https://dergipark.org.tr/en/pub/turkager 2024, 5(2): 262-270 DOI: 10.46592/turkager.1570191

Turkish Journal of Agricultural Engineering Research
(Turk J Agr Eng Res)
e-ISSN: 2717-8420

TURKAGER

Effects of Using Seed Tube on Seed Distribution Uniformity in Single Seed Planters

Mehdi GÜVEN[a], Nisanur YAKUT[a], Emrah KUŞ[a*]

[a]*Iğdır University Faculty of Agriculture Department of Biosystems Engineering, Iğdır, TÜRKİYE*

ARTICLE INFO: Research Article
Corresponding Author: Emrah KUŞ, E-mail: *emrah.kus@igdir.edu.tr*
Received: 19 October 2024 / **Accepted:** 02 December 2024 / **Published:** 31 December 2024

Cite this article: Güven, M., Yakut, N., & Kuş, E. (2024). Effects of Using Seed Tube on Seed Distribution Uniformity in Single Seed Planters. Turkish Journal of Agricultural Engineering Research, 5(2), 262-270. *https://doi.org/10.46592/turkager.1570191*

ABSTRACT

In single-seed sowing of small seeds, in addition to seed size and shape, critical problems can be experienced due to the electrostatic force that occurs during seeds adhering to the plate holes. To find a solution to these problems, the effect of using seed tubes in single-seed planters was the subject of the study. For this purpose, the study, designed with two different seed drop heights (115 mm and 200 mm) and without and with seed tube, was carried out at three different forward speeds (0.5 m s^{-1}, 1.0 m s^{-1}, and 1.5 m s^{-1}). According to the analysis results applied to the data, it was determined that the seed distribution uniformity was negatively affected by the increase in seed drop height and progress speed, and the planting quality deteriorated. While it was expected that the use of seed tubes in single-seed planters would have a positive effect on the uniformity of seed distribution intra-rows and inter-rows, it was found that on the contrary, the uniformity of seed distribution deteriorated and there was a high degree of variation. The best values for seed distribution uniformity were obtained with a forward speed of 0.5 m s^{-1}, a seed drop height of 115 mm, and no seed tube.

Keywords: *Small seeds, Seed dropping method, Seed drop height, Forward speed*

INTRODUCTION

Single-seed planters are machines used to plant large and small seeds that require special care. It is aimed to provide the needs of the plants such as a living space, water, and nutrients during and after the emergence process of the seeds planted through these machines. Single-seed planting of small seeds is relatively more difficult than large seeds. The reasons for this difficulty are the inability of small seeds to adhere well to the seed plate holes due to size, weight, and shape, and the electrostatic force caused by the plate peripheral velocity (Barut, 2008). The coating of small seeds is one of the common methods used to overcome these problems and to avoid undesirable uniformity of seed distribution. Since the seed coating method provides relative facileness in the planting process, many studies have been carried out so far (Hacıyusufoğlu *et al.*, 2015; Rocha *et al.*, 2019; Afzal *et al.*, 2020). Another method is to monitor seeds in real-time during planting using sensors. Many of the monitoring devices used in this method are based on piezoelectric, capacitance, radio wave, and photoelectric detection theories (Liu *et al.*, 2019). In this context, numerous studies have been conducted using advanced systems developed to monitor seed flow rates. Some of these studies include piezoelectric sensors (Dongyan *et al.*, 2013; Youchun *et al.*, 2017; Youchun *et al.*, 2018), capacitance sensors (Liming *et al.*, 2010; Yujing *et al.*, 2013; Jakub *et al.*, 2017), high frequency radio wave sensors (Linco Precision, 2024), photoelectric sensors (Deividson and Rosane, 2014; Haotun *et al.*, 2018; Marko *et al.*, 2018) and camera systems (Karayel *et al.*, 2006). The fact that the seed coating method requires an additional cost and that sensor systems are not yet widespread in seed planters shows that simpler solutions for the farmer should be emphasized.

