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# Development and evaluation of Pakistany "Naeem drill" for barley grains

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**Abstract**

*The aims of this study is to develop and evaluate a simple constructed seed-drill imported from Pakistan as an accepted technology for Egyptian workshops and farmers. The main results in this study can be summarized in the following points:*

- *Discharge (per revolution of device) of barley grains decreased with the feeder speed.* At different gate-openings 10, 20, 30, and 40 mm, this discharge decreased by 4.94, 2.55, 1.29, and 0.8 % respectively, when the speed was increased from 20 to 50 rpm (from 0.097 to 0.259 m/s feeder speed).
- *The visible damage of barley grains increased and germination decreased as the feeder speed increased for all gate-openings.* In laboratory tests, increasing feeder speed from 0.097 to 0.259 m/s (ground-wheel speed from 20 to 50 rpm or 2.18 to 5.46 km/h) increased visible-damage percent from 0.089 to 0.172 %, increased invisible-damage percent from 0.15 to 2.89 %, and decreased percent of germination of barley grains from 89.261 to 86.438 %. But in field tests, increasing forward speed from 2.18 to 5.46 km/h (feeder speed from 0.098 to 0.28 m/s) decreased percent of germination of barley grains from 88.6 to 85.9 % at gate-opening width of 10 mm.
- *The CV of grain spacing in laboratory tests ranged from 4.9 to 6.13 % at forward-speed range of 2.18-5.46 km/h. But the CV of plant spacing in field tests increased about 20 % in the same speed range.*
- *The minimum slip percent range of 0.55-4.41 % was recorded with rubber-wheel but the maximum slip percent range of 10.76-14.21 % was recorded with pegged-wheel type at forward the speed range of 2.2-6.4 km/h" and depth of 1 cm.*
- *It was found that the barley grains ranging between 1.95-1.50 ton/fed resulted at forward speed range of 2.2-6.4 km/h. Meanwhile, the mass of 1000 kernel 50.1-51.8 g.*
- *Operation cost of 9 L.E/fed is less than with other imported grain-drills (about12 L.E./fed).*

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## I - Introduction and Review of Literature

Grain drilling is very important in saving hand labor, improving production, and allowing further mechanization. A study by Abou-Sabe, 1956 showed that the right placement of seed gives an increase of 10 % in yield crop. Sharma et al. (1983) stated that the use of seed drill gives an increase of 12.5 % in wheat yield and it reduces the time required for sowing by 40 %. Beside this, uniform placement of seed saves about 50 % of its quantity.

Awady (1982) mentioned three prerequisites for appropriate technology: (1) economy, (2) the machine must be properly able to handle work which it is designed for and (3) matching with the present technical stage and maintaining the operators safety. Also, he mentioned that the inappropriateness in Egypt of the imported machines is generally due to poor economy, difficulty of operation, and maintenance.

It was, important that a seed drill with a simple construction and with low initial cost be introduced to Egyptian popular-workshops and farmers. It is in this context that a Pakistany "Naeem" seed-drill was developed and tested for drilling barley. This machine was imported by Agricultural Engineering Research Institute in the year 1990 as a simple technology to try to be fabricated by popular-workshops in Egypt. It was tested in wheat season of 1992 and the following disadvantages were found:

(1) The exposed lengths of fluted delivery-wheel were not equal for different grain feeder.

(2) There was no covering device.

(3) Slip of pegged ground wheel was very high (11-15 %).

But the advantages of this machine were:

(1) Low cost.

(3) Simplicity of construction.

(4) Ease of operation, adjustment, repairs, and mentainance.

(5) Uniform placement of seed.

(6) Arrangement for adjusting seed rate.

(7) Suitable depth-control mechanism.

The objective of this study is to develop and evaluate the simple-construction seed-drill imported from Pakistan as an accepted technology for Egyptian workshops and farmers.

Bahnasawy (1992) found that the grain yeild decreased with increasing forward speed, where, the highest yield of grain was recorded at 3 km/h speed. Meanwhile, the lowest yield was recorded at 8 km/h speed. These results may be due to that increase in velocity causes disturbance in speed-depth and seed spacing; slip percent increases with speed, and affects plant population and grain yield.

Awady et al. (1996) found the relation between number of seeds per hill (n), feeding area (a), and seed type for their designed planter as follows: $n = n_1 a (1 - Cs^k)$

Where: $n_1$ = 3.18, 1.2, 0.85, and 0.73 for soybean, peas, corn, and haricot beans, a = feed opening, $cm^2$, C: constant = 0.027, k: constant = 0.555, and s = feeding-wheel speed, rpm.

