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EVALUATING A LABORATORY TEST-RIG FOR CALIBRATION OF A GRAIN DRILL FOR EDUCATIONAL PURPOSE

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ABSTRACT

A simple laboratory test-rig for calibrating and testing seed drills was developed and evaluated for educational purpose. It was consisted of variable speed electric motor, two gears and magnetic pickup for measuring rotational speed. The developed test-rig was checked by operating a mounted seed drill (SOLA TRISEM 294/R ESP) Model No.37193 TIPO250 under different treatments, which included four simulated ground wheel speeds and three types of seeds. The outputs which affected by these treatments were application rate and coefficient of variation. The results showed that, the developed test-rig had ability to move the feeding shaft on the seed drill with constant speed. Average of the coefficient of variation of weight of the wheat seeds deposited from tubes varied between 2.65 to 0.07% based on seed type and ground wheel speed. The relative ease with which the test-rig is adjusted in the laboratory suits to study the factors affected the seed drill performance.

Keywords: seed drill, testing, calibration, wheat.

INTRODUCTION

The application of machines to agricultural production has been one of the most significant developments in the agricultural world. The largest part of production increase is attributed to the increased utilization of mechanical energy and development of more effective machines and implements. Among the machines contributing to higher yield in current farming are planting machines such as seed drill [1]. The seed drill (Figure-1) is the most commonly used machine to plant seeds in Saudi Arabia.

Figure-1. Seed drill (http://www.alibaba.com).

Increased productivity of any crop can be obtained by genetic improvement or by the use of efficient production practices or by the combination of the two [2]. Also, precise amount of seeds in rows is an important factor in crop production, which can affect growth and yield and this to a great extent depends on the performance of the metering mechanism of the seed drill/planter [3]. Therefore, testing of a seed drill/planter is an essential job to show the performance characteristics which affect seeding rate, seeding distribution…etc. Also, each element of a seed drill including furrow openers, press wheels and seed metering device affect the crop stand [4]. There are different factors like traveling speed, tire inflation, seeder drive wheel slippage; differences in the seeds affect the seeding rate [5]. However, Anantachar *et al*. [6] reported that adjusting the forward speed of the planting equipment is important task to obtain the recommended seed rate and seed spacing. They used three forward speeds of the planting equipment viz., 2.0, 3.5 and 5.0 km/h for the experiments during planting peanut seeds. Todoric and Borosic [7] tested the Gloria drill, which has a drilling belt for small seed, in laboratory conditions and found that the increase in operating speed over 5.2 km/h resulted in reducing drilling precision. Wahby *et al.* [8] showed that the forward speed had significant effect on the performance of wheat grain drill. Babeir and Al Suhaibani [9] showed during their study on performance of two grain drills in sandy loam soil when planting wheat crop that the planting speed had significant effect on emergence rate. Guler [10] showed that the flow rate of seed in seed drill increased as the flute diameters, the fluted roll speeds, and the active roll lengths increased. However, his tests were conducted with the aid of a test stand including a variable speed motor, speed control unit and speed monitor. Depending on the type of metering mechanism used in a seed drill, two methods are commonly available to change the seeding rate: (a) changing the active feed-roll length, and/or (b) changing the seed meter drive shaft speed [11]. A laboratory test for calibration of the seed drill was conducted on a test rig. Two rotational speeds of 16 and 23 rpm were selected for the seed meter drive shaft. Speeds of 2.5 and 3.6 km/h were chosen for the movement of the test rig [11].

A suitable laboratory test-rig is needed to test the seed drill in laboratory to indicate its performance in easily way. However, different test-rigs were developed for testing or calibrating a seed drill inside the laboratory, although, these processes could be manually (Figure-2). Bahnasy *et al.* [12] developed a simple unit for calibrating and testing seed drills. The results showed that, the developed unit had ability to move the ground wheel with

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stable speeds. Aboukarima *et al.* [13] developed test-rig to drive seed meter drive shaft using electric motor and some sprockets system through the ground wheel (Figure-3). The system had ability to drive seed drill shaft in the laboratory in easy way. Al-Hamed *et al.* [14] also developed a simple set-up for calibrating grain drills in the laboratory.

Figure-2. Calibration of seed drill could be done by driving feeding shaft manually [15].

