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Flow of seeds in 4-bar seeder metering device

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Abstract

The aims of this study are to investigate factors relevant to design of a 4-bar feeding device, to accept a variety of seeds including: maize, wheat, sunflower, peas and cotton. Study included: a computer program to draw the mechanism in different configuration. Machine speed; wheel slip; and construction of agitator were also studied. The main results can be summarized in the flowing points:

-The appropriate 4-bar proportions are: 1.0, 1.5, 1.6, and 1.73 for crank, swing rod, con. rod, and base respectively.

-The average forward walking speed was 3.5-4 km/h.

-Hopper was found to need an agitator device, to regulate seeds distribution for big seeds like maize, sunflower and peas.

-Metering device could be used in small grains, like wheat without agitator (with only 1.19 % missing spaces).

-The relationship between furrow depth and wheel slip was as follows:

$S = 0.1802x + 1.3359$, where "S" slip %, "x" depth cm.

-In cotton seeds "Giza 86", it was found that the best feeding rate for coated cotton seeds (6 seeds/hill) is at gate height 2 cm, with 6.72% ratio of missing hills, comparing to uncoated seeds (up to 58.5%).

1- Introduction

Planters are still not common in Egypt, although manual planting is a tedious work. This is because most of the Egyptian farms are small and divided into small plots, in addition to the high expense of machine operation in small farms.

Mechanized planting is very important because:

-The burden and drudgery of farm work is reduced and the output per worker is greatly increased.

-Mechanization encourages a better management of farm.

-Overall cost reduction as a result of mechanization.

-Uniformity of plant- population, placement of seeds depth, and spacing, leads to 10% saving in seeds (Abo Sabe, 1956, Awady 1994).

- Ease of mechanization of row-crop operations to follow.

-Possibility of adding chemicals or pesticides to seeds.

-Possibility of adding machine attachments likes fertilators, and tillers in combined machines.

This investigation aims to study the following:

-Design and construction possibilities of a new metering device based on 4-bar mechanism.

-Performance of seeder metering device, for producing a small seeder (one row, hand pushed, and cheap) for small farms.

-Physical and mechanical properties (dimensions of seed, coefficient of friction, and angle of repose), to serve in developing the planter prototype.

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II- REVIEW OF LITEATURE

Awady (1979) stated that the static and kinetic coefficients of friction of agricultural materials must be determined to serve particular applications. The usual methods include tilting of an inclined plane. A paper cylinder full of grain mounted on a tilting top is used to determine the angle of repose for grain. The tabletop is tilted until the grain begins to move down the inclined surface. The angle of the inclined grain surface is then measured as the angle of repose for particular sample.

Khurmi and Gupta (1997) mentioned that according to Grashof's law for a 4-bar mechanism, the sum of the shortest and longest link lengths should not be greater than the sum of the remaining two link lengths if there is to be continuous relative motion between the two links.

Kohli and Agrawal (1993) stated that a method has been proposed for optimization and dynamic analysis of a transplanting unit for a paddy (rice) transplanter. It has been also shown that determination of pin forces, link forces, and shaking forces are necessary for good design of the mechanisms as a whole. An improper design affects the performance of the system. Results are given from the use of kinematics and dynamic analysis. The article presented a method for design of a multi-row paddy-transplanter with main emphasis on structural and kinematics design for seedlings raised by the conventional method.

Awady (1996) suggested using a 4-bar mechanism in some applications such as: traction, tillage, agitation, winnowing and sieving, reciprocating feeder, and transplanting mechanisms. He developed a "Q-basic" program to trace animated motion of the mechanism to select the most suitable paths.

Yangkui et al. (1996) described a computer simulating and analyzing system for of rice transplanting mechanism with four bar linkages.

Cotton seed treatment:

Awady (1970) mentioned that the delinting of fuzzy cotton seeds is required for passage through the regular planter mechanism, and as a result, more uniformity of distribution will be expected.

Ghosh and Awady (1973) coated six 150 g samples of cotton seeds with starch (in solution) concentrations by weight of 0.08, 0.17, 0.33, 0.67, 1.34 and 2.68%. Finely ground commercial starch was mixed with 25 ml of boiling water. The seeds wereadded to the cooled liquid and mixed vigorously for 5 min before sun drying in thin layer. In the first 3 samples the amount of starch appeared to be insufficient to provide a smooth and even coating, while the last 3 produced individually coated seeds with good flow characteristics. Coating with mud showed good possibility.

III-MATERIALS AND METHODS

(PC) computer:

A "PC" (P III, 750 MHz). was used to elaborate the suitable drag tracks of the 4-bar model as shown in flow-chart (diagram 1). "QBASIC" was used in electronic modeling of mechanisms. The program depends on Inputting of dimensions of bars to draw the 4-bar mechanism and the path of a shovel end by trial and error.