Awady et al. (1997a) concluded that seed discharge slightly decreases as the speed of ground wheel increased. This is believed to be due to insufficient time available for seeds in the flute to move and replace the continuously discharging seeds. Discharge varied between ± 0.0027 - 0.013 %. The seed discharge is directly proportional to the gate opening area.

Awady et al. (1997b) found that ground-wheel slip increased with the forward speed and sowing depth with different types of ground wheels. Maximum slip percent (15.06 %) resulted from pegged wheel at 3.8 km/h and sowing depth of 1 cm. Minimum slip was 1.8 % at 2.38 km/h, and depth of 5 cm using rubber-rim wheel.

Yehia (1997) found the relation between length, width of square gate, and seed discharge as follows: q = 35.91 + 108.01 L, Where: q = Seed discharge, g/20-feeder revolutions, L = Length of gate opening, cm, and W = Width of gate opening, cm.

Awady et al. (1998a and b) mentioned that the visible seed-damage increased by increasing feeder speed. That is considered due to increasing the momentum changes. The impact force increases by acceleration resulting in visible seed-damage.

## II- MATERIALS AND METHODS

The Agricultural Engineering Research Institute imported the Pakistany "Naeem" grain-drill used in this study in 1990. The grain drill is shown in fig. 2-1 with the following dimensions: total length 109 cm, total width 295.5 cm, effective width 225 cm, greatest height 97cm.

The main parts of "Naeem" grain-drill are as follows: seed box made of iron sheets, feeder mechanism is fluted-wheel type made of plastic (dia. = 50 mm, length = 40 mm. no. of flutes = 12, flute width = 9 mm, and flute depth = 6 mm (fig. 2-2a), frame made of steel angles, plastic grain-tubes, steel furrow-openers, chains covering-device (after development), pegged (total dia. = 50 cm, No. of pegs = 16, peg dia. = 1.5 cm, and peg height = 4 cm, fig. 2-3) and rubber (68 cm dia.) ground-wheels (before and after development), and steel disc-markers and rods made from iron rods and supported by sleeve bearings on the frame of grain drill.

Variation of seeding rate is achieved by adjusting the exposed length of the flutes in the seed cup with the aid of calibrated sliding lever as shown in fig. 2-2b.

***Seeds used in the investigation:*** In the experiments, barley grains of variety of Giza 123 was used.

Two experiment-groups were carried out on the effect of some factors on the grain-drill performance as follows:

(1) Laboratory experiments: were carried out to find the factors affecting feed rate, grain damage, and longitudinal grain-distribution. These factors are: ground-wheel speed and gate-opening area. All treatments were replicated five times to give more reliable averages.

(2) Field experiments: were carried out to determine the following points: germination percentage, longitudinal grain-distribution, final grain yield, and estimating the costs of using the machine.

Planting intensity was 50 kg of barley seeds per fed. (after El-Khishen,1977). The experiment included four forward speeds (2.2, 4.28, 4.89, and 6.4 km/h) and two different types of ground wheels (rubber and pegged).

***Seed discharge:*** barley was used by the tested grain-drill at different ground-wheel speeds (20, 30, 40, and 50 rpm or 0.097, 0.146, 0.194, and 0.259 m/s) and gate opening widths ( 10, 20, 30, and 40 mm). A Nasr tractor of 65 hp (48.51 kW) drew the tested grain-drill was used. The fed seeds were collected in plastic bags during a certain number of ground-wheel revolutions.

***Seed damage and germination:*** In the previously mentioned factors, the damaged grains were sorted manually and weighed. The percentage seed-damages were calculated, and related to the seed discharge.

Five hundred barley grains 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 (Yehia, 1993):

Actual germination percent = Germination % of unused seeds - (Visible seed-damage, % + invisible seed-damage, %)

Visible seed-damage, % = (Weight of damaged seed/Total weight of seed)x100

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

The number of plantings per meter of the row was counted for the four tested- speeds ٢,١٨, ٣,٢٨, ٤,٣٧, and ٥,٤٦ km/h( to determine the germination ratio according to the following formula:

$$\text{Germination ratio} = \frac{\text{Average No. of plants per sq. m}}{\text{Average No. of delivered grains per sq m}}$$

***Longitudinal seed-distribution:*** For fluted-wheel speeds, the barley grains received on 4-meter length flat belt were counted to determine the longitudinal seed-distribution. The test rig (designed by Yehia, 1997) was used to evaluate the seeding distribution performance of the previously mentioned-factors.

