EVALUAYION OF LOCAL POTATO PLANTER PERFORMANCE USING AUTOMATIC AND SEMI-AUTOMATIC FEEDING MECHANISM

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ABSTRACT

Two types of feeding mechanism namely automatic and semi-automatic were investigated to determine an appropriate system for potato planting under Egyptian conditions. The uniformity of seed distribution, performance rate, energy requirement and cost operation were investigated under different levels of operating speed. The results show that the uniformity distribution of seed spacing is a greatly affected by the forward speed of mechanical unit. The mean value of coefficient of variation increased with increasing travel speed. The lowest value of variation was obtained at forward speed of 2.0 Km /h with automatic & semi-automatic feeding mechanism. Increasing of forward speed of mechanical unit lead to increase the void tubers percentage under two feeding mechanisms.

INTRODUCTION

In Egypt, the primitive potato manual planting is still carried out, which consuming time, cost and non- uniformity distribution is expected. As it is well known that, Mechanical planting is very important in saving hand labor, improving production, and allowing further mechanization. Increasing and improving the potato production is considered the important goal. Therefore, many agriculture researches were carried out in order to increase potato production quality and quantity. **Abdo, (1985)** stated that, the mechanical of potato planting is considered as a positive factor to increase potato yield. The average potato yield increased(14.97%) using mechanical planting compared with manual planting.

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Kidokro and Yoneyama (1990) stated that, the mechanical of potato planting was satisfactory for planting depth, spacing, and reduced working times by approximately 35.5%. **Gupta et al.(1990)** showed that the labor requirements of plating potatoes was reduced by 90%, compared with the traditional method. **Arsenault et al. (1996)** showed that labor requirements for planting with the planter were 40-60% less than for hand planting. **Bagheri (2006)** evaluated potato planter performance by seed spacing, planter speed and seed depth. He pointed out that planter speed had consistent importance for achieving good planter performance. **Ismail (1991)** stated that, depth of planting has an effected on yield and deep planting may be reduce total yield. Depth of planting should be adjusted according to the soil conditions. Generally, he concluded that variations in depth within the normal range of 0 -7.5 cm blow ground level appear to have little effect. In this aspect the tuber should be covered with sufficiently deep layer of soil to protect the tubers from direct light (which causes them to become a green), from high temperature (second growth) and from insect damage.

Abd El-Maksoud et al. (2011) found that:

1- The green tuber percentage decreased from 0.25 to 0.0 and from 0.052 to 0.0 ton/fed as the planting depth increased from 3 to 7 cm for sponta and lady rosette varieties respectively.

2- The field capacities for all planters at the same travel speed were decreased with sensible rates by increasing either planting depth (3, 5 and 7 cm) or decreasing the essential planting

3- Increasing planting depth lead to decreasing field efficiency for all planter.

CIP (1993) state that potato is planted in a wide range of soil, it succeeds when planted in the light soils which consist of high level of organic matter. The ideal potato ridge width ranges from 65 to 0.90 m. They added that row might have a cross – sectional area of about 0.075 m2 and the distance within the row (0.25-0.3m) depends on other factors such as the yield, variety of potato and type of soil. **Kistanov and Oshrkov (2001)** used 70, 75 or 90 cm between rows, forward speed of 0.56 – 1.89

km/h and tuber spacing in row of 35, 70 or 105 cm planting depth was 4-12 cm the corresponding plant density was 20000 -40000 tubers/hectare.
El- sahrigi et al. (2003) the result can be summaries as follows:
1- The reliable operating stability factor (k =2) Was corresponding to draught requirements was 5.5 kW /row, as double –row flat ridge constructed at operate speed of 3.5 km/h and ridge deformation depth of 12 cm.

2- The highest seed spacing uniformity, the highest tuber yield and the maximum percent of desired shape quality were obtained when using cut instead of whole tubers, replacing cup instead of spoon cell, lowering the dropping height down to 10 cm and adapting the metering belt speed at 0.6 m/sec.

3- The less soil swept from both ridges a side was accomplished by planting cut tubers seed inside the double row flat ridge.