Seeder design:

The seeder is hand pushed of a single-raw design. It was constructed in "Emagro, Tanta Motors Factory" according to the design made in this study. The view of the machine is shown in (Fig. 2).

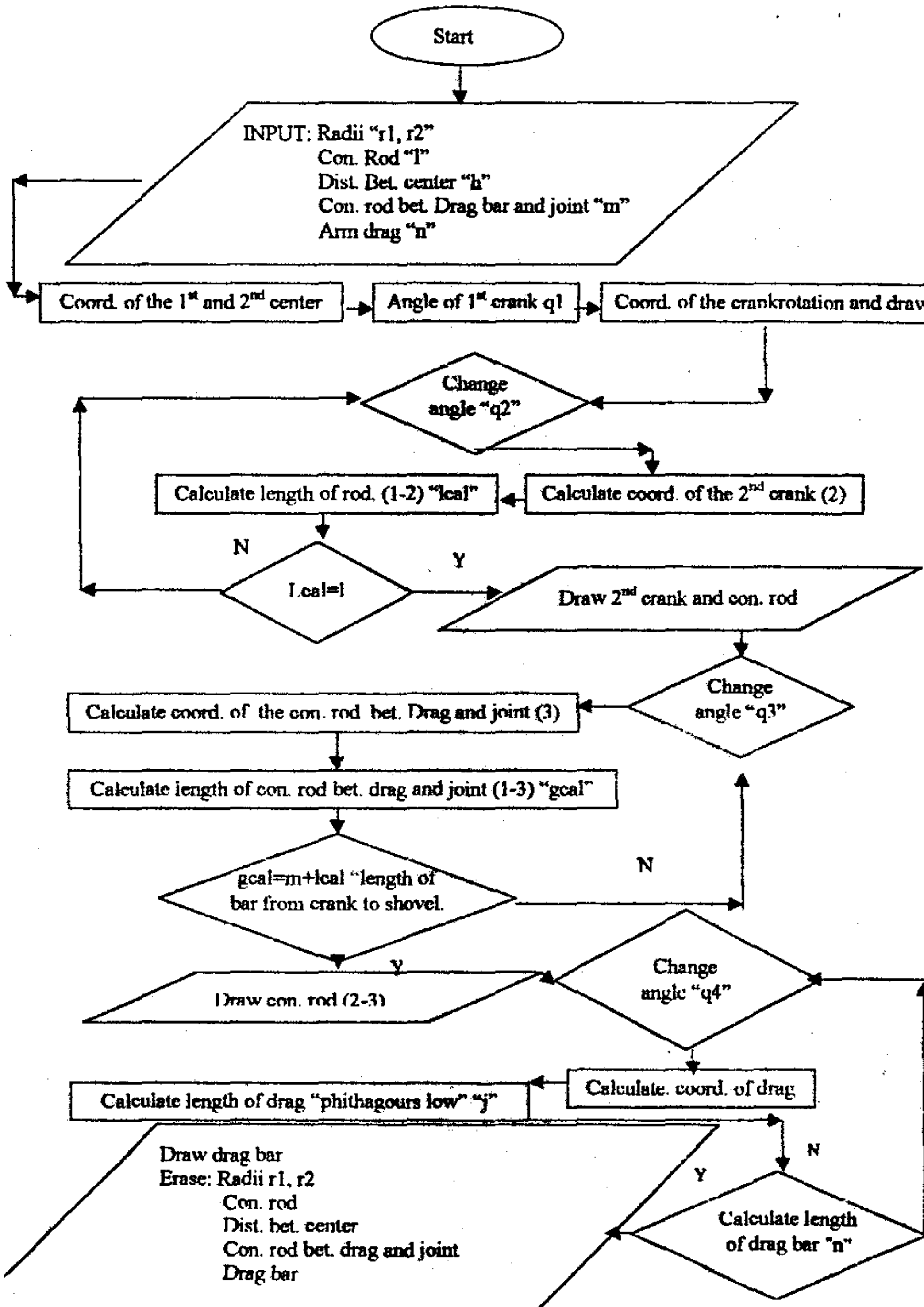

Fig. 1: Flowchart of drawing and animation for 4-bar mechanism. (Trial and error, Awady 1996)

The main machine parts are as follows:

Feeding mechanism: The feeding mechanism box (Fig. 3) was built from steel sheet "1 mm" thick of "16.5 cm" height, "23.5 cm" length and 2.2 cm width. The feeding box is mounted on the frame by bolts. The feeding mechanism has a 4-bar structure. It was made of steel plates of "1.5 cm" width and "2 mm" thickness (Fig. 3).