The seed distribution was analyzed to determine coefficient of variation (CV) of seeds spacing according to the following formula:

$$CV, \% = \frac{\text{SD of grain or plant spacings}}{\text{Recommended grain spacing}} \times 100$$

Where: SD is the standard deviation.

***Slip of ground wheel:*** is an important factor that affects sowing rate per area. The percentages of slip were estimated for four different ground-wheel types, three forward speeds, and three depths. Slippage percentage was calculated by using the following equation (Awady, 1992).

$$\text{Slippage } \% = \frac{\text{Actual distance - Theoretical distance}}{\text{Theoretical distance}} \times 100$$

where theoretical dist. = No. of wheel revs. x $\pi$ x wheel diam.

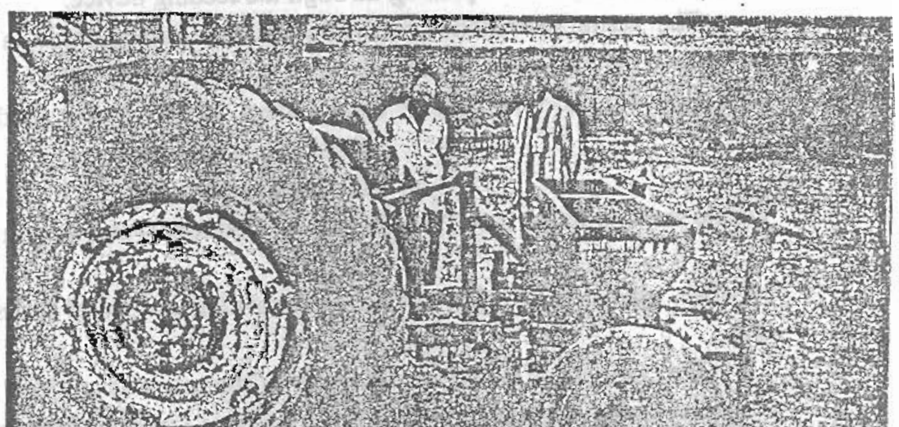
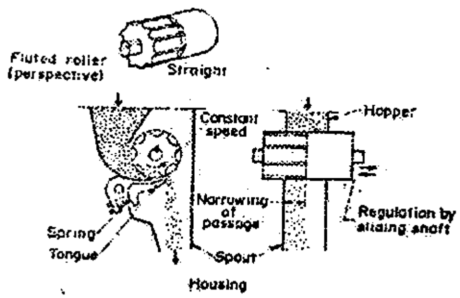
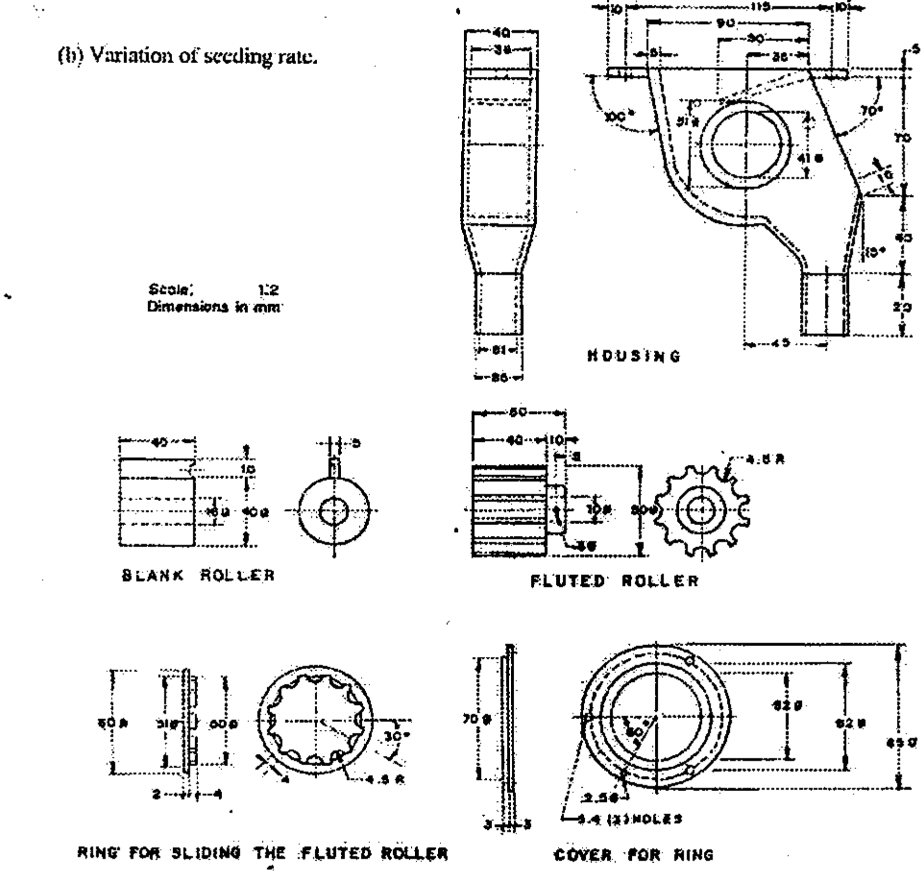