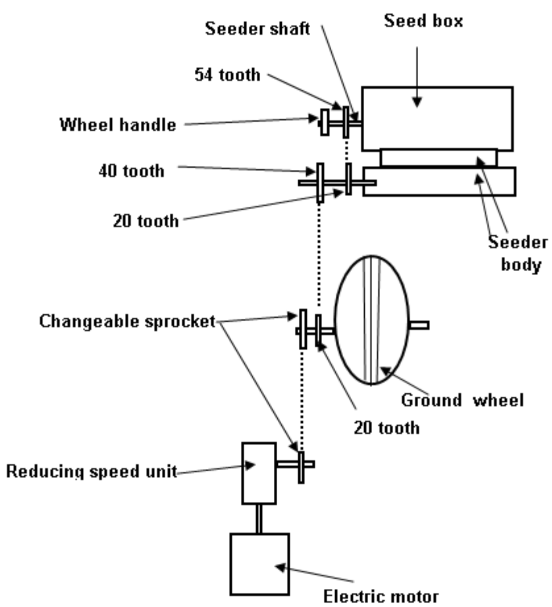

Figure-3. The laboratory arrangements to drive seed meter drive shaft [13].

The lack of seed drill testing test-rig has been a problem in laboratory farm machinery classes for educational purposes. The test-rig can assist students to apply standard test methods for such machine. This led to the study of the feasibility of the developed test-rig to run seed drill test procedure according to [16] to eliminate such problem. So, the objective of this study was to investigate the ability of the developed test-rig to run seed drill test procedure according to [16].

MATERIALS AND METHODS

Description of the new test-rig: The ground wheel of the seed drill was replaced by a driven gear (360 mm diameter with 228 teeth), (Figure-4) which in turn was derived by a small gear (60mm diameter with 38 teeth) (Figure-5). The electric motor (2.2 kW); (Figure-6), was rotating at variable speeds and this was done by an electric convertor which allowed a wide range of speed at the drive gear. A magnetic pick-up was placed on the driven gear to measure the rotational speed of that gear and to control the reduction ratio between the ground wheel (large gear) and the feeding mechanism of the seed drill (Figure-7). The test-rig frame was constructed in such a way that allows the seed drill to rotate or tilted in all directions, so that the tests could be done as if the seed drill is moving on a precise slope.

Figure-4. Driven gear.

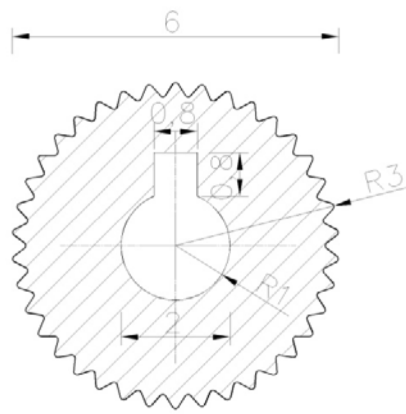

Figure-5. The small gear.

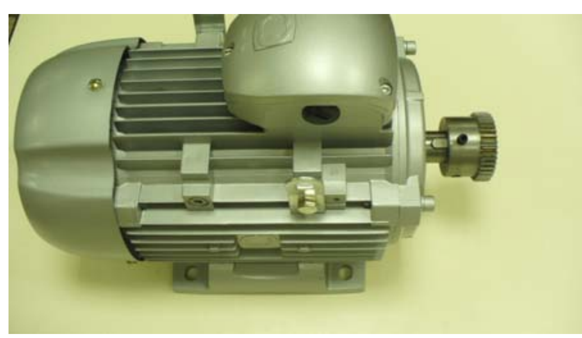

Figure-6. The electric motor used to drive the feeding mechanism of a seed drill.

Figure-7. The contacts between designed gears and the seed drill.

Description of the seed drill under test: A mounted seed drill (SOLA TRISEM 294/R ESP) Model No.37193 TIPO250 was used in testing experiments (Figure-8). It has (17x0.15m) furrow openers with total sowing width of 2.55 m. The ground wheel was replaced by a driven gear. The seed application rate was controlled by different ways. The ground driving wheel diameter was about 70 cm, and the perimeter was about 2.19 m.

Figure-8. The seed drill with the new test-rig.

Instrumentation: Digital balance (NAGATA-FTH-08) has an accuracy of 0.1 g with maximum capacity of 3000 g was used to get the weight of the seeds collecting by the plastic bags placed below the seed drill tubes. Digital stopwatch (Casio) has an accuracy of 0.01 sec with maximum capacity of 10 h was used to record time. A 30 m cloth tape (Chinese model) was used to record perimeter of the ground wheel. Rotational speed of the ground driving wheel was measured by the magnetic pick-up and digital monitor. Seed length, width and thickness were measured using digital caliper and the volume of seeds was measured using glass cylinder and **b**ulk density was calculated.

