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Full Research Paper

Prediction of Seed Flow Rate of a Multi-Slot Rotor Feeding Device of a Corn Planter

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Abstract

In this study, a model was developed for predicting the seeding rate of corn seeds of a typical row-crop planter equipped with a multi-slot feeding device. To this, nine multi-slot rotors (with 4, 5 and 6 slots in three angles of mouth including 23°, 25° and 27°) were designed and manufactured. Tests were carried out at four levels of angular velocity of 40, 52, 62 and 78 rpm on grease belt moving at constant speed of 3.5 km h^{-1}. Tests were completed in three replications. Discharge flow rate was measured and recorded for each treatment. The data were used to develop a model which can be used for predicting the seeding rate under various numbers of slot, mouth angle and rotor angular velocity. According to the results, angle mouth of slots, number of slots, angular velocity and the dual interaction between them showed increasing effects on weight flow rate of seeds (*P-value*<0.01). In the next step, raw data were used to develop the two desired models: based on the dimensional analysis technique and response surface methodology (RSM). The models outputs were compared to experimental data. The standard error of estimate for flow rate for dimensional analysis and response surface methodology (RSM) were 68.13 $mm^3\ s^{-1}$ and 475.59 $mm^3\ s^{-1}$, respectively. The dimensional analysis model was closer to experimental data rather than the RSM method. Thus, to predict the volume flow rate of seed, the dimensional analysis model is recommended.

Keywords: Corn, Dimensional analysis, Response surface methodology, Row planting

Notation

Vertical intersept	C	Solids volumetric Flowrate ($mm^3\ s^{-1}$)	Q
Effective diameter of seed (mm)	d	Number of rotor	R
Effective diameter of Rotor (mm)	D_e	Rotor thikness (mm)	t
Casing inside diameter(mm)	D	The mean width of slots (mm)	W
Acceleration of gravity (=9806)	g	Solid mass flow rate (g min^{-1})	$\dot{W}$
Depth of the slot (mm)	h	Angle of repose (degree)	θ
Slope of logarithmic line	K	Angle mouth of slot (degree)	β
Mean seed longitude (mm)	l	Density of solid particles (g min^{-1})	ρ_s
Rotating speed of rotor (rps)	n	Loose bulk density (g min^{-1})	γ
Slots number	N	Function of ….	φ

Introduction

Some of the seeds planted per unit area cannot survive through germination and emergence stages. Hence, the seeds number must be greater than the desired plant stand (Raheman and Singh, 2003; Srivastava, 2006). Therefore, a planter must meter seeds at proper rate and also must control the horizontal placement of seeds in the desired pattern.

The seed metering mechanism is one of the main components of a planter that affects directly on yield efficiency (Ani *et al.*, 2016). Seed metering devices are categorized as either precision or dune flow metering based on planting pattern result (Murray *et al.*, 2006). Single-seed metering devices have been developed to provide precision for seed spacing planters which can provide exact and unique placement of single seeds at equal intervals within each rows. However, in this

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technique, less attention has been given to the physical properties of seeds (Khan, 2008).

Precision meters attempt to meter single seeds. While there is a large range of precision metering devices, most of them can be broadly classified as ‘plate’, ‘belt’, ‘disc’, ‘drum’ or ‘finger’ types. The classification largely depends on the design and/or shape of the principle moving element that enables seed simulation (i.e. the selection of single seeds from the seed lot) (Gray and Maclntyre, 2012). Plate metering devices consist of a driving disk with indents on its periphery, and their efficiency depends on the seeds size (Ani *et al*., 2016). They can be sub-categorized as horizontal and vertical plate types (Murray *et al*., 2006). In this context, the multi-slot rotors are classified among the vertical sheet metal metering devices.

Among the agricultural crops, corn has great importance as food, livestock and poultry feed, industrial and medicinal consumptions and as a rich source of carbohydrates, protein, iron, and vitamin B (Al-Mallahi and Kataoka, 2013; Ani *et al*., 2016). It is necessary to cultivate corn seeds in a row. Therefore, the distance between consecutive seeds should be kept constant to minimize damage to them. This distance depends on the correct forward speed of the planter, rotational speed of the metering device and the space of the metering device cells (Anantachar *et al*., 2011).

Rebati and Zareian (2003) fabricated a metering device for hill-planting with parallel slots on its roller surface which was used for hill-planting of roof rice in laboratory conditions. In order to evaluate the performance of the unit, forward velocity and diameter of the seed metering device were considered. According to their findings, the seeding speed of 3 km h^{-1} was considered as the optimum speed for minimum seeds’ damage. In another investigation, Jafari (1991) considered main characteristics of a fluted-roller metering device of a grain drill and developed a model equation for predicting discharge volume flow rate.

