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A Smart Feeding System for Planting Machine

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ABSTRACT

An electronic feed device system has an accelerometer (ADXL345), Arduino Uno microcontroller, pull-type solenoid, and a 12-V battery. The system used to design and create a new method to measure and adjust the distance between seeds into hills. The seed metering devices connected with the seeding unit was calibrated laboratory and experimentally studied at the "Test and Research Station of Tractors and Farm Machinery, Alexandria Governorate" to evaluate an electronic feeding device performance for seeding paddy and sorghum seeds. The experiment variables included four operating speeds of 0.5, 0.8, 1.2 and 1.5 k.m.h^{-1} with a distance between hills of 10, 15 and 20 cm, respectively. The results showed that the maximum qualities of feed index for sorghum seeds were 98.09, 96.96, and 96.11% at operating speed of 0.5 k.m.h^{-1} at distances between hills of 10, 15 and 20 cm, respectively. The maximum values of seeds longitudinal deviation (C.V.) for sorghum seeds were 9.25, 14.51, and 15.7% at operating speed 1.5 k.m.h^{-1} at distances between hills of 10, 15 and 20 cm, respectively. An electronic feed device showed a high accuracy for adjusting the distance between hills with no high effect of seeds germination.

***Keywords**:* electronic feeding, accelerometer, Arduino Uno, solenoid.

INTRODUCTION

The seeding metering device system is responsible for controlling the seed's descent into holes. It depends on the movement of the land wheel. When any problem occurs during the machine operation, such as wheel slipping or a technical malfunction, the seeds do not fall into the feeding hole. Therefore, the absence happens. It means that the seeding rate per unit area decreases the device field productivity decreases. Raheman and Singh (2002) used an infra-red emitter sensor connected to tube seeds for both of seed drills and planters to measure seed flow from seed metering device. Iacomi and Popescu (2006) designed an electronic seed meter device system. They used an optical device mounted on a slotted disc with different numbers of slots when the machine moves forward, the ground wheel rotates and gives a signal to the solenoid. They mentioned that the solenoid moves the seed disc horizontally to lower the seeds into the seed tube. Singh and Mane (2011) developed an electronic metering mechanism device to measure the ground wheel rotating speed by a proximity sensor. The wheel rotating speed data will be fabricated by the microcontroller and sent the voltage to a DC motor which rotates the seed plate to drop seeds in the seeding tube. Nandede *et al.* (2012) developed a sensor to measure the spacing between seeds and seed flow rate. The system measures the seed flow rate by an optical sensor for measuring the operating speed by proximity sensor they saved and analyzed the data through a DAS computer. Aware and Seema (2014) developed a seed metering mechanism device to drop a single seed into a seeding tube. A system based on an optical device mounted on the machine land wheel to give pulses to micro controller, operating a DC motor depends on micro controller system; the DC motor rotates the seeding plate to drop the seeds through the seeding tubes. The designed control system for seeding seeds was done by Kamgar *et al.* (2015). It measures the rotating speed of the land wheel. It receives and fabricates the obtained data through the control system to send a voltage to a mounted DC motor with the rotating shaft to drop seeds through the tube seed. Gaixia *et al.* (2015) designed a metering device of a pneumatic seeder, they reported that the metering device is mainly composed of an adjustable screw rod, sprocket wheel, Stirring teeth, regulating mechanism and casing body. It takes its motion from the machine land wheel. Kole *et al.* (2017) developed an electronic seed metering device system. The system based on the proximity sensor to measure the rotating machine land wheel that sends the rotating number to microcontroller to decrease or increase the rotating speed of the seeding plate by DC motor. Leela and Saravanakumar (2019) designed an electronic metering device system to measure the seeding flow rate by using a proximity sensor; to send a signal to a microcontroller which sends the pulses to the solenoid which moves the seeding plate to allow seeds to drop through seeding tube. Liu *et al.* (2021) investigated an adaptive roller speed control method. The system is based on the calculated transmission ratio of the seed plate speed and operating speed by the microcontroller to measure the seed flow rate by the infrared sensor and to send the pulses to the stepper motor to move the seed plate. Hensh and Raheman (2021) studied the performance of the seeding metering mechanism in the Laboratory. The device measures the rotating machine land wheel by a proximity sensor and sends the data to the Arduino Nano board. The other design was done by Ismail *et al.* (2022). The chief purpose of their work is to design and develop new technology for pneumatic medicinal seed planting (PMSP). It is identified at activates the air vacuum system. It is made of two drums one, inside the other. The clearance between them considers a suction chamber. Regulated space affects the suction