Treatments: The treatments during testing the seed drill included four different simulated ground speeds and three seed types. The hopper of the seed drill was in half capacity. Untreated commercial wheat, barley and sorghum seeds were brought from local market. The main physical properties of the used seeds are presented in Table-1.

Test procedure: The tests were conducted with the aid of the developed test-rig as static test. The test-rig was at horizontal level (no slope at any directions). The laboratory experimental work and measurements were carried out in the Educational Farm of College of Food and Agriculture Sciences, King Saud University, Riyadh city, Saudi Arabia. The seed box above the three tubes was half filled with tested seeds. Plastic bags were placed on each of the discharge tubes to collect the deposited seeds. Seed dispenser, seed mobile bottom, seed dispensers trapdoors and seed speed variator lever position of the seed drill were adjusted for each seed type.

Table-1. Main physical properties of the used seeds.

Seed type	Bulk density (g/cm^3) (Mean value ± s$^+$)	Weight of 1000 seed (g) (Mean value ± s)
Wheat	0.82± 0.01	43.2 ±1.5
Barley	0.63± 0.02	27.8±1.3
Sorghum	4.44± 0.14	23.26±0.2

Seed dimensions* (mm) (Mean value ± s)							
Wheat			Barley			Sorghum	
Length	Width	Thickness	Length	Width	Thickness	Diameter in longitude direction	Diameter in latitude direction
6.92± 0.39	3.43 ± 0.19	2.89 ± 0.22	7.89± 0.65	3.14 ±0.22	2.33 ±0.24	3.48±0.22	2.63 ±0.23

* Seed dimensions shown are the averages of 100 measurement trails.
\+ s is standard deviation.

Four rotational speeds (N, rpm) of the drive gear were achieved namely 40, 54, 50 and 55 rpm by helping of the electric motor. So, the simulated ground wheel speed, V, could be calculated as follows:

$$V\ (km/h) = \frac{N \times P \times 60}{1000} \quad (1)$$

Where N is rotational speeds (rpm) of the drive gear and P is the perimeter of the ground wheel (m). The resulted simulated speeds are 5.28, 5.94, 6.50, and 7.20 km/h. Each test was completed in time T and repeated three times. The seeding rate (q, g/s) was calculated as follows:

$$q = \frac{W}{T} \qquad (g/s) \tag{2}$$

Where, W is the total mass of the deposited wheat seeds from 3 tubes of the seed drill (g) and T is the test time (sec). The seeding rate (Q, kg/ha) was calculated as follows:

$$Q = \frac{q \times 36}{V \times b} \qquad (kg/ha) \tag{3}$$

Where T is the test time (sec), b is the seed drill working width (m) under test, V is speed (km/h) and 36 is conversion factor. Coefficient of variation (CV, %) was evaluated to reflect the sensitivity of the seed drill test. The CV is widely used to evaluate the spinner type of seed and granular fertilizer applicators [17-20]. It is defined as the sample standard deviation divided by the sample mean, and is often expressed as a percentage [21]. It was calculated as follows [22]:

$$CV = \frac{s}{W_{mean}} \times 100 \qquad (\%) \tag{4}$$

Where s is standard deviation of seed weight (g) collected from seed drill tubes and W_{mean} is the mean of seed weight (g) collected from seed drill tubes.

Statistical analysis: The data for seeding rate were statistically analyzed, using two-way analysis of variance (ANOVA) for the randomized complete design with three replicates. The used software was SPSS [22].

RESULTS AND DISCUSSIONS

The raw data during laboratory experiments using different seeds are illustrated in Table-2. It is clear that from Table-2, the testing time is nearly 30 sec. There are differences of seed weight among tubes for all speeds and seed types. These differences of seed weight resulted variations, which measured by CV (Figure-9). The CV of seed weight decreased with increased speed and thus seed metering at a speed of 55 rpm (7.26 km/h) is more accurate than that of 40 rpm (5.28 km/h) for all seed types. Increasing the speed of the driven gear from 40 to 55 rpm decreased the CV of seed weight from 1.3 to 0.07% for wheat, and from 1.33 to 0.21% for barley, and from 2.65 to 0.24% for sorghum. More seeds in the seed tube resulted in more constant flow of seeds. CVs were at very low values for all speeds, and for all type of seeds. Thus, the seed drill showed a very high level of evenness for all type of seeds. The values of CV between 10% and 20% were considered "acceptable," the values between 5% and 10% "good," and the values less than 5% "very good." [10].