In pneumatic single-seed planters, seed tubes are generally not required since the drop height from the seed cell to the furrow is shorter than in conventional seed drills (Kuş, 2014). However, the height at which the seed drops into the soil is relatively low and can vary depending on the type of furrow opener used on the planter. Moreover, research suggests that ensuring uniform seed distribution with single-seed planters is quite difficult due to the many factors that can affect planting (Kuş, 2021a; Kuş, 2021b; Kuş, 2021c). To tackle this challenge, the idea of integrating seed tubes into pneumatic single-seed planters has emerged as a viable solution. The aim of this study was to determine whether the use of a seed tube would make a positive contribution to seed distribution uniformity on small-grained seeds in pneumatic single-seed planters that do not use a seed tube. For this purpose, small-grained seeds were sown without coating, and the performance of the seed device unit was examined under the influence of forward speed, seed-dropping height, and seed-dropping method.

MATERIALS and METHODS

The study was conducted using a sticky band test setup located in the Biosystems Engineering Laboratory of the Faculty of Agriculture at Iğdır University, Türkiye. Mung bean (*Vigna radiata* L.) seeds were used in the experiments. Thousand-grain weight (g), bulk density (kg m^{-3}), angle of repose (°), sphericity (%), and laboratory germination degree values of the seeds determined according to ASAE Standard (2005) were 5.0, 87.2, 18.1, 88.3 and 83.3, respectively. Taking into account the practical values commonly used for mung bean seeds, an inter-row spacing of 500 mm and an intra-row spacing of 50 mm were selected.

The experimental stand consists of three parts: a fan unit, a seed metering unit, and a sticky band. The fan unit was employed to generate the vacuum pressure needed for the small seeds to adhere to the holes of the metering disk. For mung beans, 40 perforated discs were used, and following preliminary trials, the optimal disc hole diameter was determined as 2 mm.

The sticky band stand mounted among two rollers, with a diameter of 145 mm, was 10 meters in length and 0.5 meters in width. The sticky band was divided into 400 across strips, each 25 mm wide, using a laser. Furthermore, a continuous line was drawn along the band's longitudinal axis, precisely in the center. This line is called the Band Center Line (BCL) and is used to determine the row deviation amount of the seeds. As it is well known, the inter-row spacing of seeds (i.e. deviation from the row) in field conditions are determined by accounting for the deviations of the seeds to the left and right of the furrow once emergence is completed. The BCL line drawn longitudinally from the center of the band was used to represent the bottom of the furrow in laboratory conditions. To measure the deviation of the seeds from the normal during the experiments, the BCL was positioned to align with the metering disc point where the seeds of mung beans were freely released from the metering unit. While the seeds were falling freely on the sticky band, the amount of grease on the surface of the band was determined by preliminary experiments and examined in each replicate to prevent bounces (Figure 1). The fan, seed metering unit, and sticky band are each powered by separate electric motors and controlled via speed drivers. The electric motor that drives the fan unit adjusted with a speed driver to be equivalent to the 540 rpm PTO of the tractor.

The experiments were carried out with three different band forward speeds (0.5 m s^{-1}, 1.0 m s^{-1}, and 1.5 m s^{-1}) two seed drop heights (115 and 200 mm), and two seed dropping methods (without seed tube and by seed tube), by design a factorial trial layout with three replications. At each repetition, the band is greased, the fan is turned on, and when it reaches the appropriate speed (the speed equivalent to the 540 rpm PTO of the tractor) the seed metering device is started, and finally the electric motor that drives the belt is started. In the closure process, the reverse procedure was applied, and each repetition was completed. Afterward, to determine the uniformity of seed distribution, the spacings between consecutive seeds in rows and the spacings from the right and left to the BCL line were measured by a scale. The measurements were conducted over a 6000 mm section of the sticky band.

Performance indicators were used to determine the sowing quality: if the spacing between consecutive seeds was greater than 1.5 times the target seed spacing (Z), it was evaluated as the miss index (Imiss>1.5Z), if it was equal to or less than half of the target seed spacing, it was evaluated as the multiple index (Imult≤0.5Z), and if it was greater than half of the target seed spacing and less than 1.5 times, it was evaluated as the quality of feed index (0.5Z<Iq≤1.5Z) (Kachman and Smith 1995; Singh *et al.*, 2005). To determine the impacts of forward speed, seed drop height, and seed dropping method on the planting quality and seed distribution uniformity, analysis of variance (ANOVA) was performed using the SPSS package program. Duncan's Multiple Range was then applied to recognize dissimilarities and similarities among the parameter levels.