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volume to get high/low vacuum pressure. Through the indoor experiments, the best vacuum space is identified by two holes on the circumference inner tube with an 8.0 mm diameter. The performance of the prototype was evaluated by studying some variables; forward speeds "1.7, 2.0 and 2.4 kmh^{-1}, vacuum drum speeds "20, 22, 24 and 26 rpm", and vacuum pressures "9.0 and 11.0kPa" per constant vacuum holes on the outer drum of 0.75mm diameters. To reduce the deeds void, double and improve the seeds application rate per unit planting area. So, the study objective is to develop and test an electronic feed device for controlling and accurately placing seeds in the groove during the planting process.

MATERIALS AND METHODS

Physical Properties of Seeds

Seeds samples were taken randomly to study some physical properties of sorghum Giza 15 and paddy Giza 178 such as length, width, thickness, geometric diameter, and the mass of 1000 g, as indicated in Table (1).These measurements were done in the crop lab, rice technology training center, Alexandria government, crop field institute, agriculture research center.

Table 1. Some Physical properties of sorghum and paddy seeds

Seeds physical properties	Sorghum	Paddy
Average length, mm.	-	5.39
Average width, mm.	-	2.52
Average thickness mm.	-	2.06
Average geometric diameter, mm.	3.4	2.14
Average Mass of 1000, g.	30.28	23.72

Development of the Seed metering device mechanism

Fig. (1) shows the seed metering device development, it consists of a frame, seeds hopper, metering plate and an electronic circuit.

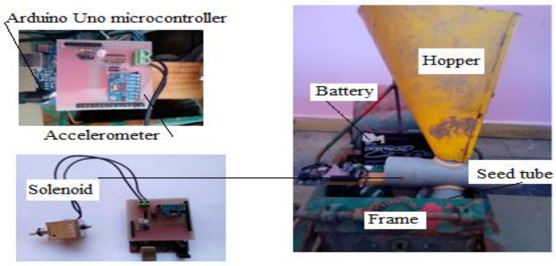


Fig. 1. Seed metering device mechanism

Construction of the seeding unit

It consists of "L" shape mild steel where is the frame bar with a dimension of (20 × 20 × 1.5 mm) and seeds hopper made from a sheet of steel of a 2.0 mm thickness. The metering plate was fixed with the plunger of a solenoid. It is a rectangular shape with a hole of a 10 mm diameter attached below the bottom of the seeds hopper with a clearance of one millimeter and connected to the seeds tube.

Construction of electronic circuit of the metering device

An electronic instrument based on the accelerometer indicated in Fig. (2) has been used to develop the planting machine. The electronic circuit diagram of the seeds metering device shown in Fig. (3) consists of an accelerometer (ADXL345), Arduino Uno microcontroller, pull-type solenoid, and12-V battery.

Accelerometer

The accelerometer (ADXL 345) requires a low-power and small module. It is suitable for movable machine applications; it measures dynamic acceleration resulting from any motion in 3-axis Fig. (4). Breakout boards for these modules feature on-board with 3.3 voltage regulation which makes it easy to interact with the Arduino Uno microcontroller Earl, B. (2018).