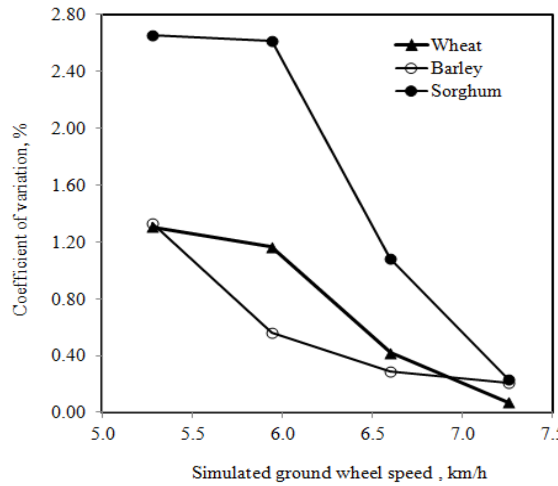

Figure-9. Variations of coefficient of variation (CV) of seed weight with simulated speed and seed types.

Table-3 illustrates source of variation, degree of freedom (df) and significance from ANOVA seeding rate (q). Significant differences were detected among the variances of the seed rates for speeds of 40, 45, 50 and 55 rpm. Significant differences were detected among the variances of the seed types for wheat, barley and sorghum.

A graphical comparison of all the seeding rate (g/s) obtained from the test versus the speed obtained from the electric motor is shown in Figure-10. The regression analysis showed that the seeding rate correlated well with the corresponding speed for all seed types. Coefficients of determination were 0.99, 0.99 and 0.99 for wheat, barley and sorghum, respectively. These high correlations indicate that the seeding rate equations can be used instead of another test to obtain quantitative evaluations of seed weight of such seed drill. The intercepts of the regression equations were 4.32, 3.46 and 5.46 g/s and the slopes were 4.41, 1.7 and 3.79 for wheat, barley and sorghum seeds, respectively.

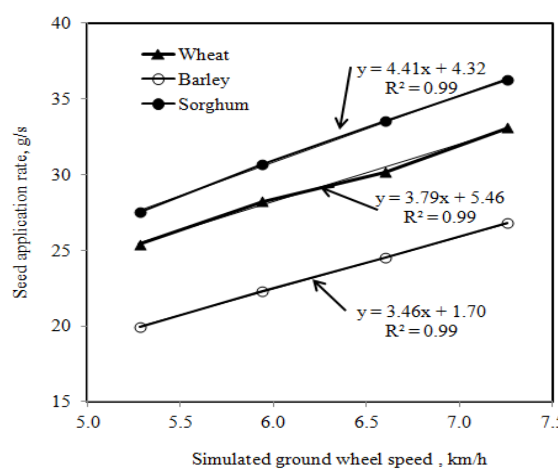

Figure-10. Variations of seeding rate (g/s) with simulated speed and seed types.

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Table-2. Raw data during experiments using different seeds.

Seed type	Replicates	Seed weight			Rotational speeds of the drive gear	Testing time
		Tube1	Tube2	Tube3		
		(g)	(g)	(g)	(rpm)	(sec)
Wheat	R1	243.3	269.5	264.3	40	30.74
	R2	246.4	256.9	268.7	40	30.85
	R3	249.0	265.6	277.0	40	30.61
	R1	271.8	296.0	296.6	45	30.39
	R2	250.2	287.2	310.2	45	30.58
	R3	270.1	295.6	299.8	45	30.36
	R1	310.8	302.2	315.2	50	31.65
	R2	297.6	314.2	310.2	50	30.50
	R3	296.1	312.5	320.6	50	30.05
	R1	320.2	331.2	332.6	55	31.01
	R2	317.7	333.2	334.2	55	29.55
	R3	318.2	335.6	330.2	55	28.80
Barley	R1	187.2	206.9	206.8	40	30.46
	R2	191.1	210.6	215.0	40	30.80
	R3	187.8	206.6	211.2	40	30.28
	R1	210.0	236.2	237.9	45	30.49
	R2	212.1	231.2	237.8	45	30.75
	R3	209.8	233.4	233.4	45	30.34
	R1	228.7	256.1	259.1	50	30.30
	R2	229.1	254.6	256.4	50	30.16
	R3	229.5	255.9	258.2	50	30.44
	R1	270.2	273.2	268.3	55	30.45
	R2	269.3	271.3	271.3	55	30.33
	R3	271.3	270.3	273.1	55	30.28
Sorghum	R1	285.6	269.3	278.2	40	30.20
	R2	289.5	270.9	276.7	40	30.32
	R3	278.4	256.6	262.5	40	29.17
	R1	310.3	308.6	308.7	45	30.30
	R2	309.0	285.7	291.2	45	28.97
	R3	307.2	290.3	290.2	45	28.76
	R1	345.7	321.0	330.9	50	29.99
	R2	351.9	326.5	330.0	50	30.03
	R3	352.2	331.7	335.5	50	30.27
	R1	366.3	362.3	374.2	55	29.17
	R2	365.2	364.6	378.3	55	31.26
	R3	364.2	365.3	376.2	55	31.07