A new methodology to estimate the mass of grain seeds, which flow in the shape of clumps, was suggested in a study. The methodology used an off-the-shelf digital fiber sensor to detect the behavior of the clumps and multiple linear regression modeling to estimate the mass by the parameters detected by the sensor which were the length and the density of the clumps. An indoor apparatus was used for modeling which resembled the sowing process using the grain drill. A fluted roller was installed in the apparatus to regulate the flow of seeds. Results showed that the digital fiber sensor could be used for estimating mass flow of seeds at variable sowing rates within the speed limits of the grain drill (Al-Mallahi and Kataoka, 2013).

In the absence of any characteristic relationship for predicting volume flow rate of a multi-slot rotors in row-crop planting, the current investigation was aimed to fabricate a test rig and establish a model for estimating the volume flow rate of corn seeds.

Materials and Methods

Laboratory tests were conducted to measure the discharge flow rate of feeding device for a number of treatments. Treatments were three rotors having different slots (4, 5 and 6), each rotor having three angle of mouth (23°, 25° and 27°) at four angular velocity (40, 52, 63 and 78 rpm). Tests were replicated three times.

Development of the required test-rig

A test rig was assembled to measure the discharge flow rate for each settings (Figure 1), the rig consists following parts:

1- Metering device: In the design of the metering device, the shape and number of slots are important factors. The dimensions of each slot are associated with the seed size and the number of seeds cells. Three fundamental design variables including the effective diameter of the metering devices (D_e), the slot depth (h) and the angled mouth of slots (β), as shown in Figure 2 (Rebati and Zareian, 2003). Considering the shape and size of the corn seeds, three angles of 23°, 25° and 27° were calculated and defined as the angles mouth of slots. Angles have direct effect on the depth of the slots and the effective diameter of the metering devices. In order to provide different distance between consecutive seeds on the ground, the fluted rotors with 4, 5 and 6 slots were used. Therefore, the nine rotors were designed in SolidWorks software (SP 3.0, Dassault Systèmes, Vélizy-Villacoublay, France, 2016) and were fabricated from Polytetrafluoroethylene material (Figure 3).

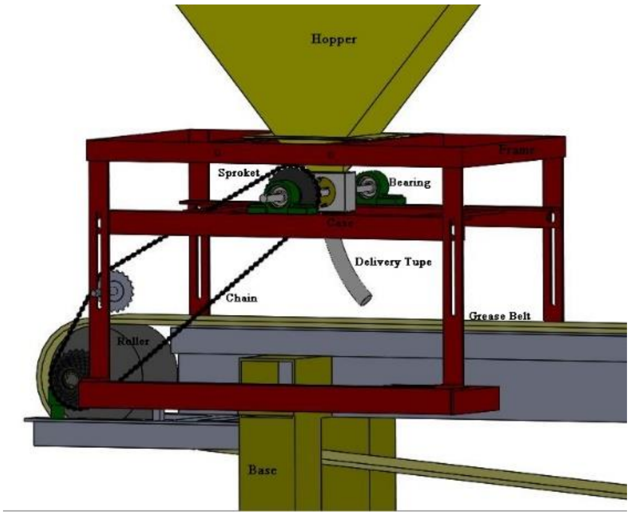


Fig.1. The layout of the test apparatus

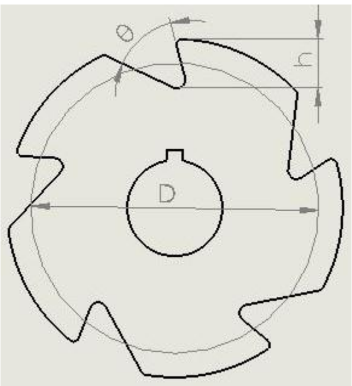


Fig.2. Variables related to design of the metering devices

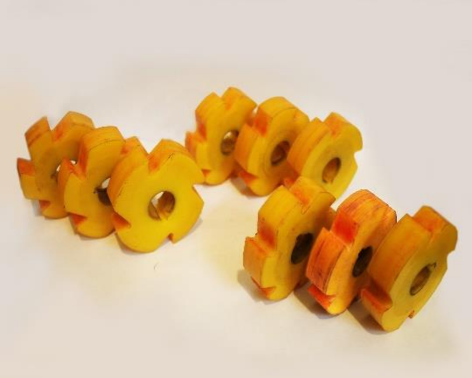


Fig.3. Metering devices used in this study

2- Metering device Case: The metering device case was fabricated from polyethylene material with dimensions of 50 mm×100 mm×75 mm. This case has a 50 mm×25 mm intake gate and 50 mm×13 mm outlet opening, and a ball bearing (B17-99) was used to accommodate the shaft of the metering device in the center of the case.