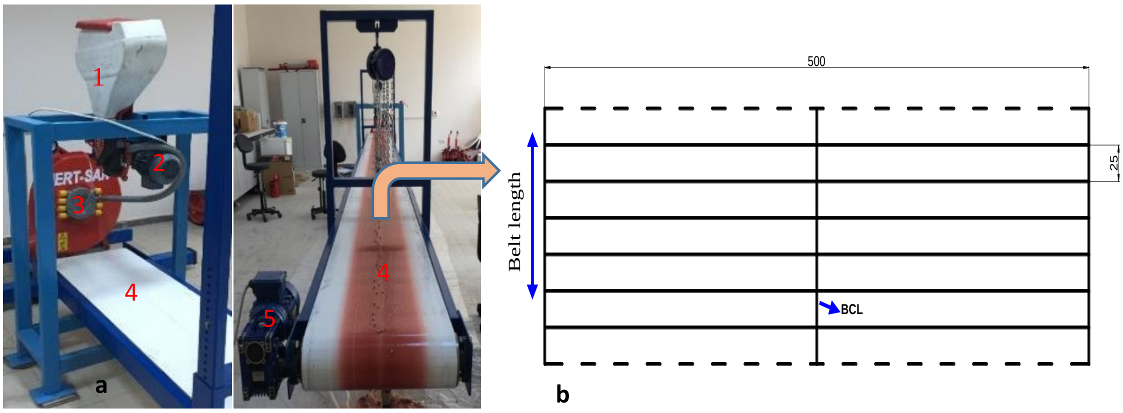

Figure 1. *The parts of the sticky band test rig: (a) seed box (1), AC driving (2), vacuum unit (3), sticky band (4), and AC motor (5). The dimensions are measured in millimeters (b), (Kuş, 2021a).*

RESULTS AND DISCUSSION

The effects of forward speed, seed dropping height, and seed drop method on the seed distribution uniformity and planting quality of mung beans (*Vigna radiata* L.) using a single-seed planter were determined by applying variance analysis and multiple range tests to the data (Tables 1 and 2). By the outcomes of the ANOVA, although the signification levels of forward speed effects on seed spacing of the intra-row, deviation from the row, miss and multiple indexes, and QFI varied, they were generally found to be significant. The effect of seed drop height was found to be very significant only in the intra-row seed spacing, while the seed dropping method was found to be significant in all other parameters except for the miss index. Additionally, another result to consider in the analyses is the interactive effects of the parameters. While the seed-dropping method does not statistically affect the miss index, the interaction between forward speed and the seed-dropping method was determined to be very significant. As it is known, the increase in forward speed affects the peripheral speed of the seed disc, while the use of a seed tube influences the way the seeds fall. It is assumed that a significant relationship exists between these interactions, which could be a result of the effect of forward speed on the free fall of the seeds and their movement within the seed tube. Furthermore, it has been determined that the three-way interaction significantly influences horizontal seed distribution, particularly in terms of intra-row and inter-row (deviation from row) seed spacing.

Table 1. Significance levels (P values) of variance analysis results.

Sources of Variation	SS	DFR	MI	MU	QFI**
Forward speed (S)	0.000*	0.002	0.040	0.000	0.000
Seed Drop Height (SFH)	0.000	0.766	0.097	0.231	0.779
Seed Drop Method (SFM)	0.000	0.003	0.946	0.000	0.000
S x SFH	0.010	0.019	0.085	0.090	0.028
S x SFM	0.736	0.023	0.000	0.132	0.001
SFH x SFM	0.734	0.001	0.654	0.029	0.041
S x SFH x SFM	0.004	0.030	0.695	0.556	0.644

* : P < 0.01 is greatly significant, P < 0.05 is significant and P >0.05 is insignificant. **: SS; Intra-Row Seed Spacing, DFR; Deviation from Row, MI; Miss Index, MU; Multiple Index, QFI; Quality of Feed Index

According to the results of the multiple range tests conducted to determine the difference between the forward speed levels, all levels had different effects on the intra-row seed spacing. There was no statistical difference between the first and second levels (0.5 m s^{-1} and 1.0 m s^{-1}) in deviation from the row and miss index, and between the second and third levels (1.0 m s^{-1} and 1.5 m s^{-1}) in multiple index and QFI (Table 2).