Fig. 2-1: The "Naeem" Pakistany grain drill.

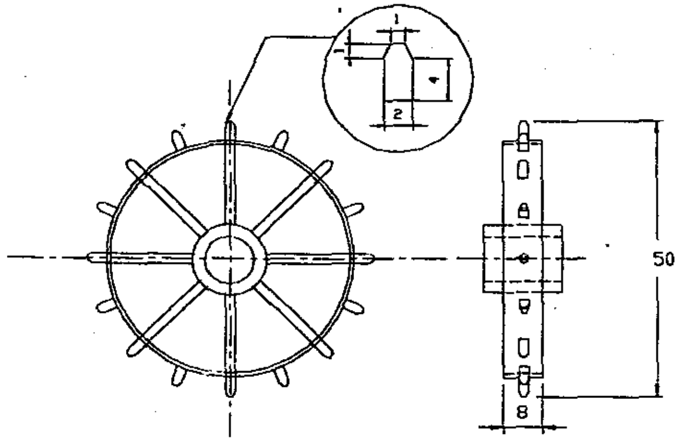



(b) Variation of seeding rate.




(a) Details of fluted-wheel.

Fig. 2-2: Feeding device of Pakistany grain-drill.




Dims. In cm.

Fig. 2-3: Pegged wheel of Pakistany drill.

***Final grain-yield:*** The yield of each plot was measured to study the effect of the above-mentioned factors on barley crop. A frame of 1 x 1 $m^2$ was used for measuring the yield. It was placed at random once every 20 plots. The yield of the crop located within the frame was measured. The average number of stems, grain yield and straw yield were calculated for all treatments in kg/fed.

***Estimating the costs of using the machine:*** Cost of operation was calculated according to the equation given by Awady (1978), in the following form: $C = p/h\ (1/a + i + t/2 + r) + (1.2\ w.s.f) + m/144$,

Where: C = hourly cost, p = price of machine, h = yearly working hours, a = life expectancy of the machine, i = interest rate/year, t = taxes, r = overheads and indirect cost ratio, w = power of the machine kW, s = specific fuel consumption L/kW, f = fuel price L.E./L, and m= monthly wage ratio. "1.2" is a factor to take lubrication and greasing into account. "144" is estimated monthly working hours. Notice that all units have to be consistent to result in L.E/h.

## III - RESULTS AND DISCUSSION

***Grain discharge:***

Different ground-wheel speeds of 20, 30, 40, and 50 rpm (0.097, 0.146, 0.194, and 0.259 m/s feeder speed) were used in these tests. Each speed was used with the following gate-opening widths: 10, 20, 30, and 40 mm (breadth 30 mm). The delivered grains per twenty ground-wheel revolutions were collected from each tube and weighed.

Experimental results are shown in fig. 3-1. The delivered seeds per ten revolutions were found to decrease slightly as the speed of the feeding shaft (ground wheel) increased from 20 to 50 rpm for all gate opening widths.

At different gate-openings 10, 20, 30, and 40 mm, discharge decreased by 4.94, 2.55, 1.29, and 0.8 % respectively, when the speed increased from 20 to 50rpm (from 0.097 to 0.259 m/s feeder speed). This is believed to be due to the insufficient time available for grains in hopper to move and replace continuously discharging grains.

Increasing gate-opening width from 10 to 40 mm increased the amount of delivered grains at all ground (feeder-wheel) speeds. The delivered seeds from 15 tube increased from 26.3 to 185.6 g/(twenty ground-wheel revolutions) by increasing gate-opening width from 0.8 to 3.2 cm at ground-wheel speeds of 20 r.p.m.