The 4-bar mechanism dimensions are shown in (Fig. 3).

Agitator devices (Shaking base): was made from spring steel sheet, as shown in (Fig. 3). When the metering shovel is down to drag seeds, it touches with spout base, thus shaking it to ease flow. A sponge pad is layed below the base to prevent seed intrusion underneath. A spring provided flexibility to the base shaking.

Frame and Handles: The frame was made of steel angle-sections 4×4 cm x 4 mm, (Fig. 2). Two handles were made to push the seeder during operation. The handles were made of steel tubes 25-cm diameter with adjustable height through a swivel.

Seed hopper: The seed hopper is illustrated in (Fig. 3). It volume capacity is 0.029 m^3.

Furrow opener: Hoe furrow opener has a slot for adjusting the furrow opener depth, and max. depth 6 cm (Fig. 2).

Covering wheel, Ground Wheel: as shown in (Fig. 2).

Transmission: The front ground wheel drives the feeding mechanism through belt and pulleys. The speed ratios can be changed through three different pulleys 16, 18, and 20 cm-dia., mounted on the ground wheel. The driven pulley of "4 cm" dia. is mounted on the metering device. The belt is stretched through a slot on the frame.

Electric drive motor:

An electric motor of " 1/3 hp" (0.25 kW) and 1440 rpm was mounted on the frame to drive the mechanism, lifted off ground, during lab tests, for variable speed.

Methods of measurements:

Experiments were carried out to find factors affecting feed rate, seed damage and seed distribution on furrow, as follows:

(1) Seeds: different seeds and kernels included been, maize (corn), sunflower, wheat, peas, haricot and cotton.

(2) Feeding mechanism: four feeder speeds included 84, 94, 104 and 144 rpm for lab tests.

(3) Different gate-height openings were used depending on the kind of seeds or kernels. In laboratory study, three-gate heights (0.5, 1 and 1.5 cm) were used.

Gate opening:

Gate height affects feeding rate. The metered seeds were collected and weighed by using an electronic balance.

Seed damage and germination:

With the previously-mentioned factors, damaged seeds were sorted manually and weighed. The percentage damage was calculated, related to the seed discharge. One hundred seeds of maize, sunflower seed or peas were germinated to give the real germination ratio before passing through the feeding device. The actual germination ratio of seeds after passing through the feeder was calculated by the following equations (Yahia, 1993).

Actual germination % = Germination % of unused seed - (Visible seed – damage % + invisible seed damage %).