Table-3. Source of variation, degree of freedom (df), F and significance from ANOVA seeding rate (q).

Source	Type III Sum of squares	df	Mean square	F	Significance
Corrected model	764.51[a]	11	69.5	186.79	0.000
Intercept	28617.64	1	28617.64	76911.09	0.000
Seed types	464.68	2	232.34	624.42	0.000
Speed	296.39	3	98.79	265.52	0.000
Seed types * Speed	3.44	6	0.573	1.54	0.208
Error	8.93	24	0.372		
Total	29391.08	36			
Corrected total	773.44	35			

[a]R Squared = 0.988 (Adjusted R Squared = 0.983).

In general, the seeding rate (kg/ha) decreased as the simulated forward speed increased for all seed types. The average seeding rate values were between 364.5-384.67 kg/ha (Figure-11) for wheat seeds. Meanwhile, this average was between 295.11 - 301.74 kg/h for barely seeds. The average seeding rate values were between 399.8-416.84 kg/ha (Figure-11) for sorghum seeds. The regression analysis showed that the seeding rate (kg/ha) correlated well with the corresponding speed for all seed types. Coefficients of determination were 0.90, 0.98 and 0.98 for wheat, barley and sorghum, respectively. These high correlations indicate that the seeding rate (kg/ha) equations can be used instead of another test to obtain quantitative evaluations of seeding rate of such seed drill. The intercepts of the regression equations were 445.02, 320.5 and 464.37 kg/ha and the slopes were -11.37, -3.50 and -8.83 for wheat, barley and sorghum seeds, respectively.

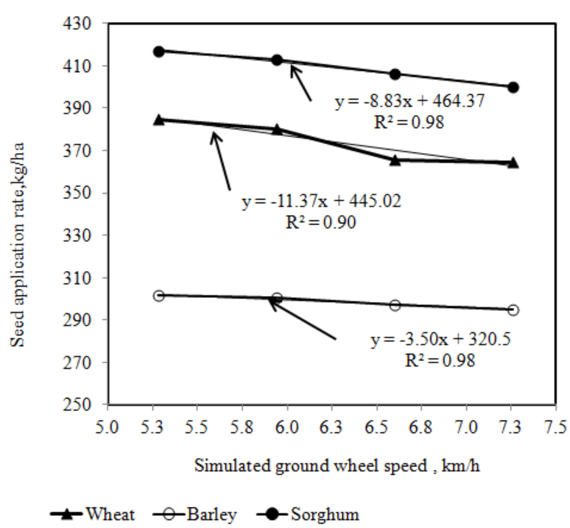

Figure-11. Variations of seeding rate (kg/h) with simulated speed and seed types.

CONCLUSIONS

A simple laboratory test-rig was fabricated from available locally materials, to suit the need of the calibration and test seed drills. It was found to be suitable for these purposes. The testing results of that test-rig showed that it is suitable for educational purpose for students in farm machinery classes. The average of the coefficient of variation of weight of the wheat seeds deposited from tubes during checked the developed test-rig varied between 2.65 to 0.07% and affected by seed type and ground speed. The regression analysis showed that the seeding rate (kg/ha) correlated well with the corresponding speed for all seed types. And the developed equations can be used instead of another test to obtain quantitative evaluations of seeding rate of such seed drill.

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REFERENCES

[1] Maleki M.R., Jafari J.F., Raufat M.H., Mouazen A.M and Baerdemaeker De J. 2006a. Evaluation of seed distribution uniformity of a multi-flight auger as a grain drill metering device. Biosystems Engineering. 94(4): 535-543.