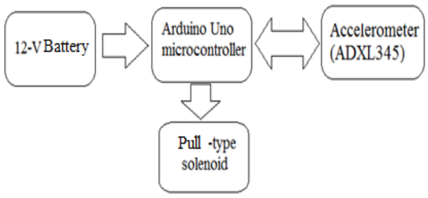


Fig. 2. Flow chart of the electronic circuit

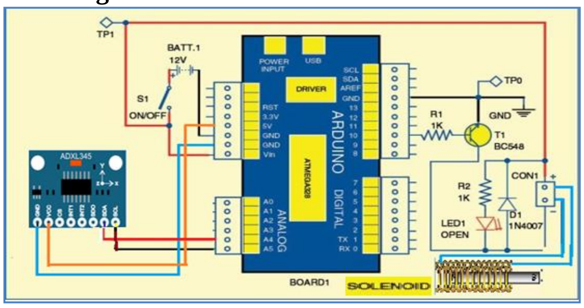


Fig. 3. Electronic circuit diagram for machine metering device system

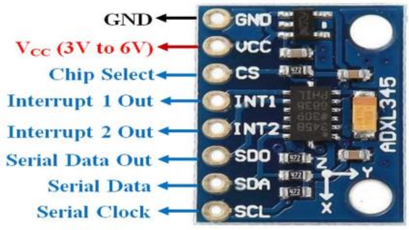


Fig. 4. The accelerometer (ADXL 345)

Arduino Uno microcontroller

Using the Arduino Uno microcontroller can write the program code which used to measure the acceleration of a machine through the accelerometer (ADXL 345) and calculate the distance between hills from equations (1) and (2).

$$v(t) = v(t_n) + \int_{tn}^{t} axdx \qquad v(t) = a \times t \qquad (1)$$

$$s(t) = s(t_n) + \int_{tn}^{t} vxdx \qquad s(t) = \frac{1}{2} a \times t^2 \qquad (2)$$

Solenoid

Solenoid it is a pull-type. It works directly with 12 voltages and D.C. current two ampere, it has stroke of 15 mm, net mass is 38 g, with a dimension of (30 x 17 x 14 mm) and pulling forces is 20 N. The solenoid was mounted on a metering plate below the seeds hopper.

Laboratory calibration of the development seed metering device

Fig. (5) shows the calibration of the developed seed metering device mechanism, an electric motor with a power of 1.5 hp operates the gear box which is used to move the developed machine at forward speed of levels of 0.5, 0.8, 1.2, and 1.5 km.h^{-1} and three different distance between seeds of 10, 15, and 20 cm were calibrated by changing the code with Arduino Uno microcontroller. When the developed machine moves forward the seeds drop through the seeds tube to the land surface, then the actual distance between seeds were measured. The error ratio was calculated and the code corrected on Arduino Uno microcontroller.

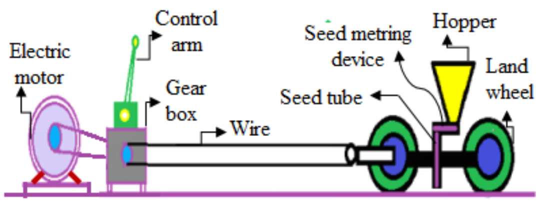


Fig. 5. Sketch drawing of the developed seed metering device calibration

Missing index (Ms)

According to ISO (1984), the missing index (M_s) was calculated as follow:-

$$Ms = \frac{n_1}{N} \times 100, \% \qquad (3)$$

Where:-

***N* = total number of observations.**

***n_1* = number of spacing's in the region > 1.5 times of the theoretical spacing.**

Multiple index (MU)

According to ISO (1984), the multiple indexes were calculated was follow:-

$$Mu = \frac{n_2}{N} \times 100, \% \qquad (4)$$

Where:- n_2 = number of spacing's in the region less than or equal 0.5 times of the theoretical spacing.

Quality of feed index

According to ISO (1984), the quality of feed index was calculated was follow:-

$$Qu = \frac{n_3}{N} \times 100, \% \qquad (5)$$

Where:-

n3 = number of spacing's between 0.5 times and 1.5 times of the theoretical spacing.

The longitudinal scattering

According to Liu *et al.* (2021), the longitudinal scattering was determined as follow:-

$$SD = \sqrt{\frac{\Sigma(x-x^-)^2}{N-1}} \quad (6) \qquad C.V = \frac{SD}{X^-} \times 100, \% \quad (7)$$

Where: C.V =the coefficient of variation. SD=standard deviation.

X⁻=the mean distance between seeds in 10 m along seeds row.

X= distance between hills in the row. N=number of observation.

Lateral distribution around the planting row

The lateral distribution of seeds around the sowing center line was determined according to Ismail *et al.* (2009) and Ibrahim *et al.* (2013). The lateral distribution is the ratio between the scattering seeds with different distances from the planting row to the total number of the planting distance between seeds center line.