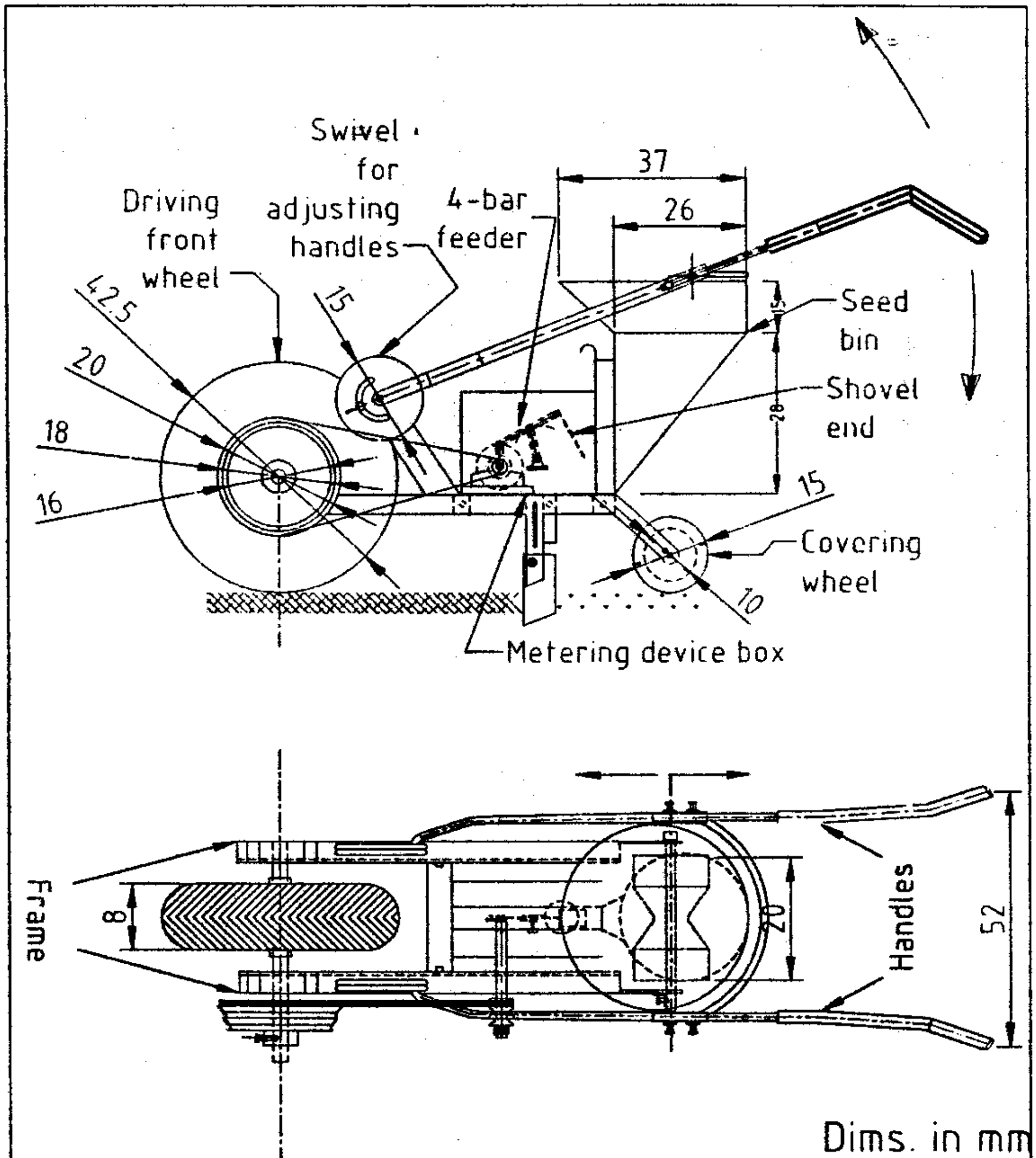

Fig. 2: Planter views.

