) Effects of water stress on processing tomatoes yield, quality and water use efficiency with plastic mulched drip irrigation in sandy soil of the Hetao irrigation district. Agric. Water Manag. 179, 205–214.

تطوير الرشاشة اليدوية لتلائم رى صوانى الشتلات

طارق حسني الشبراوي*

قسم الهندسة الزراعية ـ كلية الزراعة – جامعة المنصورة

تعتبر إعداد و زراعة صوانى الشتلات و عمليات الخدمة لهذه الصوانى من تحضين و رى و تهوية من الأمور الهامة و التى تؤثر على إنتاجية المحصول بصورة كبيرة، و تتم عملية الرى لصوانى زراعة الشتلات ذات العيون داخل صوب التحضين بطريقة تقليدية يدوية بواسطة العامل (خرطوم ري – رشاشة ظهرية يدوية) مما يؤدى الى عدم انتظام توزيع كمية مياه الرى المناسبة على الصوانى فقد تزيد كمية المياه فى عيون زراعة عن أخرى مما قد يؤدى إلى نمو الفطريات فى بيئة الزراعة (البيتموس) و تعفن البذور، و قد تقل كمية مياه الرى مما يؤدى الى موت البذرة أو ضعف نمو البادرات و من هنا تمت هذه الدراسة بغرض تطوير الرشاشة اليدوية المحمولة على الظهر لتلائم عملية رى صوانى الشتلات حيث زودت بعجلة للنقل و سهولة الحركة و شاسيه لتسهيل جرها بدلا من حملها و إضافة نظام ميكانيكى لنقل الحركة لرداخ طلمبة الرشاشة بدلا من الذراع اليدوى و ايضا روعى فى التصميم الجديد بجانب سهولة التشغيل للرشاشة رفع كفاءة العمل و ذلك بمضاعفة أعداد بشابير الرى و إجراء عملية الرى فى إتجاهين. و لتطوير الرشاشة أيضا تم دراسة الأبعاد التصميمية لصوب التحضين و صوانى زراعة الشتلات و طريقة رص الصوانى داخل الصوبة و أجريت تجارب مبدئية بغرض تحديد أفضل زاوية ميل ذراع خرطوم الرى على المحور الأفقى و الذى يحقق تساوى فى معدل تصرف البشبورين (الداخلى و الخارجى) على نفس الخرطوم و كانت متغيرات الدراسة فى التجارب المبدئية : زوايا ميل مختلفة لذراع خرطوم الرى (0، 5، 10، 15 و 20) درجة ، نوعين من بشابير الرى (الصغير النقاط ، الرذاذ)، ثلاثة نسب سرعة دوران عجلة الرشاشة : السنتريك We (1:1، 2:1 و 4:1). و أوضحت نتائج التجارب المبدئية: انتظام معدل تصرف البشبورين لكلا النوعين (الصغير النقاط ، الرذاذ) على نفس خرطوم الرى عند زاوية ميل 10 درجة بينما تصرف البشبورى النقاط أكثر انتظاما عند We = 4:1 و للبشبورى الرذاذ عند We = 2:1. تم إجراء التجارب بإحدى صوب تحضين صوانى زراعة شتلات الخضر بقرية القطنة – بلقاس – محافظة الدقهلية (مارس /2019) عند متغيرات دراسية : ثلاثة نسب مختلفة لسرعة دوران عجلة الرشاشة: سنتريك نقل الحركة لرداخ الطلمبة We (1:1, 2:1 و 4:1) ، نوعين من بشابير الرى Nt (الصغير النقاط ، الرذاذ) ، ثلاثة مستويات لإرتفاع ذراع تثبيت خرطوم الرى عن سطح صوانى زراعة الشتلات H (13، 15 و 17) سم. ، و للحكم على أداء الرشاشة المطورة و كفائتها فى عملية رى صوانى زراعة الشتلات تم تقدير التصرف Q لتر/ثانية و رسم منحنى تشتت توزيع المياه على صوانى الشتلات، و أوضحت النتائج انتظام تصرف البشبورى ($6,3 \times 10^{-2}$ لتر/ث) و انتظام توزيع مياه الرى بزيادة We من 1:1 إلى 4:1 مع إرتفاع رى 13 سم لكلا نوعين بشبورين الرى ، و يوصى بإستخدام الرشاشة المطورة فى رى صوانى زراعة الشتلات لإجراء عملية الرى بسهولة و لضمان إنتظام تصرف و توزيع المياه.