Ismail & Abou – Elmagd (1994) found that the operating cost of the automatic planter (cramer) was 20.7 LE/ fed compared with 12.4 LE/fed for the semi-automatic planter (local). **Siemens and Bowers (1999)** state that the fuel consumption is expressed as specific volumetric fuel consumption (4.0 kW.h) which is generally not affected by engine size and pointed out that for diesel engine typically it ranged from 0.24 to 0.56 4.0kW.h. **About EL-magd (2001)** reported that, the choice of potato planting system is of great importance that is because environmental condition are greatly influencing potato production quantity and quality. **Hanafi (2004)** state that, it is the number one pest of potato throughout the middle East and north Africa. It damages both foliage and tubers. Rainy winter period, but increase to significant levels during the hot and dry summer months. In the field, the potato tuber moth can damage up to 25% particularly if the harvest is delayed but in strong it can damage 100% of the tubers.

The main objective of this work is to investigate two systems of mechanical feeding mechanism to obtain the appropriate planting method for the Egyptian farmers .To achieve this objective a local potato planter include two feeding mechanisms namely automatic and semi-automatic was used in this investigation.

MATERIALS AND METHODS

The experiments were carried out on one feddan at the Experimental Farm of Faculty of Agriculture, Suez Canal University. Potato tubers of Nicola Varity were used in this study.

Physical properties of Potato Seed

Random sample of potato tubers were investigated to determine some physical properties as shown in table (1):-

Table (1**):** The physical properties of potato seeds

Dimensions	Range		Mean	C.V%
	Max	Min		
Length ,mm	44.0	129.5	80.88	16.46
Width, mm	38.5	73.0	55.37	11.42
Thickness, mm	31.6	64.0	45.96	12.56
Volume ,mm	45000	270000	108600	35.83
Mass, g	45.0	252.0	101.32	46.34
Geometric diameter, mm	44	80.1	58.8	11.73
Shape index – k	0.98	2.14	1.61	11.8

Potato planter

A locale potato planter (constructed at Institute of Agriculture Engineering, center of Agriculture Researches, Ministry of Agriculture) include two type of feeding mechanism (automatic and semi- automatic) was fabricated as show in Figs (1 and 2). It can be mounted on the three hitching point of the tractor 65 hp. The main specifications of the planter as the following:-

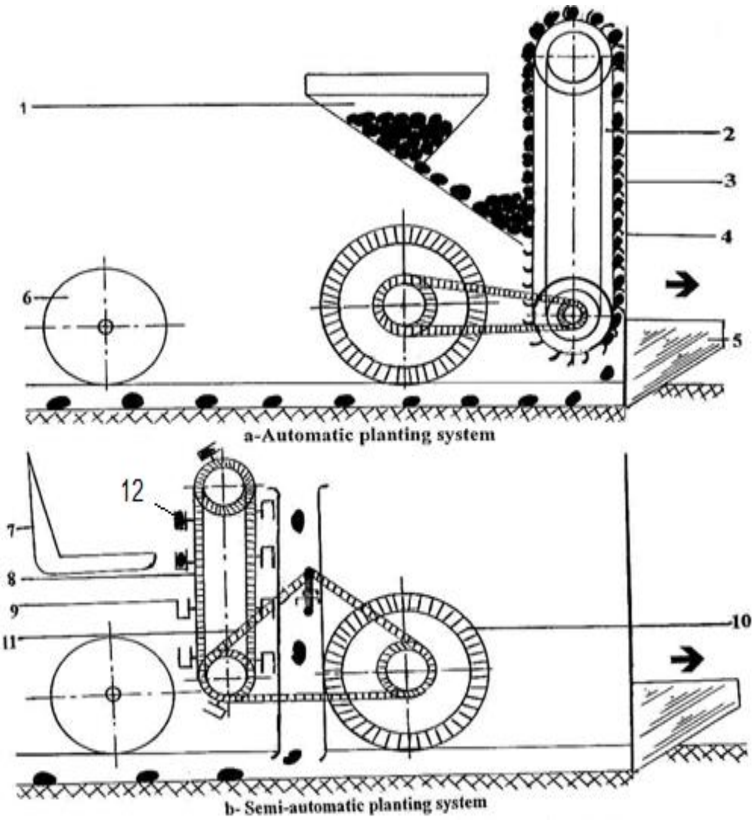
Automatic feeding mechanism

Feeding mechanism in automatic system is a belt with spoons as shown in Fig (1). The belt takes its motion from the ground wheel. The bottom of the seed hopper is opened in such a way that potato seeds flow easily to the spoons. Tubers are feeding from the hopper to the spoons which moving upward traveling by a controlled speed to adjust the planting space between tubers. On the downward travel of the belt the potato seed is held on the back side of the spoon until it is dropped into the furrow.