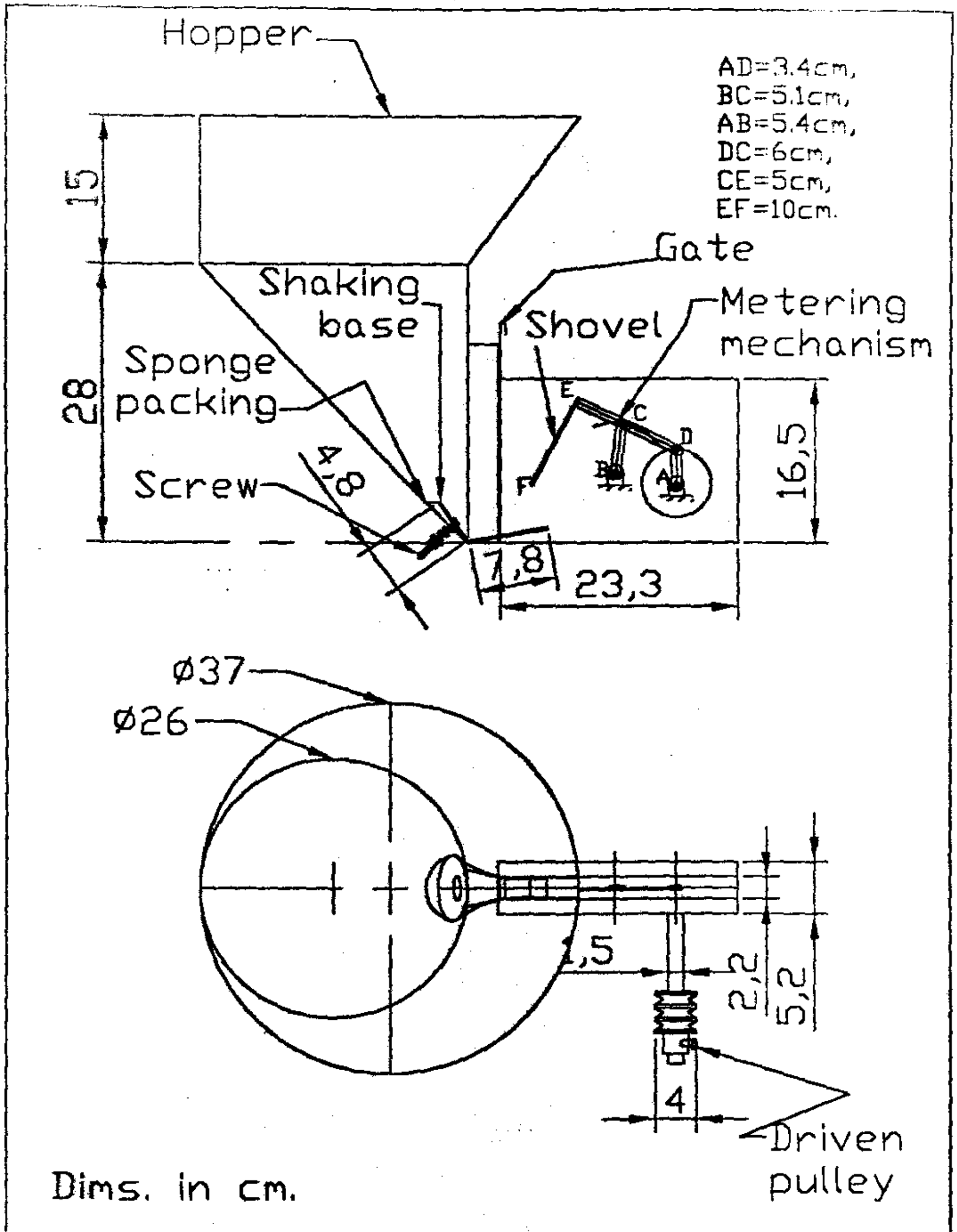

Fig. 3: Hopper , metering device and shaker.

Visible seed damage %=(Weight of damage seeds / Total weight of seeds) x 100.
Invisible seed-damage % = (No. of shoots / Total No. of seeds) x 100.

The germination tests were simultaneously done for all treatments, where they were provided with necessary water for germination. There was no control on temperature during these experiments. The main objective of the germination test was to detect the loss in seed germination if any, due to the passage through the feeding mechanism.

The plant shoots were counted after fifteen days from planting.

Seed-distribution on furrow:

For each feeder speed, the seeds received on the soil furrow were counted to determine the longitudinal seed distribution. Missing hills were calculated in field by measuring the distance between seeds emergence on a row. When the distance >= 1.5 time of the calculated spacing between hills, then it was considered missing. In cotton seeds, when the number of seeds <= 2 seeds, it was considered as missing hills.

Wheel slip:

Slip percent was estimated from both theoretical distances (L_{th} = No. of turns x (22/7 x diameter of wheel), and actual distance L_{ac}. The slip percent was calculated by using following relation (Awady, 1992).

$$\text{Slip \%} = [(L_{ac} - L_{th}) / L_{th}] \times 100$$

Treatment of cotton seeds:

Cotton seeds "Variety Giza 86" were used for current study. Seeds were coated with soil, 300 g of which were put in a jar and then the required quantity "80 g soil" added with 50 cm^3 of water. The mixture was manually stirred for about 5-10 min and then the seeds were air-dried according to (Awady et al., 1973).

IV- RESULTS AND DISCUSSION

Computer–aided study on 4-bar mechanism:

Computer was used to draw paths by "Qbasic Graphics". Suitable path of bar end was obtained by changing the ratio between bars. A sample such path is shown in (Fig. 4). When the shovel end drags seeds from hopper to seed tube, the path is

r1 = 34 mm, r2 = 51 mm, L = 54 mm, h = 60 mm, m= 40 mm, n = 60 mm.

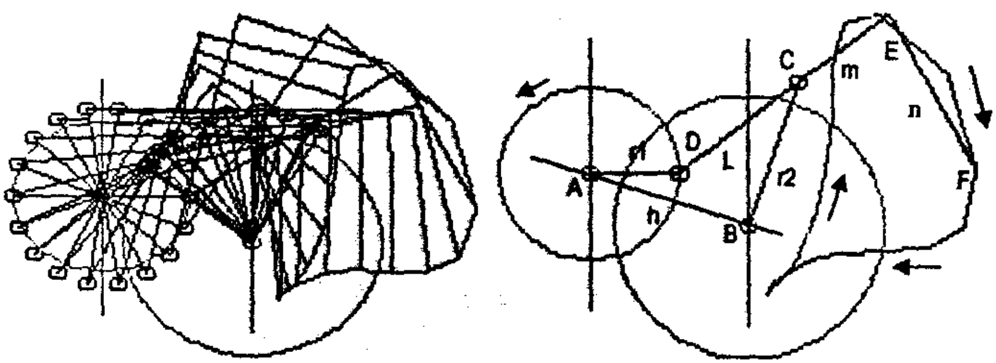

Fig. (4): Modeling of 4-bar mechanism.

selected horizontal, to shove off seeds. The two paths shown in (Fig. 4) are suitable in this sense. Suitable 4-bar proportions are: 1: 1.5, 1.6, and 1.73 for crank , swing bar, con. rod and base respectively.

Manually pushed machine-speed:

The forward machine speed range was found 3-6.5 km/h.

Field study on uniformity of seeds placement:

Effect of gate height on seeds placement (without agitator):

Figs. 5 and 6 show feeding rate/hill at different gate heights for maize and wheat. The frequency curves indicate that when height of gate increased:

-Feeding rate per hill increased (In maize, feeding rate/hill increased from zero to 4 seeds/hill, when the gate height increased from 2.5 to 3 cm).