3- Power transmission system: In order to facilitate the movement of the metering device and control the spacing of seeds along the row of the grease belt, a chain, and sprocket system was used to provide the desired rotational speeds of 40, 52, 63 and 78 rpm.

Experimental Design

The volumetric flow rate of seed discharge from a planter feeding device depends on the following groups of parameters (Jafari, 1991):

1. Metering device parameters, which include the effective diameter of the metering devices, the number of slots, the angled mouth of slots, the depth of slots and the rotational speed of the metering device.
2. Seed parameters including mean length and the effective diameter of seeds, the density of solid particle, surface characteristics, and seed shape factor.
3. Flow parameters including solids flow rate, gravitational acceleration, and friction between solids and wall.

The dimensional analysis and response surface methodology (RSM) approaches were considered to express the relationship between the selected parameters. In summary, the bulk volume flow rate of solids (depended variable) was considered as a function of nine independent variables as follow:

$$\mathrm{Q} = \varphi(\mathrm{n}, \mathrm{t}, \mathrm{g}, \mathrm{h}, \mathrm{N}, \mathrm{D_e}, \beta, \mathrm{l}, \mathrm{d}) \tag{1}$$

Thus, based on π- Buckingham theorem (Murphy, 1950), the selected model has the formula for the linear form:

$$\begin{aligned} &\mathrm{nt^3Q^{-1}} \\ &= \mathrm{C}\left[\varphi_1\left(e^{\mathrm{n}\sqrt{\mathrm{tg^{-1}}}}\right) \times \varphi_2\left(e^{\mathrm{n}\sqrt{\mathrm{tg^{-1}}}}\right) \times \varphi_3(\mathrm{th^{-1}}) \right. \\ &\left. \times \varphi_4\left(\mathrm{NtD_e}^{-1}\right) \times \varphi_5(\beta) \times \varphi_6(\mathrm{D_e l^{-1}}) \times \varphi_7(\mathrm{D_e d^{-1}})\right]^{\mathrm{K}} \end{aligned} \tag{2}$$

The Response Surface Methodology (RSM) consists of a group of mathematical and statistical techniques used in the development of an adequate functional relationship between a response of dependent and some independent variables denoted (Maged *et al.*, 2018; Khuri, 2017; Salar and Karparvarfard, 2017). The miss index, multiple index, quality of feed index and precision in spacing were considered as dependent variables as details mentioned in Balanian *et al.* (2018). The angle mouth of slots (β), number of slots (N) and the rotational speed of the rotor (n) are used as independent and changeable variables, and the volume flow rate of solids (Q) was considered as the dependent variable. The RSM model was recommended as below:

$$\begin{aligned} \mathrm{Q} = \mathrm{C_1} \times \beta + \mathrm{C_2} \times \mathrm{N} + \mathrm{C_3} \times \mathrm{n} + \mathrm{C_4} \times \beta \times \mathrm{N} \\ + \mathrm{C_5} \times \beta \times \mathrm{n} + \mathrm{C_6} \times \mathrm{N} \times \mathrm{n} \\ + \mathrm{C_7} \times \beta^2 + \mathrm{C_8} \times \mathrm{N}^2 + \mathrm{C_8} \\ \times \mathrm{n}^2 + \mathrm{C} \end{aligned} \tag{3}$$

Where C_1, C_2, …, C_8 are constants.

Considering the proposed models, the parameters in the study were selected. The average particle diameter and the length of scorn seeds were calculated according to a previously published method (Mohsenin, 1970). Besides, the loose bulk density was calculated by using the equation (4):

$$\gamma = \frac{\mathrm{M}}{\mathrm{V}} \tag{4}$$

Where M is the weight of the sample and V is the volume of the particle samples. The loose bulk density as obtained to be 0.81 g.L^{-1} which was used to calculate the volume flow rate of particles. The thickness and outside diameter of each rotor were considered to be constant and equal to 15 mm and 60 mm, respectively.