Semi- automatic feeding mechanism

Feeding mechanism in semi- automatic system is chain with cups as shown in Fig (2) The chain takes its motion from the ground wheels. The test unit have to place tubers in cups by the operator sitting on the machine. The cups moving upward by a controlling speed to adjust the planting space between tubers. On the down and as starts downward in its rotation, release the seed or force it off the point, dropping it into the seed spout, which guides it into the furrow made by the furrow opener. The mechanical unit of potato planting was adjusted to gave 25 cm between seeds in the row for two feeding mechanisms. The comparison between means of delivered seed was investigated at 25 m travel for different treatment of potato planting systems. In order to describe the seed distribution in the row, seed spacing, void tubers percentage and double tubers percentage were taken into consideration.

Fig.(1): photography view of the potato planter.



1- Hopper seeds 2- Belt- double spoon 3- Planting tube
4- Spoon 5- Furrow opener 6- Covering blade
7- seat 8- Chain with manual feeding- Operators
9- Cups 10- Ground wheel
11- Change feeding system from automatic and semi- automatic
12- Connecting point of cup with covering chain

Fig.(2): Schematic diagram of feeding mechanism of potato planter.

In order to describe the seed distribution in the row, seed spacing, void tubers percentage and double tubers percentage were taken into consideration. If the distance between two planted tubers was 40cm or more. It could be considered as void tuber. The percentage of void tubers (V_t) was calculated as follows.

$$V_t = (Nv / N) \times 100\%$$

Where:-

Nv: Number of tubers void at 25 m travel

N: Number of tubers delivered as adjustment of feeding mechanism at the same travel.

The double tubers percentage was calculated as follows:

$$D = (m/n) \times 100 \%$$

Where:-

D = Double tubers percentage.

M = number of double tubers in 25 m length.

The theoretical field capacity **(FC_{th})** for all treatments of mechanical planting was calculated using the following formula (Hanna et al. 1983).

$$FC_{th} = (S.\ W) / 4200 \qquad \text{fed /h}$$

Where:-

S: Travel speed, m/h

W: Rated width, m

The actual field capacity **(FC_{act})** for all treatments of mechanical planting was calculated using the following formula: -

$$FC_{act} = 60 / (Tu + Ti) \qquad \text{fed /h}$$

Where:-

Tu: utilized time, min /fed.

Ti: turning time, min / fed.

The field efficiency (n) was determined by using the following formula: -

$$M = (FC_{act} / FC_{th}) * 100 \quad \%$$

Fuel consumption was measured by common method for different treatments under experimental studies. The fuel tank was filled to full capacity before & after each treatment. The amount of refueling was measured by a gradated cylinder for each treatment. The rate of fuel consumption by the tractor for each treatment was calculated in L /sec.

Power Consumption ``P`` and operation time per unit area (fed) for different treatments were estimated according to the following formula : -

$$P = Fc * Fd * CV * (427 / 75) * 0.746 * \eta_{th} * \eta_m$$

Where:-

Fc: Rate of fuel consumed, L / sec

Fd: Specific density of solar, 0.85 Kg / L

Cv: Calorific value of fuel, 10000 Kcal / Kg

η_{th}: Thermal efficiency of engine considered to be 40% for diesel engine

η_{m}: Mechanical efficiency of engine considered to be 80% for diesel engine

potato tubers yield were collected and weighted to determine the lifted tubers (Lt) .Meanwhile, the burred tubers (Ult) in the soil bed were packed by hand in the same area (10m ^{2}) and weighted . The total yield (Yt) was calculated by using the following formula**:-**

$$\mathbf{Yt = (Lt + Ult) * 0.42 \text{ ton /fed}}$$

The cost of mechanical planting was determined according to the following formula

(Awady, 1978).

$$\mathbf{C = (P / A) (I / a + 1/2 + t + r) + (1.2 * w * s * f) + m /144}$$

Where:-

C = Hourly cost, LE /h P = Price of machine, LE,

A = yearly working, hours. a = life expecting of the machine, year.

I = Interest rate / year ratio, L =the taxes rate and over heads

R =Repairs & maintenance ratio. 1.2=Factor accounting for lubrication.