-The ratio of missing hills decreased (In maize, the ratio of missing hills decreased from 61.73% to 17.85% when the gate height increased from 2.5 to 3 cm).

-Hopper needed an agitator to regulate the longitudinal seeds distribution.

-Metering device could be used in small grains like wheat (Missing hills 1.19%) without agitator (Fig. 6).

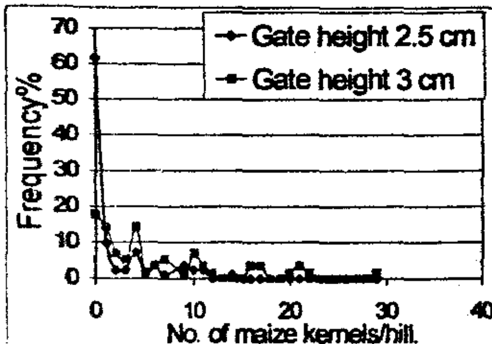

Fig. 5: Effect of gate height on longitudinal maize kernels distribution.

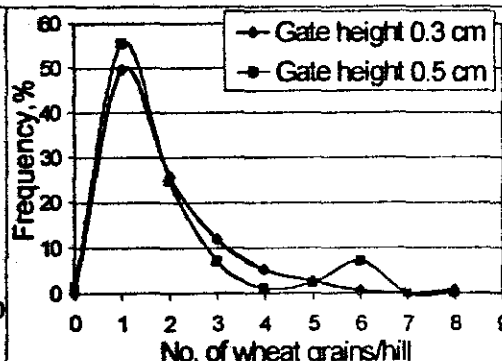

Fig. 6: Effect of gate height on wheat grains distribution.

Shaker base:

Laboratory study on metering rate:

Figs. 7 shows the effect of metering device speed on number and weight of maize kernels at different gate heights. The curve indicates that:

-The weight of fed seeds increased with gate height.

-The feeding rate slightly decreased with speed up to about 100 rpm, due to slow release of seeds from gate. Afterwards, the rate increased sharply due to enhanced shaker action at higher speeds.

Data in table 1 show the maximum visible damage for seeds types.

Table 1: Maximum seed visible damage.

Seed	Metering speed,rpm	Gate height,cm	Max. visible damage%
Maize	94	1	0.94
Peas	94	1	1.736
Sunflower	144	0.5	9.247

Data in table 2 show the recommended metering speeds and gate heights for number of seeds per hill and visible damage %.

Table 2: Recommended metering speed and gate height.

Seed	Metering speed, rpm	Gate height, cm	No. of seeds/cycle	Mass of seeds g/cycle	Visible seed-damage %
Maize	94	1.5	1.87	0.53	0
	104	1	2.25	0.65	0
		1.5	2.59	0.76	0
Sunflower	84	1	2.09	0.16	0.95
	94	1.5	2.3	0.2	0.5
Peas	104	0.5	1.66	0.32	0

Effect of shaker base on seeds distribution:

Figs. 8 through 10 show the effect of shaker base on pea and cotton seeds "Giza 86" in feeding rate/hill at different heights. The frequency curves indicate that the ratio of missing hills decreased, with gate height. Shaker base made seeds distribution more uniform. The ratio of missing hills vanished.

Data in Fig. 8 show the effect of shaker on pea seeds distribution. Increasing gate height from 1 to 1.5 cm decreased the ratio of missing hills from 4.26% to 3.45%. Single seeds are most frequent at "1 and 1.5 cm" gate height. The 50% median was 1.43 and 5 seeds at 1 and 1.5 cm gate heights respectively. Consequently, 1-cm gate height is preferred than 1.5 cm.

Tests were run to show the ability of shoving mechanism in fuzzy cotton seeds. Figs. 9 and 10 show the difference in distribution between uncoated and coated cotton seeds at different gate heights. Ratio of missing hills decreased with coating. For example: ratios of missing hills at 2-cm gate height were 58.46% and 6.72% in uncoated and coated seeds respectively. The more frequent rates were at 2-cm gate height of 7 and 1 seeds per hill for coated and uncoated cotton seeds.

In the cotton seeds "Giza 86", it was found that the best feeding rate for coated seeds (6 seeds/hill) was at gate height of 2 cm, with ratio of 6.72% missing hills.

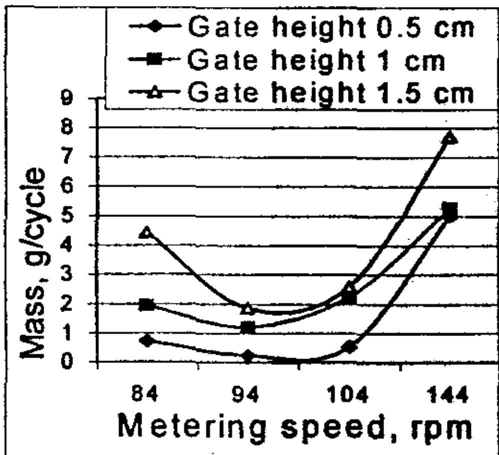

Fig. (7) Effect of metering speed and gate height on mass of maize seeds/ cycle.