[2] Saleem A., Abbas K., Asad Kh. and Anjum M. S. 2013. Best statistical model estimation for mustard yield in Azad Kashmir, Pakistan. Pakistan Journal of Science. 65(1): 77-82.

[3] Raheman H. and Singh U. 2003. A sensor for seed slow from seed metering mechanisms. IE (I) Journal AG. 84:6-8.

[4] Maleki M.R., Mouazen A.M., Ketelaereand B. Baerdemaeker De J. 2006b. A new index for seed

distribution uniformity evaluation of grain drills. Biosystems Engineering. 94 (3): 471-475.

[5] Hendawy N.A. 1996. Factors affecting seed drilling rate. Misr Journal Agricultural Engineering. 13(1): 202-210.

[6] Anantachar M., Kumar G.V. P. and Guruswamy T. 2011. Development of artificial neural network models for the performance prediction of an inclined plate seed metering device. Applied Soft Computing. 11: 3753-3763.

[7] Todoric I. and Borosic J. 1990. Sowing small-seed vegetables. Proceedings of Current Tasks of Agricultural Engineering, Opatija, Croatia.

[8] Wahby F., Al-Janobi A. and Aboukarima A.M. 2000. Performance of wheat grain drill using different covering methods. Emirate Journal Agricultural Science. 12: 60-79 (In Arabic).

[9] Babeir A.S. and Al Suhaibani S.A. 1995. Performance of two grain drills in sandy loam soil when planting wheat crop. Journal of King Saud University 7, Agricultural Science. (1): 155-164 (In Arabic).

[10] Guler I. E. 2005. Effects of flute diameter, fluted roll length, and speed on alfalfa seed flow. Applied Engineering in Agriculture. 21(1): 5-7.

[11] Jafari M., Hemmat A. and Sadeghi M. 2010. Development and performance assessment of a DC electric variable-rate controller for use on grain drills. Computers and Electronics in Agriculture. 73:56-65.

[12] Bahnasy A. F., Aboukarima A. M., Morsi M. E. and Abd El Halim S. N. 2007. Development a simple laboratory unit for calibration and testing seed drills. Journal Agricultural Science Mansoura University. 32(12): 10109-117.

[13] Aboukarima A. M., Abd El Halim S. N. and Morghany H. A. 2008. Uncertainty evaluation of seeding rate during laboratory testing of seed drill. Journal Agricultural Science Mansoura University. 33(8): 5791-5808.

[14] Al-Hamed S.A., Wahby M. F. I. and Tabash I. S. 2013. A simple set-up for calibrating and testing grain drills. Archives Des Sciences. 66 (2): 317-326.

[15] St. John L., Cornforth B., Simonson B., Ogle D. and Tilley D. 2008. Calibrating the Truax Rough Rider seed drill for restoration plantings. Technical Note, USDA - Natural Resources Conservation Service Boise, Idaho, TN Plant Materials No. 20: 15.

[16] ISO. 1984. Sowing equipment - Test methods - Part 2: Seed drills for sowing in lines. ISO 7256-2: 1984.

[17] ASAE. 1998. ASAE Standards S341.3. Procedure for measuring distribution uniformity and calibrating granular broadcast spreaders. ASAE Standards, St. Joseph, MI, ASAE, USA.

[18] Erbach D. C., Lovely W. G. and Bockhop C. W. 1976. Granular distribution uniformity. Transaction of the ASAE. 19(5): 823-826.

[19] Glover J.W. and Baird J. V. 1970. The performance of spinner type fertilizer spreaders. ASAE Paper No. 70 655. ASAE, St. Joseph, ASAE, USA.

[20] Singh R. C., Singh G. and Saraswat D. C. 2005. Optimization of design and operational parameters of a pneumatic seed metering device for planting cottonseeds. Biosystems Engineering, 92(4): 429-438.

[21] Steel R. G. D., James H. T. and Dickey D. A. 1997. Principles of Procedures of Statistics, a Biometrical Approach, (3rd Ed). McGraw Hill Book Company, New York, USA.

[22] ASAE. 2004. ASAE Standards, 51st ed. S386.2 Calibration and distribution pattern testing of agricultural aerial application equipment. ASAE Standards St. Joseph, MI, ASAE, USA.

[23] SPSS. 2010. SPSS, Inc.