W =Power, hp. S = Specific fuel consumption

F = Fuel price, LE. M = the labor wage rate per month

144 = Monthly average working hours.

RESULTS AND DISCUSSION

Seed Spacing

The variation of range, mean, stander deviation(S.D.) and coefficient of variation(c.v.)of seed spacing for two feeding mechanisms at different levels of forward speed are shown in **Fig(3-a & 3-b).** It is clear that a little variation between two feeding mechanisms at the same level of forward speed. On the other hand, the mean value of seed spacing and coefficient of variation increased by increasing of forward speed of planting machine. This result may be due to increasing forward speed lead to increase in seed spacing as affected by planter wheel slip percentage, in addition to planter vibration increase with increasing the forward speed. The results indicated that, the percentage of seed deposited in spacing range from 20 to 30 cm was highly affected by traveling speed of planting unit under two feeding mechanisms . This mean that, the metering system is doing very well, seed precision and dropping it uniformity. Increasing forward speed from 1.2 to 2.0 km tends to increase the percent of seed spacing (20 to 30 cm) by 13.8% any increase of forward speeds from 2.0 to 3.7 km lead to decreased the percent of seed spacing (20 to 30 cm) by 46% for automatic feeding. On the other side, Increasing forward from 1.2 to 3.7 km /h tends to decrease the percent of seed spacing (20 to 30 cm) by 51.7% for semi-automatic feeding.

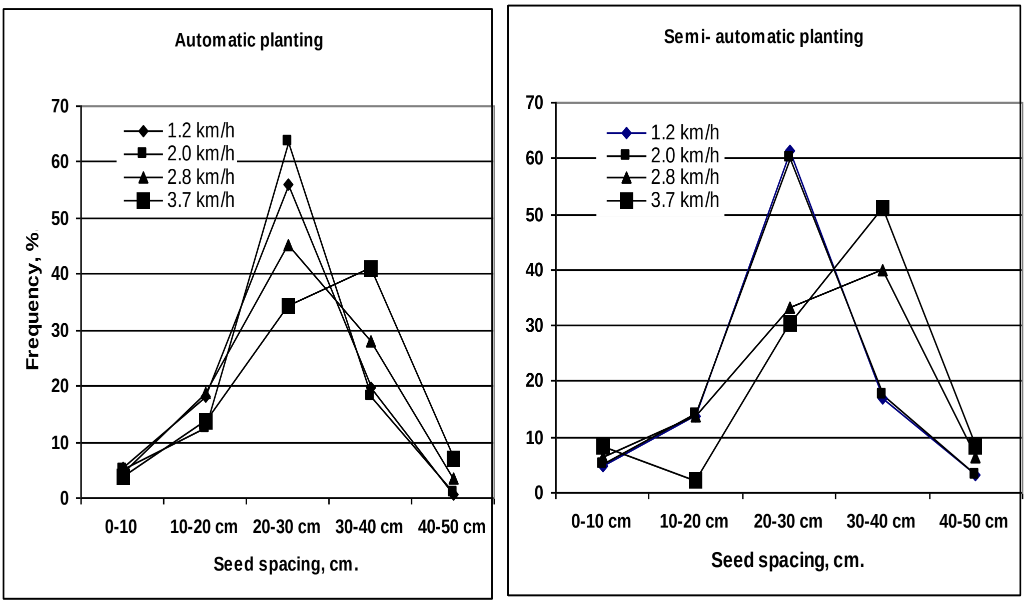


Fig.(3): The seed spacing frequency

Void tubers percentage

Fig. (4) revealed that, increasing of forward speed of mechanical unit lead to increase the void tubers percentage under two feeding mechanism . It is may be due to increasing of forward speed is followed with an increase in the miss percent of feeding device. The semi-automatic feeding mechanism recorded the highest values of void tubers percentage, which ranged from 3.23 to 8.33% followed by automatic feeding mechanism which ranged from 0.79 to 3.6 % when forward speed increased from 1.2 to 3.7 Km /h respectively. This result may be due to the linear velocity of feeding device is high as compared with velocity of feeding operation for labor . The manual planting system recorded the lowest value of void tubers percentage as compared with average value of mechanical planting system. As a result, the manual planting decrease the void tuber percent by 1.2 and 3.52 % compared with the average of mechanical planting system under automatic and semi-automatic feeding respectively.