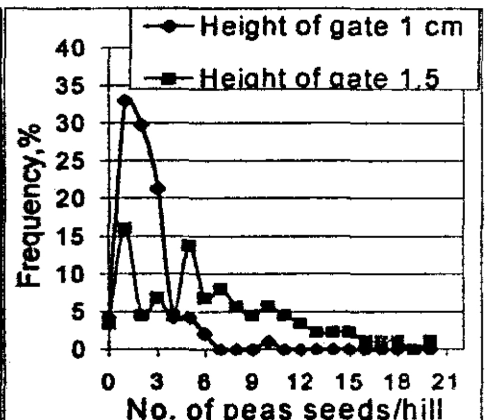

Fig. (8) Effect of shaker base on uniformity of pea metering at two gate heights.

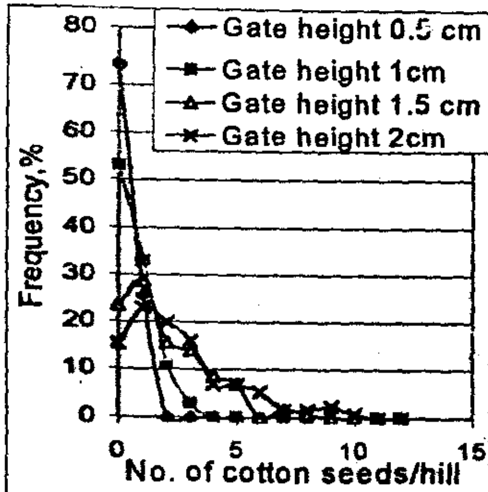

Fig. 9: Effect of different gate heights on fuzzy cotton seeds feeding /hill.

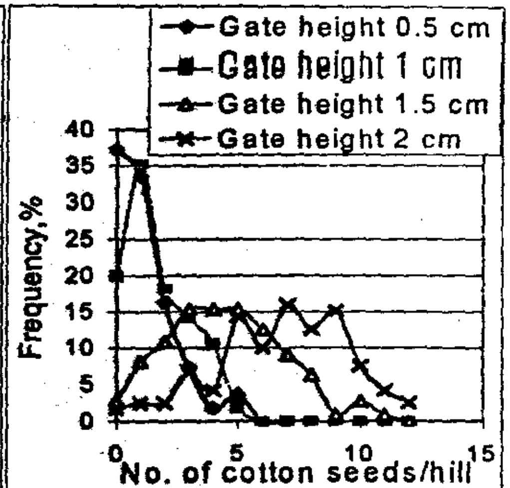

Fig. 10: Effect of different gate heights on coated cotton seeds feeding /hill.

Seed emergence in field:

Emergence of seeds run without agitator:

Fig. 11 shows distribution of wheat plant in sandy soil. The data show missing hills of 4 %. The metering device can be used with small like wheat seeds without agitator.

Effect of shaker base on seed emergence in field:

Fig. 12 shows emergence of maize with shaker. Planter and control missing hills were 27.08 and 22.22 % resp. So, the actual ratio of missing hills 4.86 % (27.08%-22.22%) at 1 cm gate height. Single plant is more frequent at 2 cm gate height.

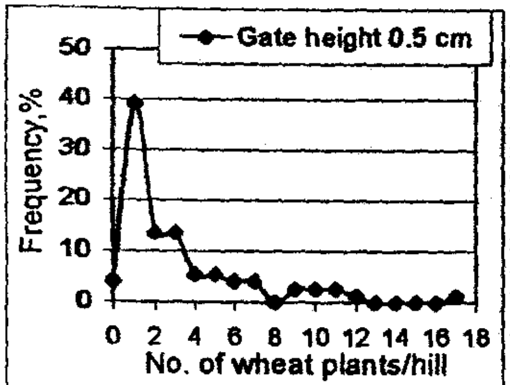

Fig. 11: Wheat emergence along furrow in sandy soil.

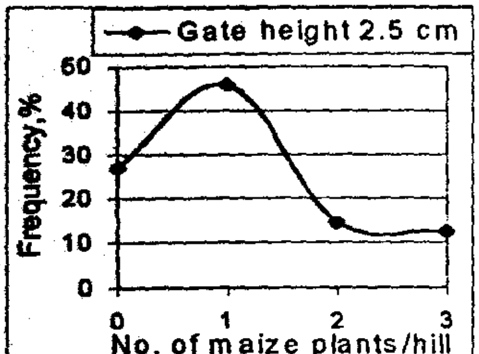

Fig. 12: Maize plants distribution along furrow with shaker.