Seeds Germination ratio (G.R)

It is the percentage between the average number of seeds Germination before and after using the seed metering device Radwan and El-Ashery (2011).

$$G.R = \frac{Nac}{N\,th} \times 100, \% \qquad (8)$$

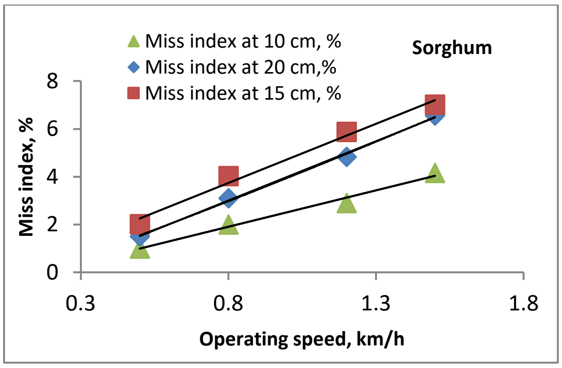
N_{ac}= Seeds germination after sowing.

N_{th}= Seeds germination before sowing.

RESULTS AND DISCUSSION

Effect of the operating speed and distances between hills on miss index

As indicated in Fig. (6), the missing index increased with increasing the operating speed in both cases of using sorghum and paddy seeds, this relationship agrees with Hensh and Raheman (2021). In the case of using sorghum seeds, the missing index at a distance between hills of 10 cm were 1, 2; 2.9 and 4.16 % but at a distance between hills of 15 cm were 1.5, 3.1; 4.83 and 6.55% while at a distance between hills of 20 cm were 2.01, 4.02; 5.88 and 7.01 % at operating speed 0.5, 0.8; 1.2 and 1.5 km.h^{-1} respectively. Also in the case of using paddy, the missing index at a distance between hills of 10 cm were 0.87 ,1.74; 2.6 and 3.47 % but at a distance between hills of 15 cm were 1.49, 2.75; 4.1 and 5.23 % while at a distance between hills of 20 cm were 1.75, 3.13; 5.15 and 6.75 % with increasing the operating speed 0.5, 0.8; 1.2 and 1.5 km.h^{-1} respectively. The increase of the missing index with the operating speed may return to the increase of the solenoid movement also the increases of the missing index with increasing the distance between hills may return to the sensitivity of the accelerometer. Those relationships in the case of using sorghum and paddy are valid through the experimental levels of speeds and distance between hills range. The relationships are valid through the experimental levels.



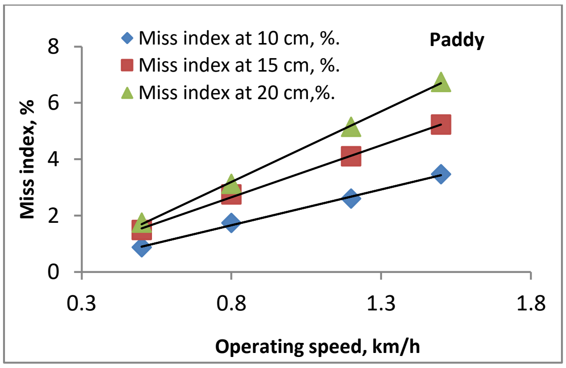


Fig. 6. Effect of the operating speed and distances between hills on miss index

Effect of the operating speed and distances between hills on multiple indexes

Fig. (7), shows that the multiple indexes increased with increasing the operating speed in case of using sorghum and paddy. Increasing the multiple indexes with the operating speed agrees with Ismail *et al.* (2009). At sowing sorghum seeds the multiple indexes at a distance between hills of 10 cm were 0.91, 1.82; 2.73 and 3.63 % but at a distance between hills of 15 cm were 1.54, 3.13; 5.1 and 6.16 % while at a distance between hills of 20 cm were 1.88, 3.77; 5.72 and 6.85% with increasing the operating speed 0.5, 0.8; 1.2 and 1.5 km.h^{-1} at respectively. Also in the case of using paddy the multiple indexes at a distance between hills of 10 cm were 0.85, 1.28; 2.17 and 3.07% but at a distance between hills of 15 cm were 1.12, 2.45; 3.88, and 4.71% while at a distance between hills of 20 cm were 1.25, 3.13; 5.15 and 6.75% with increasing the operating speed 0.5 0.8; 1.2 and 1.5 km.h^{-1} respectively. That increase of the multiple indexes with the operating speed may return to the increase of the solenoid movement also the increases of multiple indexes with the increases of the distance between hills may return to the sensitivity of the accelerometer.