Double tubers percentage

The results in Fig (5) showed that Increasing forward speed of mechanical unit lead to decrease the double tubers percentage under automatic & semi-automatic feeding. The semi-automatic feeding mechanism recorded the lowest percents of double tubers as compared with automatic feeding at different forward speeds of mechanical unit. The double percent decreased with automatic feeding by 37% and with semi-automatic feeding by 67.8% when forward speeds increased from 1.2 to 3.7 Km /h. The manual planting systems decrease the double tuber percent by 2.94 and 1.25 % compared with average value of automatic & semi-automatic feeding mechanism respectively.

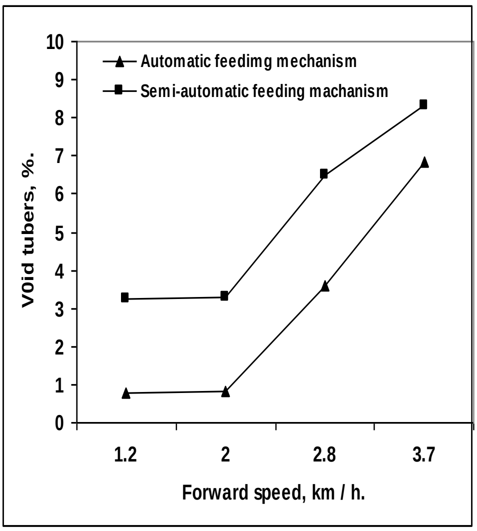


Fig.(4): Effect of forward speed on void tuber.

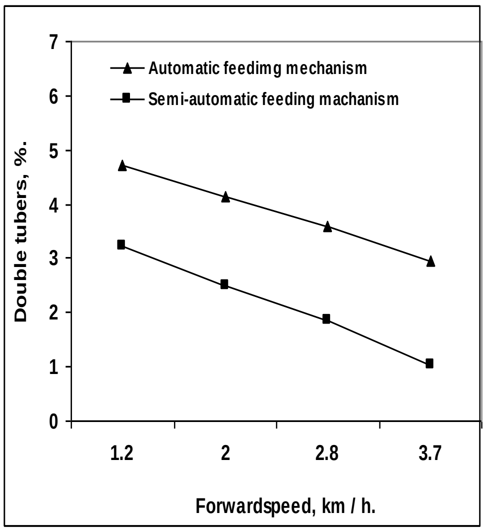


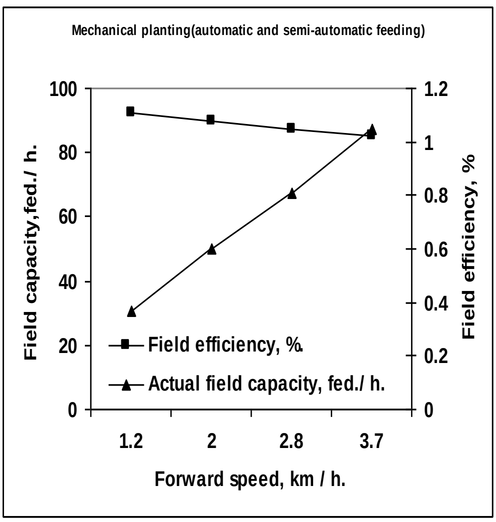
Fig.(5): Effect of forward speed on double tuber.

Field capacity & efficiency

The actual field capacity of mechanical planting system increased from 0.37 to 1.05 fed/h when the forward speed increased from 1.2 to 3.7 Km/h . This might be revealed to the decrease in the required time for planting as a result of increasing the speed at the same lost turning time per unit area (fig.6). The field efficiency of mechanical planting system decreased with increasing the forward speed . This may be due to the increasing rate of the actual field capacity was smaller than the increasing rate of the theoretical field capacity. The maximum value of the field efficiency of the mechanical unit was 92.5% at forward speed of 1.2 Km/h, while the minimum value was 85.36% at forward speed of 3.7 Km / h as shown in Fig.(6).

Fuel Consumption

The results in Fig. (7) indicated that increasing forward speed lead to increase the fuel consumption rate L/h and decrease the fuel consumption rate l/fed. The highest fuel consumption rate (9.84 L/h) and lowest fuel consumption rate (9.35 L/fed) was obtained at forward speed of 3.7 km/h. Meanwhile the lowest fuel consumption rate (4.69 L/fed) was obtained at forward speed of (1.2 and 200 km/ h) respectively. This result may be due to increasing forward speed of mechanical planting lead to reduce the performance time required for unit area.