***Grain damage and germination:***

Fig. 3-2 indicated that, increasing the ground-wheel speed from 20 to 50 rpm (2.18 to 5.46 km/h) an increased the percent of visible, invisible, and total grain-damage and decreased germination.

In laboratory tests, increasing feeder speed from 0.097 to 0.259 m/s (ground-wheel speed from 20 to 50 rpm or 2.18 to 5.46 km/h) increased visible-damage percent from 0.089 to 0.172 %, increased invisible-damage percent from 0.15 to 2.89 %.

Fig. 3-3 indicated that, increasing the ground-wheel

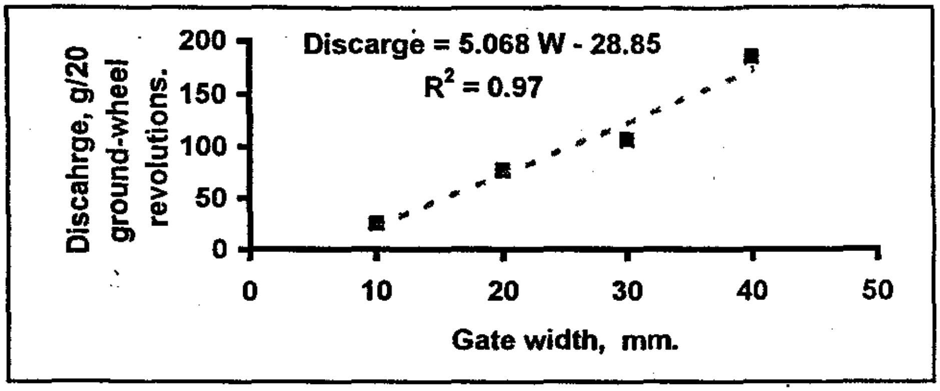



Fig. 3-1: Discharge of barely grains at different feeder-speeds and gate-opening widths.

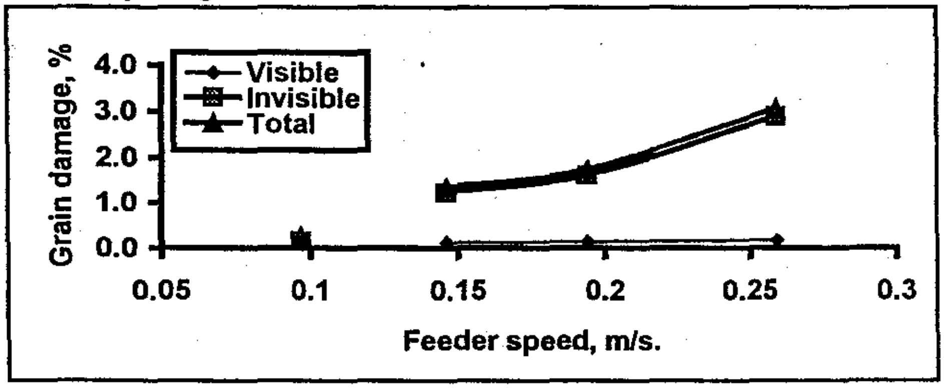



Fig.3-2: Visible and invisible grain-damage percent of barely grains at different forward-speeds and tests.

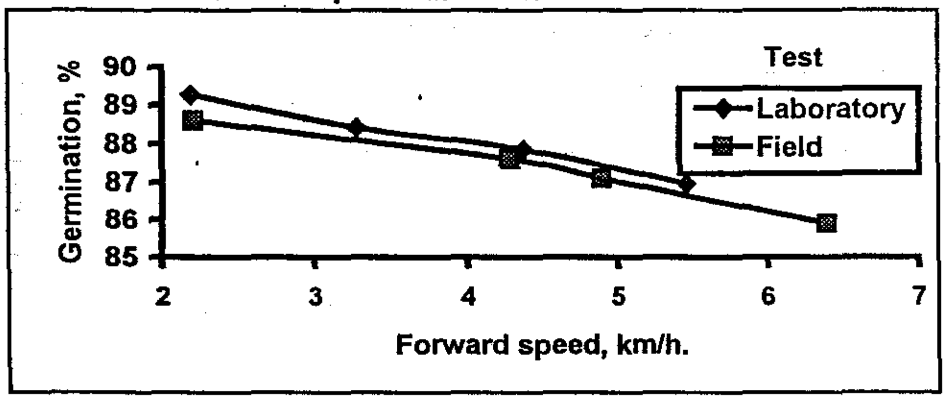



Fig.3-3: Germination percent of barely grains at different forward-speeds and tests.

speed from 20 to 50 rpm (2.18 to 5.46 km/h – in the laboratory) and forward speed from 2.2 to 6.4 km/h (in the field) decreased the percent of germination.