Table 2. Multiple comparison test results for forward speed.

Forward Speed	SS*	DFR	MI	MU	QFI
0.5 m s^{-1}	53.03 c**	2.71 b	11.68 b	9.04 b	79.28 a
1.0 m s^{-1}	56.49 b	2.97 b	12.63 ab	15.63 a	71.17 b
1.5 m s^{-1}	63.80 a	4.73 a	15.14 a	16.21 a	69.24 b

*: SS; Intra-Row Seed Spacing, DFR; Deviation from Row, MI; Miss Index, MU; Multiple Index, QFI; Quality of Feed Index
**: There is no statistical difference between the averages with the same letter in each column.

The coefficient of variation (CV) values of intra-row seed distribution uniformity are shown in Figure 2. Since the experiments were conducted according to a factorial setting, the value of each column of the forward speed in Figure 2 is the average of 12 replications, and the value of each column of the seed drop height and seed drop method is the average of 18 replications. As they can be seen in Figure 2, the highest CV values were obtained at 1.5 m s^{-1} forward speed, 200 mm seed drop height, and when the seed tube was used. The CV values were found to be coherent with the results of the ANOVA for intra-row seed spacing given in Table 1. In addition, the average values of actual seed spacing measured intra-row, depending on the effect of forward speed, seed-drop height, and seed-dropping method, were compared with the target seed spacing value in Figure 3. As it can be understood from the figure, the greatest effect of the variation occurring due to the effect of the parameters on the seed spacing intra-row caused an average deviation of approximately 27.6% in forward speed, 19.8% in seed drop height, and 18.9% in seed dropping method.

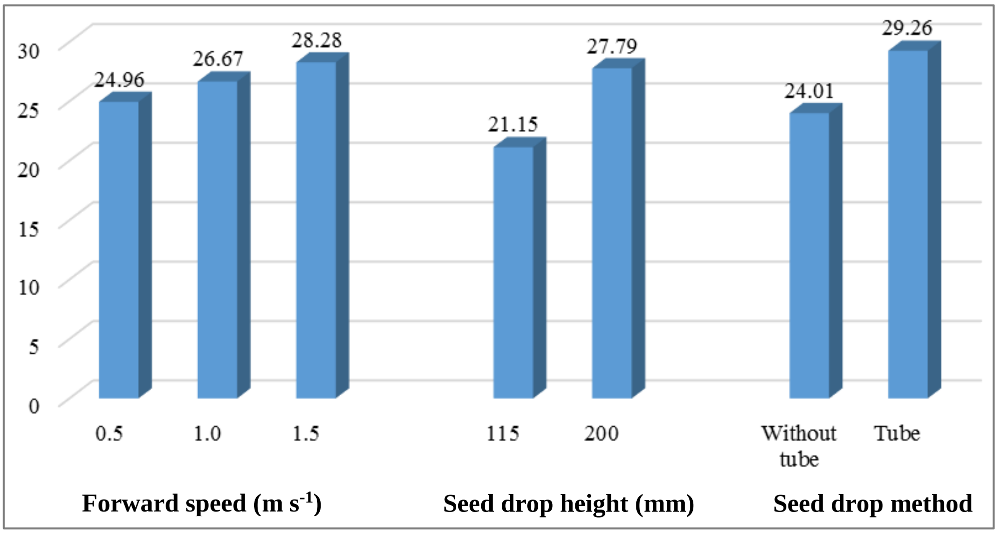

Figure 2. Values in coefficient of variation of seed spacing within the row.