Wheel slip:

Fig. 13 shows average wheel slips at different furrow opener depths (3 and 6 cm). The figure indicates a positive linear relationship between wheel slip and furrow depth. The greatest wheel slip ratio was 2.42% at 6 cm furrow depth.

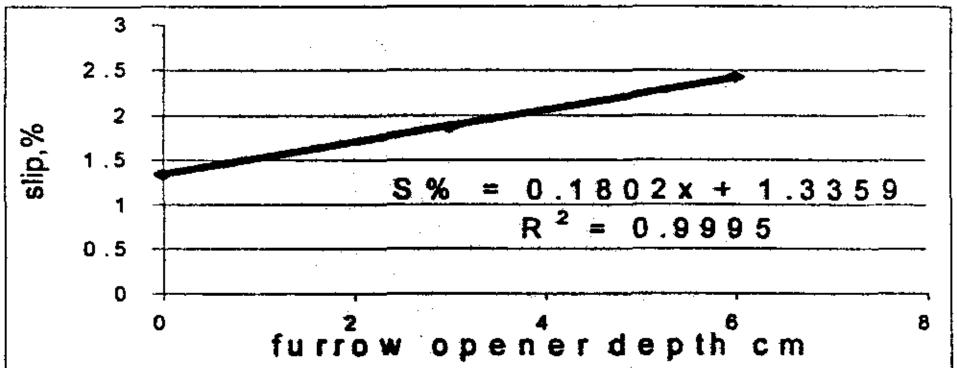

Fig. 13: wheel slip.

V-CONCLUSION

- The 4-bar mechanism his proportions are: 1.0, 1.5, 1.6, and 1.73 for crank, swing rod, con. rod, and base resp., could be used as metering device in small seeds like wheat without agitator. A shaking base could be used instead of agitator.
- In the cotton seeds "Giza 86", it was found that the best feeding rate was set by a gate height of 2 cm, at which missing hills ratio was 1.68% and the mode was 5 seeds/hill with shaker base.
- For maize, sunflower and peas, with a feeding rate 1-3 seeds/hill, the appropriate conditions were: feeding speed 80-100 rpm, feeding-gate height 0.5-1.5 cm. The visible damage in such conditions was within 1%.

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VII–الملخص العربي

سريان البذور في جهاز تلقيم لآلة بذار

أ.د./محمد نبيل العوضي* د./متولي عباس حمادة** د./عبد الفضيل القبان*** م./وليد كامل محمد سالم الحلو****

تم تصميم آلية رباعية الأضلاع كجهاز تلقيم ضمن آلة بذار يتم دفعها يدويا، و يتم التحكم في معدل التلقيم عن طريق البوابة، وتتلخص أهم النتائج المتحصل عليها فيما يلي:

-من خلال برنامج التحريك للآلية الرباعية كانت أفضل نسبة بين الأضلاع المستخدمة في هذا البحث هي: للمرفق ١، للمرفق التابع ١,٥، ذراع التوصيل ١,٦، القاعدة الثابتة ١,٧٣.

-يمكن استخدام الآلية الرباعية كجهاز تلقيم بدون مقلب مع البذور و الحبوب الصغيرة في حور.

-يفضل استخدام هزاز يكون قاعدة مخرج صندوق البذور وعتبة البذور كوسيلة لتحريك البذور.

-عند استخدام جهاز التلقيم في وجود الهزاز مع القطن وجد أنه من الأفضل استخدام القطن المغطى بالطين مع ٢ سم ارتفاع بوابة ، فقد قلت نسبة الجور الغائبة إلى ٦,٧٢% وكان المتوسط ٦ بذور لأعلى تكرار.

-وقد وجد أن أفضل سرعة لجهاز التلقيم التي تعطي أقل نسبة كسر هي كالتالي:

نوع البذرة	سرعة جهاز التلقيم ل/د	ارتفاع البوابة سم	كتلة البذور بالجرام/لفة	معدل التلقيم بالبذور/لفة	الكسر الظاهري %
الذرة	٩٤	١,٥	٠,٥٣	١,٨٧	صفر
	١٠٤	١	٠,٦٥	٢,٢٥	صفر
		١,٥	٠,٧٦	٢,٥٩	صفر
عباد الشمس	٨٤	١	٠,١٦	٢,٠٩	٠,٩٥
	٩٤	١,٥	٠,٢	٢,٣	٠,٥
البسلة	١٠٤	٠,٥	٠,٣٢	١,٦٦	صفر

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