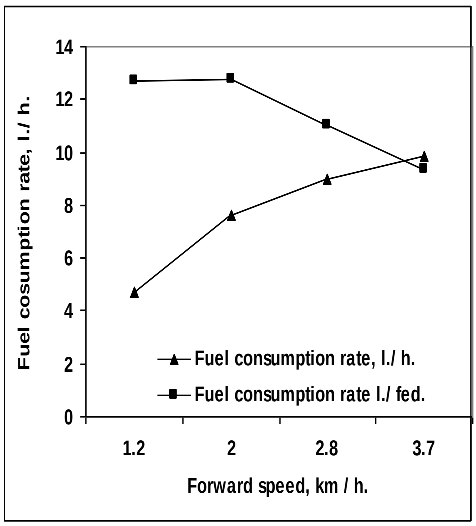


Fig.(6): Effect of forward speed on the field Capacity and field efficiency for mechanical Planting operation.

Fig.(7): Relation between fuel consumption and forward speed for mechanical Planting operation.

Power and Energy Requirement

The results in (Fig. 8) revealed that the power requirement for mechanical planting increased and energy requirement decreased with increasing of forward speed .The power increased by 107.66% when the forward speed increased from 1.2 to 3.7 Km/h. On the other hand, the energy decreased by 26.93 % when the forward speed increased from 1.2 to 3.7 Km/h.

Tubers Yield

The results in (Fig.9) indicated that increasing forward speed lead to decrease of tubers yield under two feeding mechanism, automatic and semi-automatic. This may be due to increase of void tuber and seed spacing percentage by increasing of forward speed as mentioned previously in Uniformity of seed distribution . The highest value of tubers yield was obtained with automatic feeding mechanism and different levels of forward speed as compared with semi-automatic feeding. The result also showed that the yield of potato tubers is highly affected by mechanical planting compared with manual planting. The tubers yield increased by 18.97 % and 7.19 with automatic and semi-automatic feeding as compared with manual planting respectively.

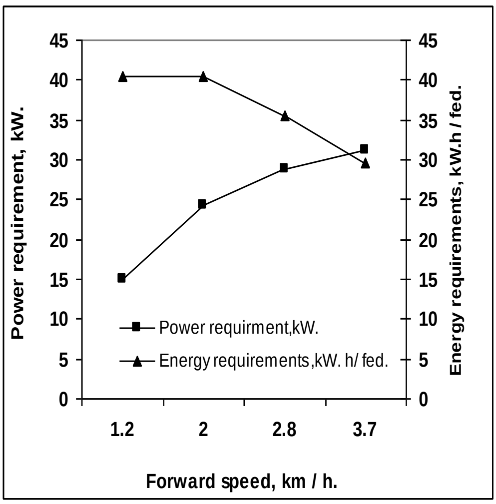


Fig.(8): Effect of forward speed on power Requirement for mechanical planting.

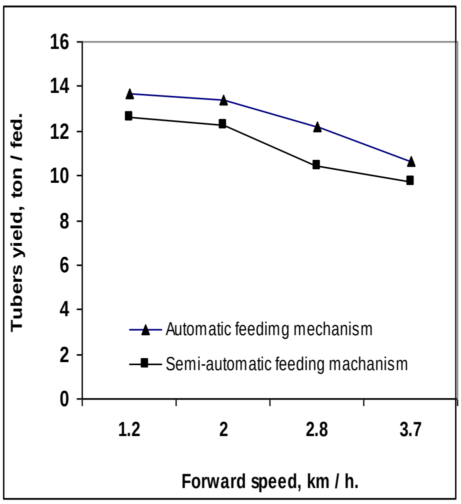


Fig.(9): Effect of forward speed on tuber yield for mechanical planting.

Operation Cost

The result in Fig (10) showed that, increasing forward speed lead to decrease the cost of planting operation under two mechanical feeding mechanisms. The mechanical planting system of potato reduced the cost of planting operation by 52.08% when compared with manual planting.