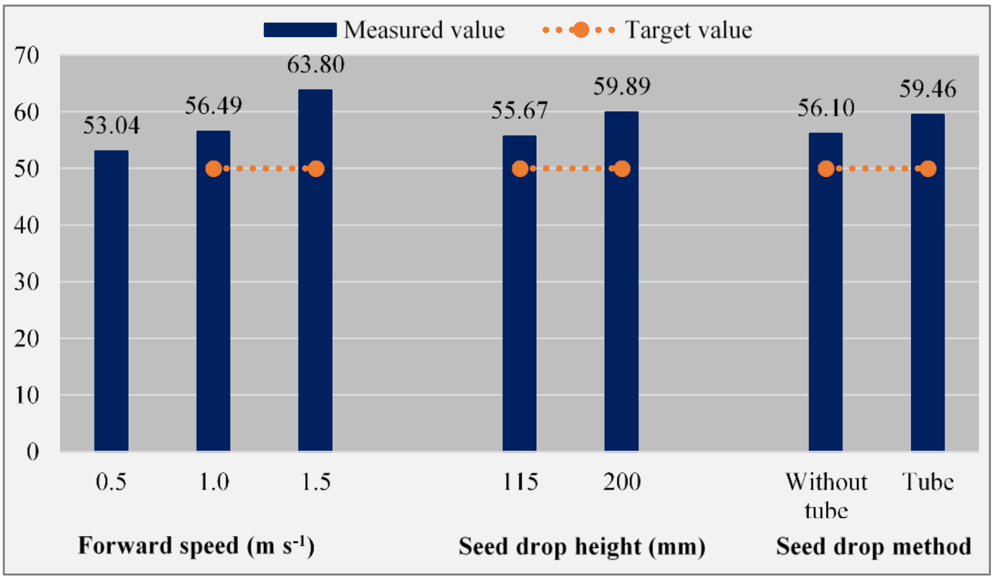

Figure 3. Comparison of seed spacing values measured in row with the theoretical value.

It is understood from the results of the analysis that the seed distribution uniformity of mung bean sown under the influence of three factors was significantly affected. The results of the previous studies with coarse-grain seeds and the effect of forward speed and seed dropping height on seed distribution uniformity were in parallel with the results of the current study with small-grain seeds for the same parameters (Kuş, 2021a; Günal and Kuş, 2021). Another issue that caused a significant worsening in the intra-row seed distribution uniformity was the use of seed tubes. While it was expected that the use of seed tubes would improve the intra-row seed spacing, on the contrary, it caused it to worsen. This distortion in the seed distribution can also be seen in the coefficient of variation values given in Figure 2. We assumed that the reason for this is the movement trajectory of the seed within the seed tube. The reason for this assumption was based on observations made during experiments with the seed tube. In these observations, it was hypothesized that the seeds would come out of the spout of the tube by bouncing or being scattered, which could be the cause of the irregularity. Yazgı *et al.* (2020) reported that the point at which the seed leaves the metering disc into the seed tube affects the intra-row seed spacing with the effect of the disc's peripheral speed and may cause bouncing and slipping in the seed tube. The information that the seed may be subjected to bouncing and sliding in the seed tube depending on the point of release supports the unevenness detected in the current study.

In addition to the CV, three indexes (the miss, multiple, and QFI indexes) are used as indicators of sowing quality. When the quality indicators of mung bean in Figure 4 were analyzed, the worst result was obtained when the seed tube was used. When the use of the seed tube was evaluated according to the without seed tube condition, it did not cause a difference in the miss index, while it caused an increase of about 3 times in the multiple index. Another noteworthy situation in the graph was that both the miss and multiple indexes increased with the increase in the forward speed. However, according to the effect of seed drop height and seed dropping methods, one of the miss index and the multiple index tended to increase while the other tended to decrease. This indicates that the speed of forward had a more inevitable effect on the deterioration of the intra-row seed distribution uniformity. To understand this effect more clearly, looking at the intra-row mean values given in Figure 4 was sufficient. Figure 4 shows that the forward speed caused the small seeds to be shifted more in the row, increasing both the miss and multiple indexes.