The number of slots, the depth of slots, the angled mouth of slots and the effective diameter of the rotors could be varied. By changing the values of the slot's mouth angle, the quantities of h and D_e were defined by using SolidWorks® software. The specification and the weight flow rate of solid for all rotors are given in Table 1. Based on the size of the rotor case chamber, the rotor thickness was considered as 18 mm. At different times, the average values for weight flow rate ($\dot{W}$) were obtained in three replications for each run. The forward speed of the grease belt was considered to be constant and adjusted as 3.5 km h^{-1}. Particles damage within the range for this test run were found approximately 5.6%.

Table 1- The specification and weight flow rate of Corn seed for each rotor used

Rotor Number	N	β (degree)	h (mm)	D_e (mm)	n (rpm)	$\dot{W}$ (g min^{-1})
R_1	4	23	7.72	52.22	40	88
					52	108.55
					63	122.83
					78	124.53
R_2	5	23	7.72	52.22	40	93.55
					52	116.17
					63	121.36
					78	136.40
R_3	6	23	7.72	52.22	40	138.37
					52	180.94
					63	186.55
					78	211.32
R_4	4	25	8.72	51.22	40	97.43
					52	124.90
					63	141.07
					78	143.85
R_5	5	25	8.72	51.22	40	125.46
					52	163.41
					63	181.60
					78	202.96
R_6	6	25	8.72	51.22	40	157.43
					52	187
					63	225.85
					78	253.11
R_7	4	27	9.72	50.19	40	120.85
					52	149.82
					63	180.98
					78	194.97
R_8	5	27	9.72	50.19	40	148.79
					52	184.09
					63	214.66
					78	233.89
R_9	6	27	9.72	50.19	40	191.81
					52	251.53
					63	284.70
					78	328.91

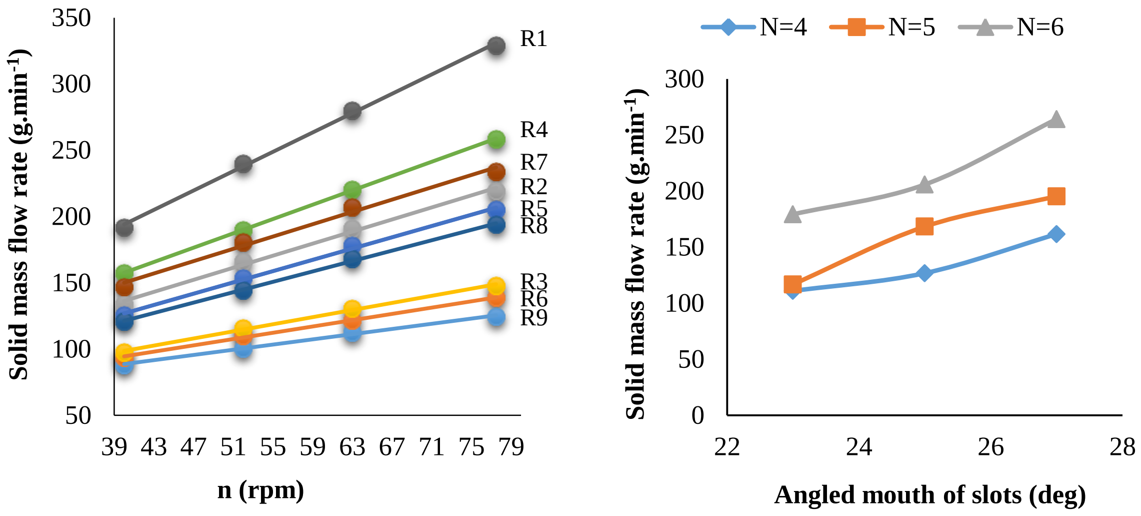
The regression equation allows us to make predictions, while no indication of the accuracy of the prediction was detected. Thus, the standard error of the estimate as the measure of the accuracy of prediction was calculated by the following equation:

$$\text{The standard error of estimate} = \sqrt{\frac{\sum(\text{measured value} - \text{predicted value})^2}{\text{the number of pairs of scores}}} \quad (5)$$

Results and Discussion

The Experimental Results

By increasing the rotational speed of rotors, the weight of solids would be increased. This increase showed a descending slope which may be correlated with further increasing the centrifugal force and decreasing the seed entrance rate to the intake gate (Figure 4a). According to Table 1, by increasing the angled mouth of slots, the number of slots and the rotational speed of rotors, the weight of solids, would be increased (Figure 4b). In other words, the factors chosen in Equations (2) and (3) could be verified. Additionally, the effect of each treatment and the dual interaction between them were significantly higher for the weight flow rate of solids (Table 2), and the coefficient of estimate of each factor was shown in Table 3. According to Table 3, since the coefficient of estimate of single effects was greater than dual effects, the results were presented based on the single effects. Then, the effect of those factors would be examined by the RSM method simultaneously while the corn seed specifications were examined by the dimensional analysis.