In laboratory tests, increasing feeder speed from 0.097 to 0.259 m/s (ground-wheel speed from 20 to 50 rpm or 2.18 to 5.46 km/h) decreased percent of germination of barley grains from 89.261 to 86.438 %. But in field tests, increasing forward speed from 2.18 to 5.46 km/h (feeder speed from 0.098 to 0.28 m/s) decreased percent of germination of barley grains from 88.6 to 85.9 % at gate-opening width of 10 mm. Decreased germination is considered due to increasing the momentum changes. The impact force increases by acceleration resulting in visible and invisible grain-damages.

It is noticed that the results obtained from field tests are very similar to those obtained from field tests.

***Longitudinal grain-distribution.***

The seed distribution was analyzed to determine coefficient of variation (CV) of seeds spacing. A low CV represents a row with more uniform seed spacing, and vise-versa.

Fig. 3-4 shows that the CV of grain spacing in laboratory tests ranged from 4.9 to 6.13 % at forward-speed range of 2.18-5.46 km/h. But the CV of plant spacing in field tests ranged between 5.61 and 7.31 when forward speed ranged between 2.2 and 6.4 km/h. The values of CV in field tests is higher than laboratory tests due to shaking of machine in a direction perpendicular to that of the motion of the grain drill.

***Slip percent.***

Fig. 3-5 shows the effect of ground-wheel type (rubber and pegged) on slip percent at different forward-speeds (2.18, 3.28, 4.37, and 5.46 km\h). Slip percent of grain-drill wheel increased with forward speed for two ground-wheel types.

The minimum slip range of 0.55-4.41 % was recorded with rubber-wheel but the maximum slip range of 10.76-14.21 % was recorded with pegged-wheel type at forward- speed range of 2.18-