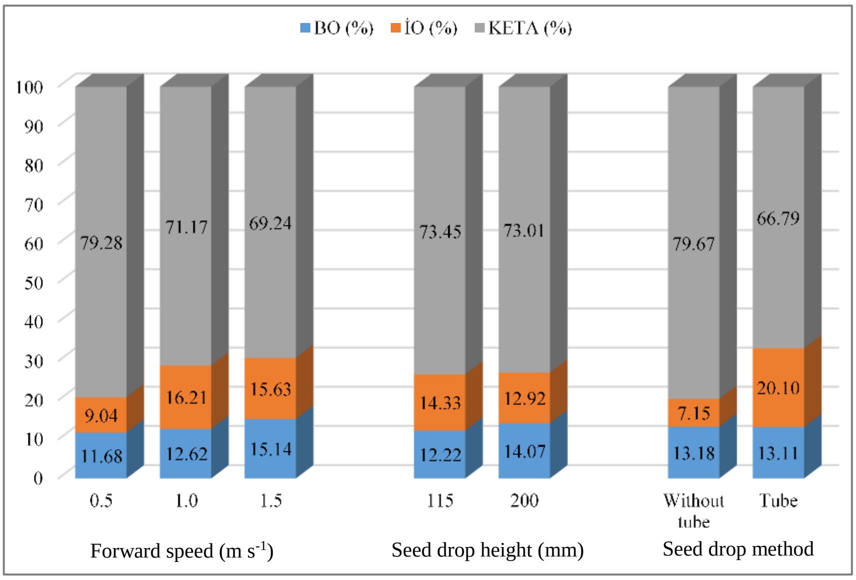

Figure 4. Sowing quality values.

CONCLUSION

The seed distribution uniformity and sowing quality in mung bean planting with a pneumatic single seed planter were affected by all three parameters. The unevenness stated as a percent of the theoretical seed spacing was perhaps affected by the circumferential speed of the seed disc, which increases with the increase of forward speed. Furthermore, the unevenness was the result of the combined effect of three factors. It shows that although it is desirable to work with high forward speeds in single-seed planters, the forward speed cannot be increased as much as desired while sowing small-grain seeds. In addition, it was determined that certain standards should be taken into consideration since the seed drop height is determined according to the size of the furrow opener and that the use of seed tubes has a negative effect on seed distribution uniformity and sowing quality contrary to what is thought.

DECLARATION OF COMPETING INTEREST

I declare that I have no conflict of interest.

ACKNOWLEDGEMENT

This project was funded within the scope of TUBITAK 2209-A - University Students Research Projects Support Program.

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

The author declared that the following contributions are correct.

Mehdi Güven: Investigation, experimental studies.
Nisanur Yakut: Investigation, experimental studies.
Emrah Kuş: Investigation, experimental studies, methodology, conceptualization, formal analysis, data curation, validation, writing, review, and editing, visualization.

ETHICS COMMITTEE DECISION

This article does not require any Ethical Committee Decision.

REFERENCES

Afzal I, Javed T, Amirkhani M and Taylor AG (2020). Modern seed technology: seed coating delivery systems for enhancing seed and crop performance. *Agriculture*, *10(11): 526.* https://doi.org/10.3390/agriculture10110526

ASAE Standard (2005). American Society of Agricultural Engineers (ASAE). Cubes, Pellets, and Crumbles-Definitions and Methods for Determining Density, Durability, and Moisture Content, ASAE S269.4 DEC01. St. Joseph Mich. USA.

Barut Z (2008). Seed coating and tillage effects on sesame stand establishment and planter performance for single seed sowing. *Applied Engineering in Agriculture*, *24(5): 565-571.* https://doi.org/10.13031/2013.25268

Deividson LO and Rosane F (2014). Usage of the DFRobot RB-DFR-49 Infrared sensor to detect maize seed passage on a conveyor belt. *Computers and Electronics in Agriculture*, *102: 106-111.* https://doi.org/10.1016/j.compag.2014.01.012

Dongyan H, Honglei J, Yue Q, Longtu Z and Honggang L (2013). Seeding monitor system for planter based on polyvinylidence fluroride piezoelectric film. *Transactions of the Chinese Society of Agricultural Engineering*, *23: 15-22.*

Günal ME and Kuş E (2021). Evaluation of parameters effective to performance of vacuum planter in single-seed sowing of the chickpea. *Fresenius Environmental Bulletin*, *11: 12140-12145.*

Hacıyusufoğlu AF, Akbaş T and Şimşek E (2015). Implement of the method of seed coating with pellet on some small-diameter seeds. *Journal of Agricultural Machinery Science*, *11(3): 257-263.* (In Turkish).

Haotun L, Jieyu R, Xin L, Shixiong L, Gang W and Yongjun Z (2018). *Review of the monitoring systems of the machine for precision sowing and fertilization of wheat. In Proceedings of the ASABE 2018 Annual International Meeting, Austin*, TX, USA, 29 July-1 August 2018; p. 1800736.