(a) (b)

Fig.4. Weight of solids versus (a) Rotational speed of rotors and (b) Angle mouth of slots

Table 2- Analysis of variance of the effect of the treatment on weight flow rate of solids

Treatments	df	Mean Square	F-Value
Angle mouth of the slot (β)	2	46075.9910	786.41^{**}
Number of slot (N)	2	65024.2958	1109.81^{**}
Rotor Speed (n)	3	27279.9565	465.6^{**}
N × β	4	1865.9782	31.85^{**}
β × n	6	1084.8282	18.52^{**}
N × n	6	1032.1254	17.62^{**}
β × N × n	12	106.6767	1.82^{ns}
Model	35		158.72
Total	108		
cv	4.504		

**= P-value ≤ 0.01 , ns = not-significant

Table 3- Coefficient of estimate of each factor

Factor	Coefficient of estimate
Angle mouth of the slot (β)	742.48
Number of slots (N)	865.11
Rotor Speed (n)	758.26
N × β	176.26
β × n	258.83
N × n	246.05
β^2	90.39
N^2	300.6
n^2	-230.43
Intercept	3386.48

Development of model, dimensional analysis approach

In the first step, 80 percent of the data was randomly selected to develop the desired equation. As mentioned, the data collected were categorized based on dimensional analysis according to Equation (2). Initially, logarithms of both sides of Equation (2) were used to have linear correlation, and then equation groups were correlated as previously worked by Jafari (1991).

$$\begin{aligned}&\mathrm{Log}(\mathrm{nt^3Q^{-1}})\\&=\mathrm{LogC}\\&+\mathrm{K}\Big[\mathrm{Log}\varphi_1\left(e^{\mathrm{n}\sqrt{\mathrm{tg^{-1}}}}\right)+\mathrm{Log}\varphi_2\left(e^{\mathrm{n}\sqrt{\mathrm{tg^{-1}}}}\right)+\mathrm{Log}\varphi_3(\mathrm{th^{-1}})\\&+\mathrm{Log}\varphi_4\left(\mathrm{NtD_e}^{-1}\right)+\mathrm{Log}\varphi_5(\beta)+\mathrm{Log}\varphi_6(\mathrm{D_el^{-1}})\\&++\mathrm{Log}\varphi_7(\mathrm{D_ed^{-1}})\Big]\end{aligned}\tag{6}$$

In Equation (6), C and K represent the intercept and the slope of the logarithmic line, which can be calculated after founding all functional correlations of the above equation. Therefore, for convenience, log C and K were considered to be 0 and 1, respectively (Karparvarfard and Rahmanian-Koushkaki, 2015).

$$\begin{aligned}&\mathrm{Log}(\mathrm{nt^3Q^{-1}})\\&=\mathrm{Log}\varphi_1\left(e^{\mathrm{n}\sqrt{\mathrm{tg^{-1}}}}\right)+\mathrm{Log}\varphi_2\left(e^{\mathrm{n}\sqrt{\mathrm{tg^{-1}}}}\right)+\mathrm{Log}\varphi_3(\mathrm{th^{-1}})\\&+\mathrm{Log}\varphi_4\left(\mathrm{NtD_e}^{-1}\right)+\mathrm{Log}\varphi_5(\beta)+\mathrm{Log}\varphi_6(\mathrm{D_el^{-1}})\\&++\mathrm{Log}\varphi_7(\mathrm{D_ed^{-1}})\end{aligned}\tag{7}$$

The functional φ_1 through φ_7 would be analyzed in the same order based on the first residuals to sixth residuals definitions. For example, the first residuals, as an independent term, represent the values of $\mathrm{Log}\varphi_1\left(e^{\mathrm{n}\sqrt{\mathrm{tg^{-1}}}}\right)$ (Equation 8) (Jafari, 1991) which has been subtracted from the corresponding value of the left-hand side, as dependent term, of equation (6) to remove the effect of this function (φ_1) and prepare to set up the next function.