Effect of operating speed and distance between hills on quality of feed index

Fig. (8), shows that the quality of feed index decreases with increasing the operation in both of cases sorghum and paddy. Those relationships agree with Ismail (2008). The maximum qualities of feed index were 98.09, 96.96 and 96.11% at operating speed of 0.5 km.h^{-1} at distances between hills of 10, 15 and 20 cm respectively, while the minimum qualities of feed index were 92.21, 87.29 and 86.14 % at the operating speed of 1.5 k.m.h^{-1} for distances between hills of 10, 15 and 20 cm respectively for sorghum seeds. Also in the case at sowing paddy the maximum qualities of feed index were 98.28, 97.39 and 97.0% at operating speed of 0.5 k.m.h^{-1} at distances between hills of 10, 15 and 20 cm respectively, while the minimum qualities of feed index were 93.46, 90.06 and 87.0 % at operating speed of 1.5 k.m.h^{-1} and distances between hills of 10, 15 and 20 cm respectively.

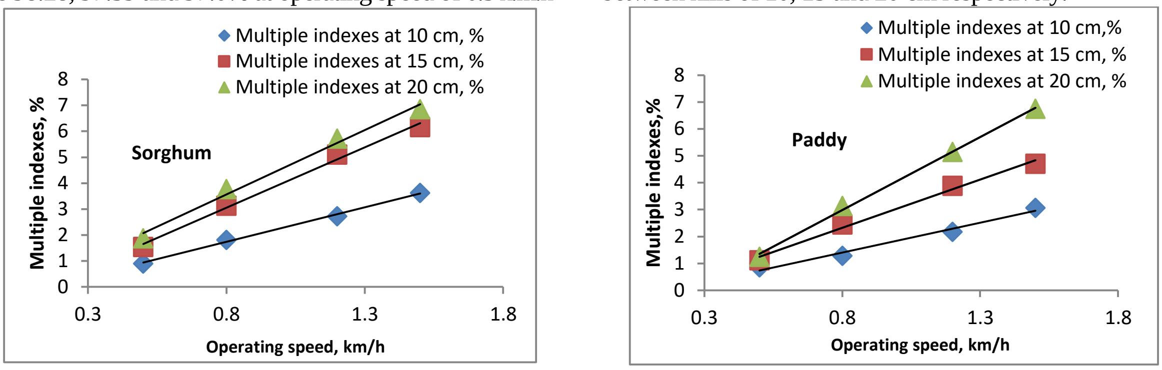


Fig. 7. Effect of the operating speed and distances between hills on multiple indexes

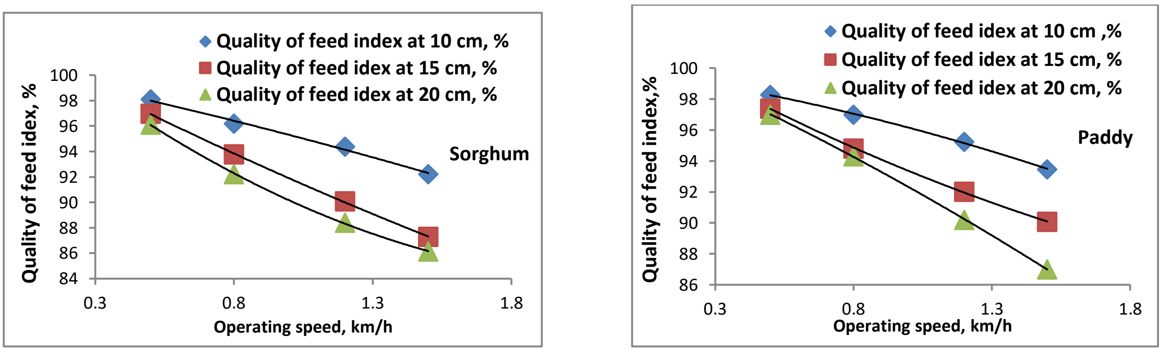


Fig. 8. Effect of the operating speed and distance between hills on Quality of feed index.