Jakub L, Václav K, Václav P and František K (2017). Capacitive throughput sensor for plant materials-effects of frequency and moisture content. *Computers and Electronics in Agriculture, 133: 22-29.* https://doi.org/10.1016/j.compag.2016.12.014

Kachman SD and Smith JA (1995). Alternative measures of accuracy in plant spacing for planters using single seed metering. *Transactions of the ASAE*, *38(2): 379-387.* https://doi.org/10.13031/2013.27843

Karayel D, Wiesehoff M, Özmerzi A and Müller J (2006). Laboratory measurement of seed drill seed spacing and velocity of fall of seeds using high-speed camera system. *Computers and Electronics in Agriculture, 50: 89-96.* https://doi.org/10.1016/j.compag.2005.05.005

Kuş E (2014). *Determination of effects of drop height of seed and ground speed on sowing qualification for conventional and reduced tillage conditions in precision vacuum seeders*. PhD Thesis, Ataturk University (Unpublished), Turkey.

Kuş E (2021a). An attempt to evaluate the performance parameters of a precision vacuum seeder in different seed drop height. *Journal of the Institute of Science and Technology*, *11(3): 1846-1853.*

Kuş E (2021b). Evaluation of some operational parameters of a vacuum single-seed planter in maize sowing. *Journal of Agricultural Sciences (Tarim Bilimleri Dergisi)*, *27(3): 327-334.*

Kuş E (2021c). Field-scale evaluation of parameters affecting planter vibration in single seed planting. Measurement, *184(3): 109959.* https://doi.org/10.1016/j.measurement.2021.109959

Linco Precision (2024). WaveVision Sensors (Precision planting). Available online: https://www.lincoprecision.com/precision-farming/precisioplanting/wavevision-sensors/ (08/10/2024).

Liming Z, Xiaochao Z and Yanwei Y (2010). Design of capacitance seed rate sensor of wheat planter. *Transactions of the Chinese Society of Agricultural Engineering, 10: 99-103.*

Liu W, Hu J, Zhao X, Pan H, Lakhiar IA, Wang W and Zhao J (2019). Development and experimental analysis of a seeding quantity sensor for the precision seeding of small seeds. *Sensors (Basel)*, *19(23): 5191.* https://doi.org/10.3390/s19235191

Marko K, Dusan R, Dragi R, Lazar S, Nebojsa D, Vladimir C and Natasa L (2018). Corn seeding process fault cause analysis based on a theoretical and experimental approach. *Computers and Electronics in Agriculture, 151: 207-218.* https://doi.org/10.1016/j.measurement.2021.109959

Rocha I, Ma Y, Souza-Alonso P, Vosátka M, Freitas H and Oliveira RS (2019). Seed coating: A tool for delivering beneficial microbes to agricultural crops. *Frontiers in Plant Science*, *10: 1357.* https://doi.org/10.3389/fpls.2019.01357

Singh RC, Singh G and Saraswat DC (2005). Optimizing of design and operational parameters of pneumatic seed metering device for planting cottonseeds. *Biosystem Engineering*, *92(4): 429-438.* https://doi.org/10.1016/j.biosystemseng.2005.07.002

Yazgı A, Demir V and Değirmencioğlu A (2020). Comparison of computational fluid dynamics based simulations and visualized seed trajectories in different seed tubes. *Turkish Journal of Agriculture and Forestry*, *44(6): 599-611.* https://doi.org/10.3906/tar-1910-15

Youchun D, Junqiang Y, Kai Z, Lili Z, Yawen Z and Qingxi L (2017). Design and experiment on seed flow sensing device for rapeseed precision metering device. *Transactions of the Chinese Society of Agricultural Engineering*, *9: 37-44.*

Youchun D, Lili Z, Junqiang Y and Kai Z (2018). Sensing device improvement and communication design on sowing monitoring system of precision planter for rapeseed. *Transactions of the Chinese Society of Agricultural Engineering*, *14: 19-26.*

Yujing S, Honglei J, Deliang R, Jingjing Y and Yang L (2013). Experimental study of capacitance sensors to test seed-flow. *Applied Mechanics and Materials*, *347: 167-170.* https://doi.org/10.4028/www.scientific.net/AMM.347-350.167