Then the first residual ($\mathrm{Log}\varphi_2\left(e^{\mathrm{n}\sqrt{\mathrm{tg^{-1}}}}\right)$) would be plotted versus their corresponding values of $\exp(\mathrm{n}\sqrt{\mathrm{tg^{-1}}})$ in this effect, and $\mathrm{Log}\varphi_2\left(e^{\mathrm{n}\sqrt{\mathrm{tg^{-1}}}}\right)$ would be obtained (Equation 9). This order would be repeated for second residuals (($\log\varphi_3(\mathrm{th^{-1}})$) that means subtracting the values of $\mathrm{Log}\varphi_2\left(e^{\mathrm{n}\sqrt{\mathrm{tg^{-1}}}}\right)$ from the corresponding values of the first residuals in order to remove its effect and would be plotted versus their corresponding values of the $\log(\mathrm{th^{-1}})$, and the $\log\varphi_3(\mathrm{th^{-1}})$ would be obtained (Equation 10).

Functional relationships for φ_1 through φ_7, have been already obtained by (Karparvarfard and Rahmanian-Koushkaki, 2015) and were recorded here as below:

$$\begin{aligned}&\log\varphi_1\left(e^{\mathrm{n}\sqrt{\mathrm{tg^{-1}}}}\right)\\&=\left[19.902\log(\mathrm{th^{-1}})\right.\\&\left.+27.093\log\left(\mathrm{NtD_e}^{-1}\right)\right]\exp\left(\mathrm{n}\sqrt{\mathrm{tg^{-1}}}\right)\end{aligned}\tag{8}$$

$$\log\varphi_2(e^{\mathrm{n}\sqrt{\mathrm{tg^{-1}}}})=-6.728\exp(\mathrm{n}\sqrt{\mathrm{tg^{-1}}})\tag{9}$$

$$\log\varphi_3(\mathrm{th^{-1}})=-14.092\log(\mathrm{th^{-1}})\tag{10}$$

$$\log\varphi_4\left(\mathrm{NtD_e}^{-1}\right)=5.2324\log(\mathrm{NtD_e}^{-1})\tag{11}$$

$$\log\varphi_5(\beta)=8.6585\log(\beta)\tag{12}$$

$$\log\varphi_6(\mathrm{D_el^{-1}})=-34.996\log(\mathrm{D_el^{-1}})\tag{13}$$

$$\log\varphi_7(\mathrm{D_ed^{-1}})=34.752\log(\mathrm{D_ed^{-1}})\tag{14}$$

At this stage, equations (8) to (14) could be combined with Equation (2) as follow:

$$\begin{aligned}\log(\mathrm{nt^3Q^{-1}})=\log\mathrm{C}&\\&+\mathrm{K}\Big\{[19.901\log(\mathrm{th^{-1}})\\&+27.093\log\left(\mathrm{NtD^{-1}}\right)\\&-6.728]\mathrm{e}^{\mathrm{n}\sqrt{\mathrm{tg^{-1}}}}\\&-14.092\log(\mathrm{th^{-1}})\\&+5.2324\log\left(\mathrm{NtD_e}^{-1}\right)\\&+8.6586\log(\theta)\\&-34.996\log(\mathrm{D_el^{-1}})\\&+34.752\log(\mathrm{D_ed^{-1}})\Big\}\end{aligned}\tag{15}$$

The final value of K and log C were obtained by plotting the corresponding value of $\log(nt^3Q^{-1})$ against the numerical values of the expressions inside bracket of equations (14) (Figure 4).

$\mathrm{K}=-0.0352$ and $\log\mathrm{C}=0.6593$

The final equation was concluded:

$$\begin{aligned}&\mathrm{nt^3Q^{-1}}\\&=4.564\Bigg\{\Big[(\mathrm{th^{-1}})^{19.902}\left(\mathrm{NtD_e}^{-1}\right)^{27.093}(1.87\\&\times10^{-7})\Big]^{\exp\left[\mathrm{n}\sqrt{\mathrm{tg^{-1}}}\right]}\times\left(\frac{\mathrm{h}}{\mathrm{t}}\right)^{14.092}\times(\mathrm{NtD_e})^{5.2324}\\&\times(\beta)^{8.6585}\times(\mathrm{D_el^{-1}})^{34.993}\\&\times(\mathrm{D_ed^{-1}})^{34.752}\Bigg\}^{-0.0352}\end{aligned}\tag{16}$$

It should be noted that the present study was carried out within the limits of the values in Table 4. Therefore above equation can be used for predicting weight flow rate discharge of a multi-slots feeding device of a row-crop planter within the limits mentioned in Table 4.