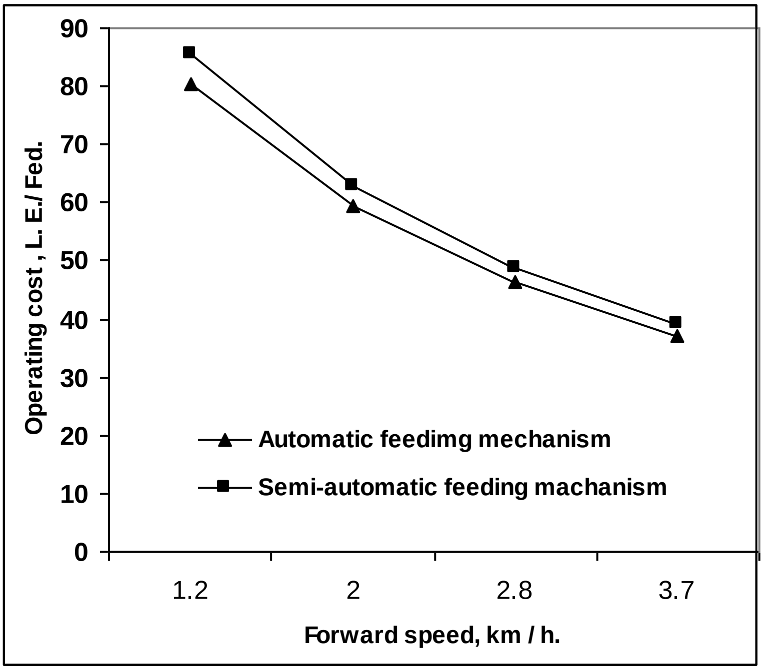


Fig. (10): Effect of forward speed on the operating cost for mechanical planting operation.

SUMMARY AND CONCLUSION

The result in the present study could be summarized in the following conclusion:

1- The dimensions of potato tuber varied from 44 to 129.5 mm with mean value of 80.88 mm in length and from 38.5 to 73.0 with mean value of 55.37 mm in width, and in thickness from 31.6 to 64.0 mm with mean value of 45.96 mm. These three principal tuber dimensions are very important when selecting the suitable cell (cup or spoon) for mechanical feeding.

2- Uniformity distribution of seed spacing is greatly affected by forward speed of mechanical feeding. Increasing forward speed of mechanical unit lead to increase the void tubers percentage under two feeding mechanism. The lowest value of void tubers was obtained with automatic feeding mechanism which was recorded 0.79, 0.83, 3.6 and 6.86 % at forward speed 1.2, 2.8 and 3.7 Km /h.

3- The field efficiency of mechanical planting system was highly affected by the forward speed. The maximum value of field efficiency was 92.5% at forward speed of 1.2 Km / h, while the minimum value was 85.36 % at forward speed of 3.7 Km/h. The energy requirement for the mechanical planting was less than the manual planting system .the mechanical planting system, save 91.25 of energy compared with manual planting.

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الملخص العربي

تقييم آداء آلة زراعة بطاطس محلية
باستخدام نظامى تلقيم أتوماتيك ونصف أتوماتيك

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أجريت الدراسة بغرض تحديد أنسب نظام لزراعة البطاطس تحت الظروف المصرية. حيث تم دراسة ميكانيكية التلقيم الآلي والنصف آلي باستخدام آلة زراعة بطاطس محلية الصنع تشتمل على نظامين (آلي ونصف آلي). أجريت التجربة العملية في مزرعة كلية ألزراعه على صنف نيقولا والتي يتم توزيعها بواسطة وزارة ألزراعه. وتشير النتائج إلأتى:-

١- انتظام التوزيع للمسافات البينية بين الدرنات تتأثر كثيرا بالسرعة الأمامية لآلة ألزراعه. القيمة المتوسطة لمعامل الاختلاف زادت مع زيادة السرعة الأمامية وسجلت أقل قيمة مع سرعة التشغيل ٢ كم/س مع نظامي التلقيم الآلي والنصف آلي.

٢- زيادة السرعة الأمامية لآلة ألزراعه أدت إلى زيادة النسبة المئوية للجور الغائبة وزيادة السعة الحقلية للآلة ونقص لكفاءة الحقلية للآلة. تحت نظامي التلقيم الآلي والنصف آلي.

٣- نظام ألزراعه الآلية للبطاطس أدت الى زيادت محصول الدرنات بنسبة ١٨,٩٧، ١٩,٧% مع نظامى التلقيم الآلي و النصف آلى على التوالى بالمقارنة بالزراعة اليدوية.

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