Effect of operating speed and distance between hills on seeds longitudinal deviation (C.V.)

Fig. (9), shows the relationship between the operating speed and the seeds longitudinal deviation at different distance between hills. The seeds longitudinal deviation (C.V.) increased with increasing the operating speed in both cases of sorghum and paddy at different distances between hills. Those relationships agree with Kamgar *et al.* (2015). The maximum values of (C.V.) were 9.25, 14.51, and 15.7% at operating speed 1.5 k.m.h^{-1} at distances between hills of 10, 15 and 20 cm respectively, while the minimum values of (C.V.) were 3.5, 4.54 and 5.59 % at operating speed of 0.5 k.m.h^{-1} at distances between hills of 10, 15 and 20 cm respectively in case of using sorghum seeds. Also, at sowing paddy seeds the maximum values of (C.V.) were 7.85, 11.05, and 14.55% at operating speed of 1.5 k.m.h^{-1} for distances between hills of 10, 15 and 20 cm respectively while the minimum values of (C.V.) were 3.12, 3.75 and 4.07 % at operating speed of 0.5 k.m.h^{-1} for distances between hills of 10, 15 and 20 cm respectively. That increase of the seeds longitudinal deviation with the operating speed may return to the increasing both of the solenoid movement and the impact force between the seeds and the soil.

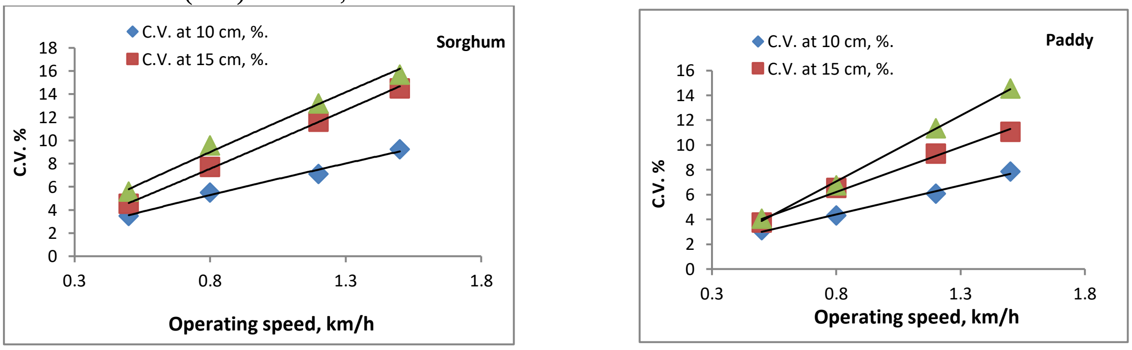


Fig. 9. Effect of the operating speed and distance between hills on seeds longitudinal deviation

Effect of operating speed and distance between hills on the lateral deviation

The normal distribution curve Fig. (10), shows the effect of the operating speed on lateral deviation. At an operating speed of 0.5, 0.8, 1.2 to 1.5 k.m.h^{-1} the lateral deviation values were 89, 87, 85 and 84% at distances between hills of 10 cm, also at distances between hills of 15 cm were 88, 86, 82 and 81% and at distance between hills of 20 cm, the lateral deviation were 87, 85, 81 and 80% respectively for sorghum seeds.

When using paddy seeds and due to the normal distribution curve, at the operating speed of 0.5, 0.8, 1.2 to 1.5 k.m.h^{-1} the lateral deviation values were 87, 85, 83 and 82% at distance between hills of 10 cm, also the lateral deviation were 86, 83, 81 and 80% at distance between hills of 15 cm, and at distance between hills of 20 cm, the lateral deviation were 84, 81, 79 and 77% respectively. We may say that the impact force increases as the soil operating speed increases which affect the seeds deviation around the sowing row.