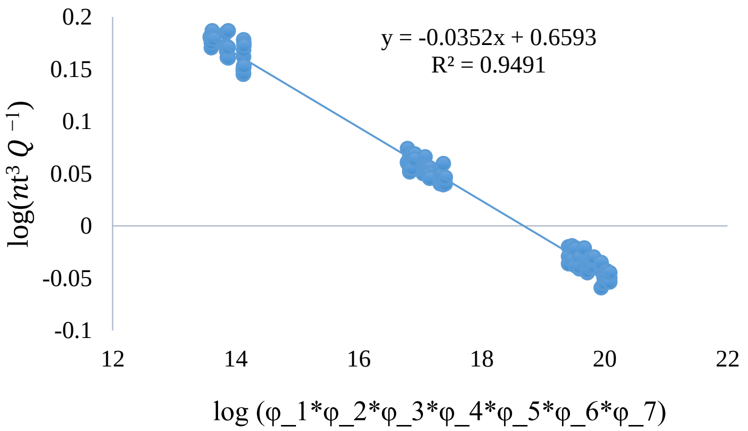


Fig. 5. Plot of $log(nt^3Q\hat{}(-1))$ versus $log(\varphi_1.\varphi_2.\varphi_3.\varphi_4.\varphi_5.\varphi_6.\varphi_7)$

Table 4- Considered a range of dimensionless groups in the present study

Variable groups	Range of variations
th^{-1}	1.646 – 2.073
$NtD_e{}^{-1}$	1.226 – 1.913
$n\sqrt{tg^{-1}}$	0.0269 – 0.0525
β	23 - 27
D_el^{-1}	5.004 – 5.206
D_ed^{-1}	6.460 – 6.721

Development of model, response surface methodology approach

The purposing of modeling performance for the single-seed metering device is crucial to establish the correlations between the requested inputs (for instance: angle mouth of slots, number of slots and the rotational speed of rotor) and outputs (bulk volume flow rate of solids). The RSM as a statistical model was applied for each performance parameter of the planting device using Design-Expert software (Version 11.0.1). Table 5 shows the maximum and minimum of data which were used in the RSM modeling. The result was the following equation which can be used to predict the bulk volume flow rate of solids.

$$\begin{aligned} Q = 31790.1 \ - 1604.92 \ \times \beta \ - 5115.55 \\ \times N \ \ - 7245.58 \ \times n \\ + \ 88.1321 \ \times \beta \ \times N \\ + \ 414.431 \ \times \beta \ \times n \\ + \ 787.949 \ \times N \times n \\ + \ 22.5983 \ \times \beta^2 \ + \ 300.6 \\ + \times N^2 \ - 2363.13 \ \times n^2 \end{aligned} \tag{17}$$

$R^2 = 0.96$

The ANOVA table of the RSM model is presented in Table 6.

Table 5- The maximum and minimum of data sets used for RSM modeling

Variable	Maximum	Minimum
B (Degree)	25	23
N	6	4
n (rps)	1.29	0.67
Q ($mm^3.s^{-1}$)	7025.029	1639.235

Table 6- Anova Table of RSM model

Source	Sum of square	df	Mean square	F-Value
Model	3.558E+6	3	1.186E+6	26.57**

**= P-value ≤ 0.01

Accuracy analysis of the RSM and dimensional analysis models

In order to assess the validity and accuracy of estimating the volume flow rate of seeds by the two proposed models, 20 percent of the data was set aside to be used for verifying the two models. The volume flow rate as predicted by dimensional analysis and the RSM model were plotted against the measured volume flow rate (Figure 6). The plot shows that the values predicted by the dimensional analysis are closer to the measured values as compared to values predicted by with the RSM values.

The standard error of estimate was 68.13 mm^3 s^{-1} and 475.59 mm^3 s^{-1} for the dimensional analysis and the RSM method, respectively.

