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Modelling of Soil Displacement Resulting from Sweep during Tillage Operation Using Image Processing

J. Massah[1*], H. Etezadi[1], B. Azadegan[2], and S. R. Hassan-Beygi[1]

ABSTRACT

The study of soil particles displacement through the passage of a tillage blade can lead to an appropriate geometrical design of soil-engaging tools, which can reduce the energy consumption required for tillage. In this study, soil displacement by a conventional sweep was measured and modelled. The sweep had a cutting width equal to 150 mm, and it was tested in an indoor soil bin containing a loam soil with 5.5% moisture content (dry basis) at a working depth of 50 mm and a travel speed of 0.133 m s^{-1}. Five pins with different colors were placed at the soil surface with a certain order in front of the sweep to model the interaction of soil and the soil-engaging part of the sweep. The pins movements were tracked for 10 seconds from the moment they were in touch with the sweep using a CCTV camera installed above the sweep. Experimental results showed a general trend of the highest displacements around the center of the path of sweep, reducing at further distance away from the center. The measured lateral displacement ranged from -167 to +71 mm due to the displacements of the pins. Furthermore, a polynomial equation was fitted to the path of each pin. The extremum of these equations indicated the highest soil displacement in the paths. The method presented in this study can be used in designing problems where agricultural engineers can study the effects of sweeps with different geometries on the trend of soil translocations during the tillage.

Keywords: Geometry of tillage implements, Soil displacement model, Soil-tool interaction, Tillage sweep, Tracer method.

INTRODUCTION

Investigating soil displacement around tillage blades has always been of interest to agricultural machinery experts. Tillage operating time, management of plant remains, wearing of soil-engaging parts, energy consumption, and ploughed soil structure are those crucial aspects that can be improved by studying soil displacement during the tillage operation. Geometry of tillage implements, operating speed, and soil physical-mechanical properties are significant features influencing the soil displacement resulting from a soil-engaging implement (Sharifat and Kushwaha, 1997; Liu and Kushwaha, 2006). Study of lateral and forward soil displacement can be a useful method to indicate the quality of the tillage. For example, high soil lateral throw is not desired, because it results in non-uniform seeding depth and sufficient soil cannot be backfilled to cover the seeds (Hasimu and Chen, 2014). Furthermore, excessive soil displacement increases moisture loss and weed seed germination (Solhjou *et al*., 2012).

Several studies have been carried out during the last three decades to investigate the effects of different parameters on soil displacement. For example, Barr and Fielke

[1] Department of Agrotechnology, College of Abouraihan, University of Tehran, Tehran, Islamic Republic of Iran.

[*] Corresponding author; e-mail: jmassah@ut.ac.ir

[2] Department of Irrigation and Drainage, College of Abouraihan, University of Tehran, Tehran, Islamic Republic of Iran.

(2016) reported that increasing the travel speed of no-till openers results in greater lateral soil throw. Sharifat and Kushwaha (1999) investigated a sweep and a furrow opener under different soil conditions, and reported an important conclusion: soil bulk density, moisture content, and rake angles of tool significantly affect soil lateral displacement. In a study, Hemmat (2009) investigated the reduction of primary tillage depth. Results indicate that the yield of irrigated winter canola is not sensitive to reduction in the depth of primary tillage or intensity of secondary tillage. Solhjou *et al*. (2012) analyzed flat-faced narrow openers with different rake angles in a soil bin and concluded that smaller rake angles moved deeper soil up to the surface, which can be useful for seed germination in dry soil conditions. Furthermore, soil forward and lateral movements for an opener with face chamfers were lower than an opener with a blunt face (Solhjou *et al.*, 2013).

In another research, Solhjou *et al*. (2014) evaluated the effect of a range of bent leg narrow opener geometries on soil displacements when operating at 120 mm depth. They showed that a bent leg opener geometry combined with a chamfered face could loosen a furrow without throwing soil laterally out of the furrow due to the shank being offset (bent) away from the central upheaval of soil. The bent leg openers were also able to loosen soil with minimal mixing of soil layers.