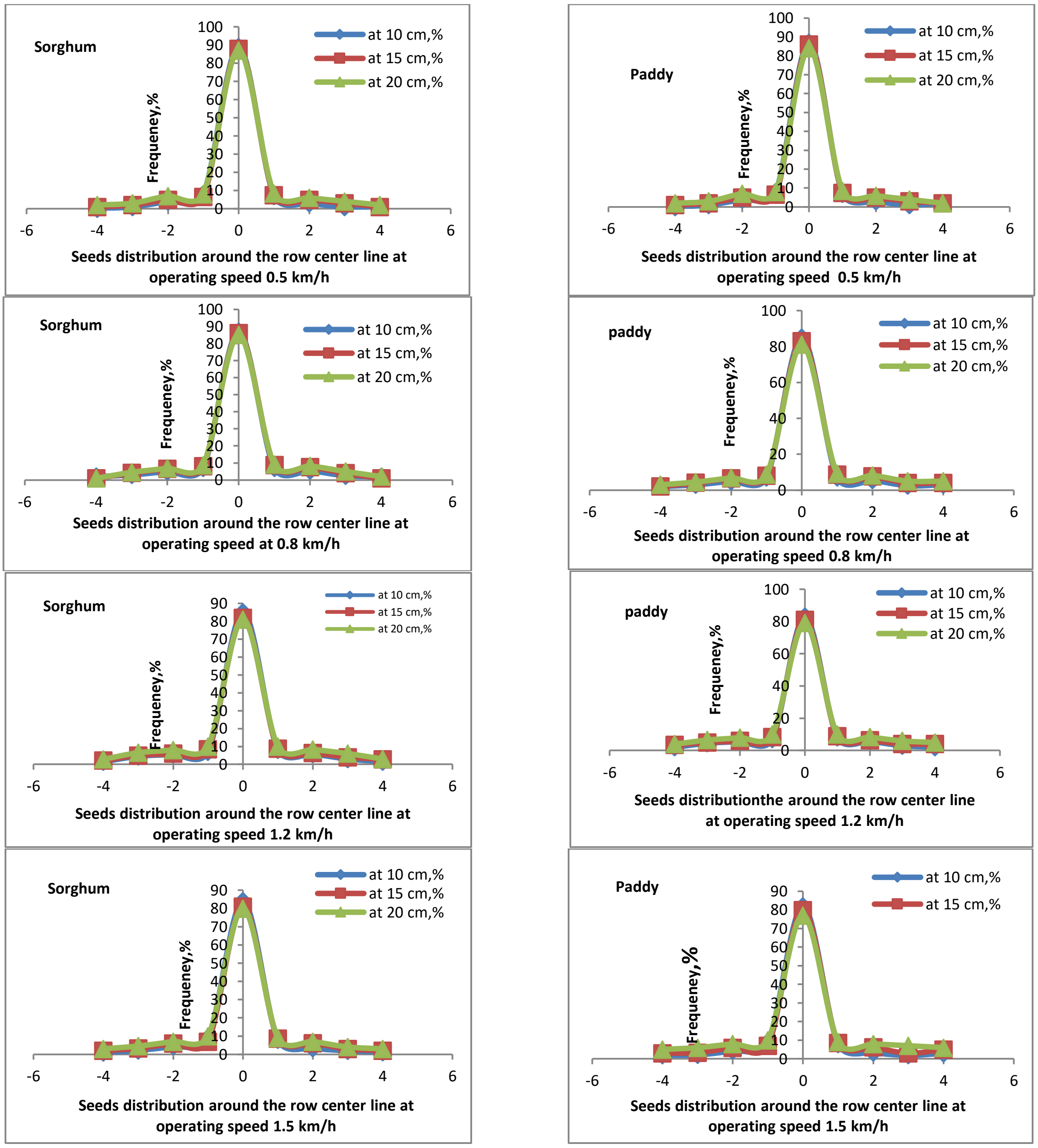


Fig. 10. Effect of operating speed and distance between hills on the lateral deviation

Effect of operating speed on the Germination ratio (G.R)

Fig. (11), shows that the seeds germination ratio (G.R) decreases as the machine operating speed increases agreeing with Radwan and El-Ashery (2011). In the case of using sorghum seeds the (G.R.) before using the electronic seed feeding was 95%, but after using the electronic seed feeding (G.R.) were 93.7 to 93.5, 93.3, and 93.1 % at operating speed increased from 0.5 to 0.8, 1.2 and 1.5 k.m.h^{-1}respectively**.** Also, when using paddy seeds the (G.R.) before using the electronic seed feeding was 93% but after using the electronic seed feeding were 92.5 to 92.1, 92 and 91.7% at the operating speed increased from 0.5 to 0.8, 1.2 and 1.5 km.h^{-1}respectively**.** The decreased of seeds germination may return to increasing the friction between the seed and the feeding plate as the machine speed increases.