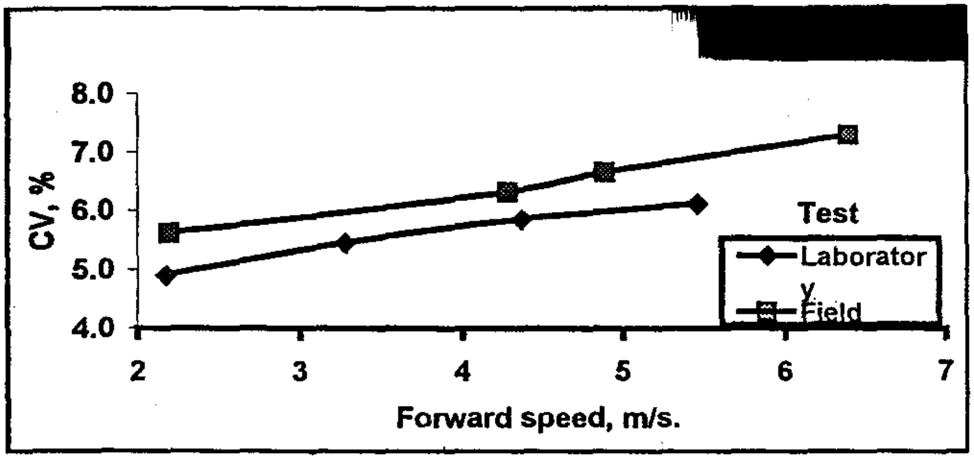



**Fig. 3-4: Coeffecient of variaion (CV) of barley grains spacing at different forward-speeds and tests.**

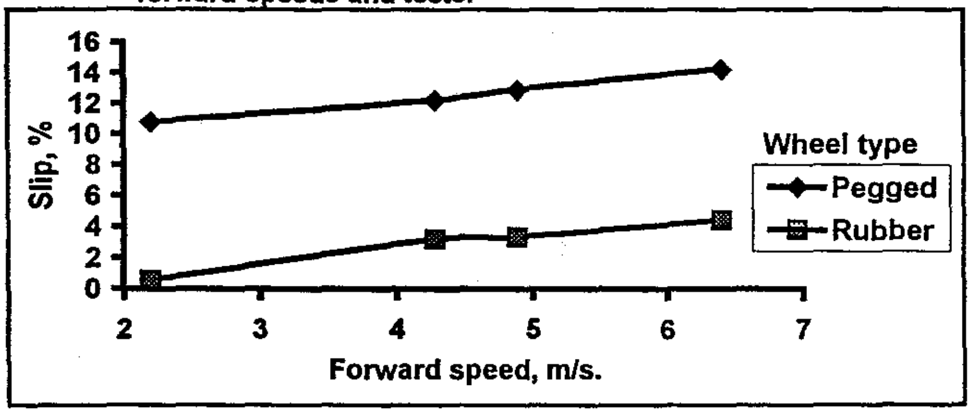



**Fig. 3-5: Slip percent for different ground-wheel types at different forward speeds.**

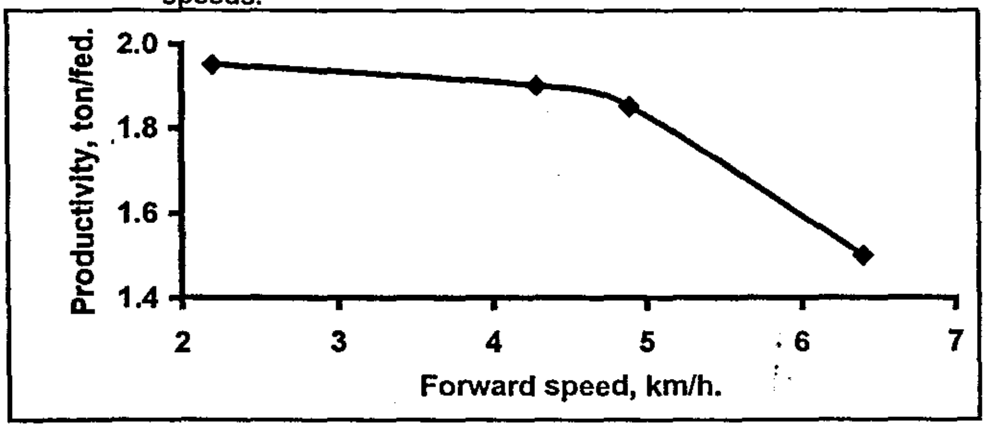



**Fig.3-6: Productivity of barely grains for Naeem drill at different forward-speeds.**

Wide variation in slip with different speeds at the same ground-wheel type is due to the vibration of seed-drill wheels caused by increasing forward speed.

The variation in slip between two ground-wheel types may be due to the following reasons:

(1) The rubber wheel slipped less, due to increased contact with soil, in addition to the presence of lugged protrusions.

(2) The pegged wheel gave the greatest slip due to two reasons: raised rim with reduced contact, and sweeping crushed soil because of its loose structure.

***Productivity of grains.***

Fig. 3-6 shows that the effect of forward speed on productivity of grains.

It was found that the mass of barley grains ranging between 1.95-1.50 kg/fed resulted at forward speed range of 2.81-5.46 km/h. Meanwhile, the masses of 1000 kernel were 50.1, 51, 51.5, and 51.8 g at forward speeds of 2.18, 3.28, 4.37, and 5.46 km/h respectively.

***Estimating the costs of using the machine.***

The operating cost of Pakistany "Naeem" grain-drill is 9 L.E./fed. But the operating cost of other imported drills that such as Amazon (made in Germany), Tye (made in Italy), and Sulky (made in France) is 12 L.E./fed. Reduced cost is due to the price of Naeem grain-drill (3000 LE) less than the other imported machines (6000 LE) that have high technology.

## CONCLUSION

The main results in this study can be summarized in the following points:

At different gate-openings 10, 20, 30, and 40 mm, discharge decreased by 4.94, 2.55, 1.29, and 0.8 % respectively, when the speed was increased from 20 to 50rpm (from 0.097 to 0.259 m/s feeder speed).

The CV of grain spacing in laboratory tests ranged from 4.9 to 6.13 % at forward-speed range of 2.18-5.46 km/h. But the CV of plant spacing in field tests ranged between 5.61 and 7.31 when forward speed ranged *between* 2.2 and 6.4 km/h._

The minimum slip percent range of 0.55-4.41 % was recorded with rubber-wheel but the maximum slip percent range of 10.76-14.21 % was recorded with pegged-wheel type at forward speed range of 2.18-5.46 km/h" and depth of 1 cm.