Novák *et al*. (2016) investigated the influence of different operating speed of disc tiller and tine tiller on soil particle translocation during shallow primary tillage. They reported that disc tiller translocated soil particles to a shorter distance than the tine tiller. Bogunovic and Kisic (2017) investigated the compaction of a clay loam soil under different tillage systems. The results showed that deep tillage was superior to conventional tillage and no-tillage treatments. Ucgul *et al*. (2017a) tested a one-third scale mouldboard plough in a soil bin where draught force, vertical force and soil movement were measured. They compared soil movement, percentage of top soil burial and forward soil movement of the soil bin tests and the Discrete Element Modeling (DEM) simulations. Results showed similar trends and patterns for both methods. In another experiment, they analyzed full-scale mouldboard plough under field conditions and showed that analysis of the depth of top soil burial predicted by the DEM was similar to the field measurements. However, the DEM simulations did show that the soil buried at a shallower depth was thrown further sideways than that measured in the field test (Ucgul *et al*., 2017b)

In a recent study, Gürsoy *et al*. (2017) showed that forward soil displacement was less for smaller sweeps, and lateral soil displacement was lower at a greater depth regardless of the sweeps. Among all the sweeps, the 153 mm wide sweep had significantly higher vertical displacements at all depths as compared to the other sweeps.

Znova *et al*. (2017) introduced a new share design (L-share) that reduces the undesired random soil movement, providing a more controlled disturbance of the upper soil layer. They showed that increasing operation speed and cultivation depths generally increased draught forces and soil movement.

The tracer method in which tracers are placed in the soil before a tillage operation has been commonly used for soil displacement measurements. In this method, the displacement of tracers after tillage is considered to be the displacement of the soil (Rahman, *et al*., 2005; Gürsoy *et al*., 2017). Different materials with different sizes have been used as tracers, such as gravels, steel, ceramic, plastic, and aluminum. Sharifat and Kushwaha (1997) used plastic tracers due to the similar density of plastic and soil. Rahman *et al*. (2005) compared cube tracers with different sizes (10, 15, 20 mm) and materials (wooden, PVC, aluminum, and steel) and recommended 10-mm PVC or aluminum cubic tracers for soil movement studies.

The tracer method has two important drawbacks. Soil disturbance associated with the tracer insertion before tillage and the

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time consuming nature of the measurement is one of these drawbacks. Another drawback is the difficulties in locating tracers after tillage.

It seems that the second knot can be untied by tracking colored tracers in the soil using an image processing module. A camera can be installed above the tillage tool to record a video during the tillage operation. The video can be then analyzed in a lab to track the colored tracers to extract the soil displacement trends.

Among the tillage impalements, sweeps as common soil-engaging tools for many field operations, such as mechanical weed control, tillage, and seeding are of importance and it seems that studying the behavior of soil-tool interactions can be useful for agricultural machinery designers. Therefore, the objectives of this study were: (1) To measure soil displacement resulting from a sweeps in a loam soil using an image processing technique, and (2) To develop a regression model to simulate the interaction of the sweeps with soil.

MATERIALS AND METHODS

Sweep and Soil Bin Facility

A commercially available sweep with width, height, and nose angle equal to 150 mm, 450 mm, and 45°, respectively, was selected for the test (Figure 1). The sweep was tested in a soil bin located in the Department of Agrotechnology, College of Abouraihan, University of Tehran, Iran. The soil bin was 6 m long, 0.9 m wide, and 0.5 m deep, and it contained a loam soil (35% sand, 40% silt, and 25% clay) with bulk density of 2,630 kg m^{-3} (Figure 2).

The soil preparation procedure including spraying water, cultivating, levelling, and compacting the soil was carried out according to as Hasimu and Chen (2014). The soil moisture content was 5.5% (dry basis) and its Cone Index (CI) was 814 kPa. The sweep was attached to an edge-on vertical shank by a bolt. The shank was mounted to the soil bin carriage. The test was run at a target working depth of 50 mm and a travel speed of 0.133 m s^{-1}, a typical speed used for laboratory experiments.