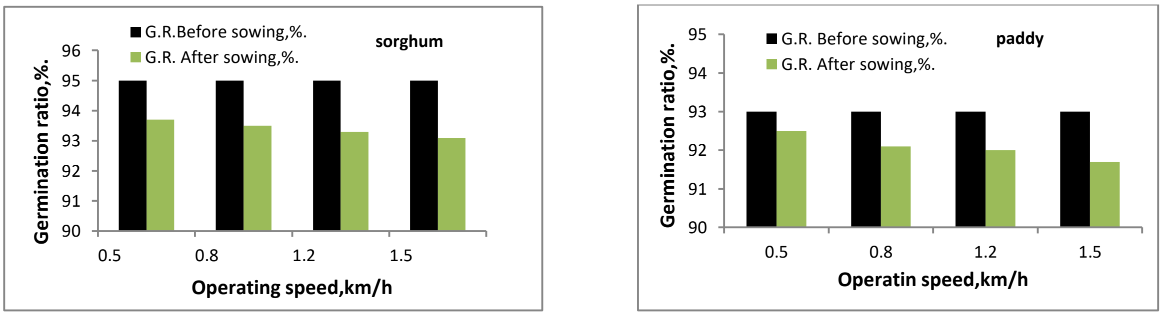


Fig. 11. Effect of operating speed on the Germination ratio (G.R)

CONCLUSION

An electronic seeds feeding device is important to be attached to the machine to obtain high accuracy of feeding seed. It improved the missing index, multiple indexes and quality of feeding index. Using an electronic device with the feeding system showed no high effect on seeds germination. An electronic feeding device is suitable for sowing some types of seeds such as paddy and sorghum. Therefore, it is recommended to attach this device to agricultural seeding machine.

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نظام ذكى لتلقيم البذور فى ألة الزراعة

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[2] قسم بحوث هندسة الرى والصرف الحقللى- بمعهد بحوث الهنسة الزراعية- مركز البحوث الزراعية

الملخص

تم تصميم نظام جهاز تغذية بذور إلكتروني يتكون من مقياس التسارع (ADXL345)، لوحة تحكم اردوينو (Arduino Uno) وملف لولبى (solenoid) من نوع السحب يتم تشغيل الجهاز ببطارية 12 فولت، وتم تركيب جهاز التلقيم الإلكترونى على وحدة الزراعة فى جور واختباره تحت الظروف المعملية في "محطة اختبار وأبحاث الجرارات والآلآت الزراعية بمحافظة الإسكندرية". حيث استخدام التصميم لقياس وضبط مسافات الزراعة بين الجور. أجرى تقييم أداء جهاز التغذية الإلكترونية عند متغيرات مختلفة من المسافات بين الجور وهى 10، 15 و 20 سم تحت أربع سرعات تشغيل مختلفة تتراوح من 0,5 ، 0,8 ، 1,2 و 1,5 كيلومتر/ الساعة على التوالي وتم استخدام نوعين مختلفيين من البذور وهما الأرز والذرة الرفيعة. قد أظهرت النتائج إن كلا من (miss indexes and multiple index) تزداد بزيادة السرعة الامامية فى حالة استخدام كلا من الذرة الرفيعة والارز أما (Quality of Feed Index) كانت أقصى قيمة هى 98,09 ،96,96 و96,11% وذلك عند مسافات بين الجور 10،15و20سم على التوالى وذلك فى حالة إستخدام الذرة الرفيعة. وكانت أقصى قيمة للتشتت الطولى(C.V.) هى 9,25، 51 ,14و 7 ,15% وذلك عند مسافات بين الجور 10،15و20سم على التوالى وذلك فى حالة إستخدام الذرة الرفيعة . وقد اشارت النتائج من خلال هذه الدراسة أن استخدام جهاز التغذية الإلكتروني مناسب لضبط المسافة بين الجور بدون تاثير ملحوظ على نسبة إنبات البذور.

الكلمات الدالة: مقياس التسارع (ADXL345) , لوحة تحكم اردوينو, جهاز تغذية إلكتروني ذكي, ملف لولبى (Solenoid)