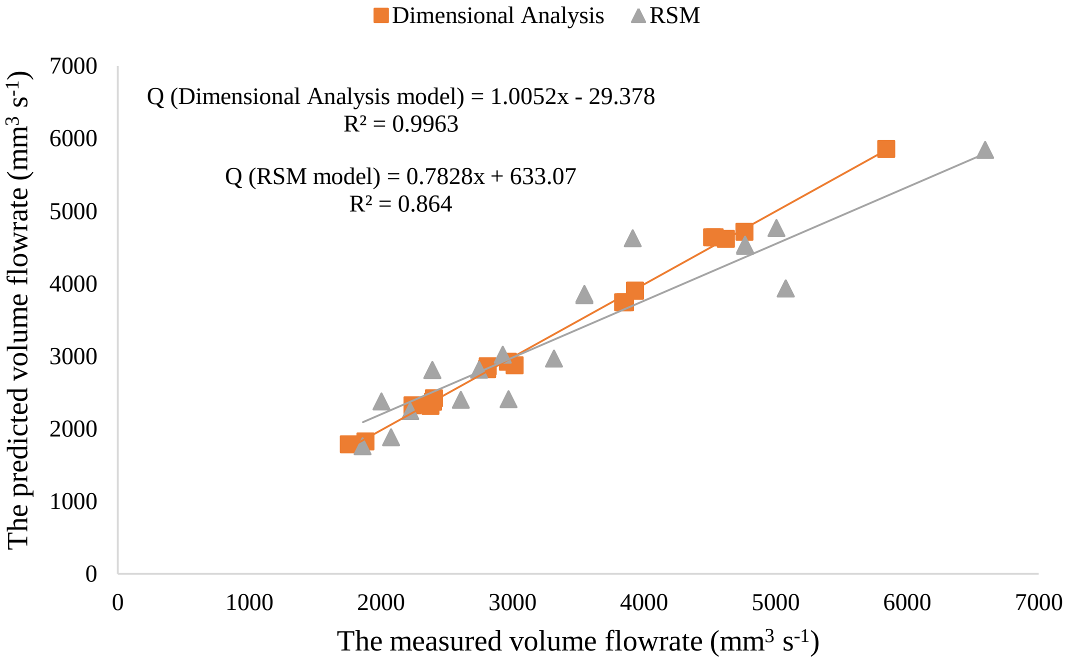


Fig.6. Plot of predicted volume flow rate versus measured volume flow rate

Conclusions

In this study, two equations were developed which can be used to predict the volume flow rate discharge of corn seeds from a new type of planter metering device the following conclusions were also made:

1. The increase in rate for a bulk volume flow rate of solids showed a descending slope by increasing the rotational speed of rotors.
2. More effective performance for bulk volume flow rate of solids can be achieved at lower rotor speeds.
3. Predictions by dimensional analysis approach is more accurate as compared to prediction by the RSM model. The standard error of estimate for dimensional analysis approach and the RSM method were 68.13 mm^3 s^{-1} and 475.59 mm^3 s^{-1}, respectively.

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نشریه ماشین‌های کشاورزی
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مقاله علمی-پژوهشی

تبیین معادله عددی به‌منظور پیش‌بینی دبی خروجی بذر ذرت در موزع‌های غلتکی شیاردار

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چکیده

در این پژوهش از یک روش جدید به‌منظور پیش‌بینی دبی خروجی بذر ذرت در دقیق‌کارها استفاده شد. بدین منظور ۹ عدد موزع با سه سطح تعداد شیار (۴، ۵ و ۶ شیار) و سه سطح زاویه دهانه شیار (۲۳، ۲۵ و ۲۷ درجه) در چهار سطح سرعت دورانی (۴۰، ۵۲، ۶۳ و ۷۸ دور بر دقیقه) مورد استفاده قرار گرفتند. سرعت پیشروی تسمه آغشته به گریس به‌طور مداوم ۳/۵ کیلومتر برساعت در نظر گرفته شد. تمامی آزمایش‌ها در سه تکرار انجام شدند. ذرت به‌عنوان یک ماده ریزدانه دارای اندازه‌های نزدیک به یکدیگر بودند. میانگین دبی خروجی بذور در مقابل سرعت دورانی محاسبه گردید. بر اساس نتایج حاصله، تغییر زاویه دهانه شیار، تعداد دهانه شیار، سرعت دورانی و اثر دوگانه آن‌ها در سطح احتمال یک درصد بر میزان دبی خروجی بذور تأثیر معنی‌داری داشت. بر اساس روش مدل‌سازی آنالیز ابعادی و سطح پاسخ، داده‌ها مورد ارزیابی قرار گرفتند. میزان خطای استاندارد برای روش آنالیز ابعادی و سطح پاسخ به‌ترتیب برابر با ۱۳/۶۸ ($mm^3.s^{-1}$) و ۵۹/۴۷۵ ($mm^3.s^{-1}$) محاسبه گردید. مدل حاصل از آنالیز ابعادی نسبت به مدل حاصل از روش سطح پاسخ به مقادیر به‌دست آمده از آزمایش‌ها نزدیک‌تر بود، بنابراین به‌منظور پیش‌بینی دبی خروجی بذور، مدل به‌دست آمده از روش آنالیز ابعادی پیشنهاد شد.

واژه‌های کلیدی: آنالیز ابعادی، ذرت، ردیف‌کار، روش سطح پاسخ

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