Measurement of Soil Displacement Using Image Processing

To measure soil particles displacement from the sweep, five pins with blue, red, yellow, green and black colors were used as soil particles. Length, diameter and weight of the pins were 45 mm, 8 mm, and 1.3 g, respectively (Figure 3). Dimension and weight of the pins, which were selected based on trial and error, were chosen in a way so they were capable of following the path correctly. They were not too light to be thrown and not too heavy to cause delay in

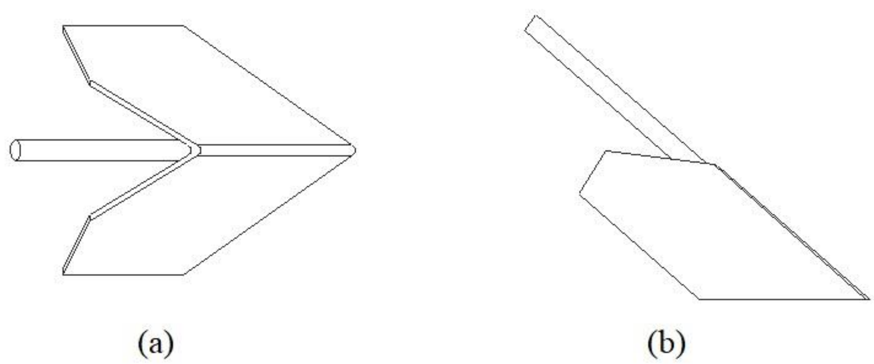

Figure 1. A schematic of the sweep used in the experiment: (a) Top view and (b) Lateral view.

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Figure 2. The soil bin used for carrying out the experiment.

Figure 3. One of the pins used in the experiment.

movements.

After several pre-experiments, which started from considering three rows of pins and locating five pins in each row on the soil surface, two rows were selected, in which three pins were located in the first row and two pins in the second row. In this arrangement, at the beginning of the experiments, the first row was closer to the sweep whilst the second row had a distance to the sweep. Top view of the pins arrangement is shown in Figure 4, which also shows the color of each pin. The distance between the pins is considered based on trial and error in a way to avoid collision among the pins during the experiments. The experiment was carried out with two replications.

In this study, a CCTV camera (MC, Hivision, Korea) installed above the sweep was used for tracking the movement of colored pins (Figure 2). A 10 seconds video was recorded from the moment that the pins were in touch with the sweep using the camera. Recorded video was then transferred to the computer using a USB 2.0 docking station DVI video card (capture card adapter, i-Tek, Germany) for image

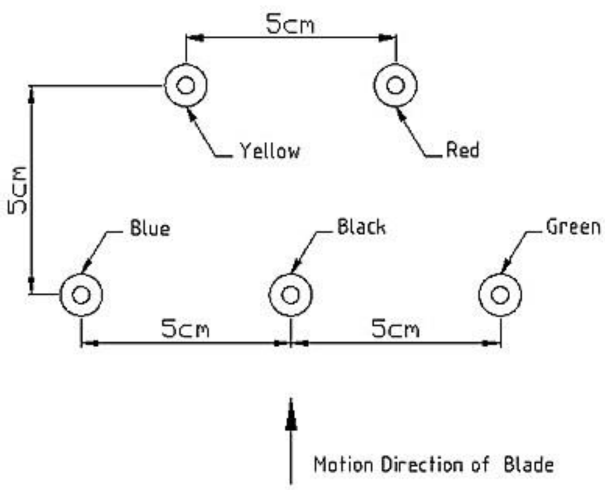

Figure 4. Top view of the pins orderly placed in the soil in front of the sweep.

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processing. A program written in MATLAB programming environment was used for video analysis. The flow chart of the image processing algorithm used for tracking the motion of the pins is shown in Figure 5. Since the video was 30-frame per seconds, 300 frames were analyzed by the program. The location of each pin in each frame was determined by the program. Then, a sequence of pin movement from the first frame to the 300th frame was extracted for each pin. This sequence shows the soil displacement during the experiment. Since the experiment was carried out with two replications, the movement of the pins in each frame obtained by the replications was averaged so a reliable path for each pin would be achieved.