The operating cost of Pakistany "Naeem" grain-drill is 9 L.E./fed. But the average operating cost of other imported drills such as Amazon (made in Germany), Tye (made in Italy), and Sulky (made in France) is 12 L.E./fed. Reduced cost is due to the price of Naeem grain-drill (3000 LE) less than the other imported machines (6000 LE) that have high technology.

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## تطوير و تقييم السطارة الباكستانية "نعيم" لزراعة حبوب الشعير

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يهدف البحث إلى تطوير وتقييم آلة تسطير مصنعة بواسطة ورشة صغيرة بباكستان (ورشة نعيم) والتى تتميز بانخفاض ثمنها و تقنيتها، وذلك بغرض تصنعيها بالورش المصرية الصغيرة.

و قد تم تعديل الآلة وتجربتها معمليا وحقليا وذلك لدراسة أهم العوامل التى تؤثر على معدل التلقيم ونسب الكسر والإنبات والانزلاق. وتم الحصول على النتائج التالية:

(١) تصرف الحبوب:

(أ) وجد أنه بزيادة سرعة عجلة الأرض، أدى ذلك إلى انخفاض معدل التلقيم بنسبة ٠,٨-٤,٩٤ % و يرجع ذلك إلى أن الوقت غير كافى لامتلاء تجاويف العجلة المموجة تماما بالحبوب عند السرعات العالية.

(ب) زيادة فتحة البوابة يؤدى إلى زيادة تلقيم الحبوب. بزيادة عرض فتحة البوابة من ١ إلى ٤ سم تزداد كمية الحبوب الخارجة من ١٩ أنبوبة بذور من ٢٦,٣ إلى ١٨٥,٦ جم/٢٠ لفة من عجلة الأرض عند سرعة عجلة أرض ٢٠ لفة/د (٠,٠٩٧ م/ث لجهاز التلقيم أو ٢.٢ كم/ساعة سرعة أمامية).

(٢) **تلف الحبوب و نسبة الإنبات:** بزيادة سرعة عجلة الأرض تزداد نسب كسر الحبوب الظاهرى و غير الظاهرى، و تقل نسب الإنبات. بزيادة سرعة عجلة الأرض من ٢٠ إلى ٥٠ لفة/د (٢.٢ إلى ٦,٤ كم/ساعة - تجارب معملية) تقل نسبة الإنبات من ٨٩,٢٦ إلى ٨٩,٩٦ % و تزداد نسب الكسر من ٠,٢٤ إلى ١٣,٠٦ % مع عرض فتحة البوابة ١ سم. بينما فى التجارب الحقلية قلت نسب الإنبات من ٨٨,٦ إلى ٨٥,٩ % بزيادة السرعة الأمامية من ٢,١٨ إلى ٥,٤٦ كم/ساعة.

(٣) **انتظام توزيع الحبوب على المحور الطولى للسطر:** يقل انتظام توزيع الحبوب على المحور الطولى للسطر بزيادة سرعة عجلة الأرض. فوجد معمليا أن معامل الاختلاف (CV) تراوح بين ٤,١٩- ٦,١٣ % عندما تراوحت السرعة بين ٢.٢-٦,٤ كم/ساعة. و وجد حقليا أن المعامل زاد بنسبة ٢٠ % عند نفس السرعات. وترجع قلة الانتظام حقليا عنه فى المعمل لزيادة تأرجح الآلة فى الاتجاه العمودى على اتجاه حركتها.

(٤) **انزلاق عجلة الأرض:** تم الحصول على أقل نسبة انزلاق تراوحت بين ٠,٥٥-٤,٤١ % مع العجلة الكاوتش (بعد التعديل)، بينما تم الحصول على أعلى نسبة انزلاق ١٠,٧٦-١٤,٢١ % مع العجلة ذات الأصابع (قبل التعديل) عندما تراوحت السرعة الأمامية بين ٢,١٨-٥,٤٦ كم/ساعة.

(٥) **إنتاجية الحبوب:** تراوحت بين ١,٩٥-١,٥ طن/فدان عندما تراوحت السرعة الأمامية بين ٢.١٨-٥,٤٦ كم/ساعة.

(٦) **تكاليف التشغيل:** وجدت حوالى ٩ جنيه/فدان، بينما آلات التسطير الأخرى المستوردة مثل Amazon الألمانية، Tye الإيطالية، Sulky الفرنسية فإن تكلفتها حوالى ١٢ جنيه/فدان.

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(١) أستاذ الهندسة الزراعية المتفرغ، بزراعة عين شمس،
(٢) باحث، بمعهد بحوث الهندسة الزراعية.