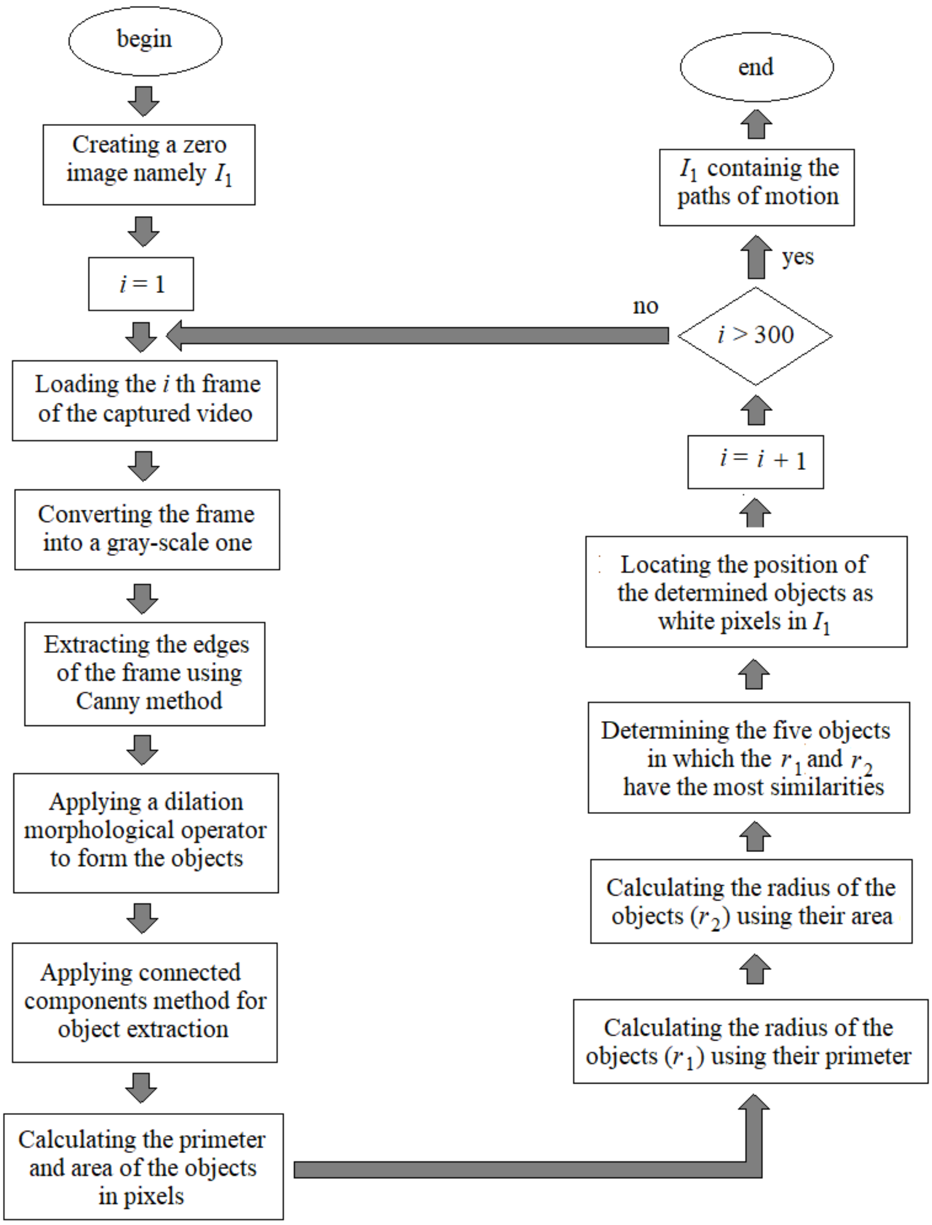

Figure 5. The flow chart of the image processing algorithm used for tracking the motion of the pins.

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Modelling the Soil Displacement Using Curve Fitting

After extracting the path of soil displacement, a 10-th order polynomial equation was fitted to each path using the Curve Fitting Toolbox of MATLAB. This equation requires 11 parameters (Equation 1), where x and y are displacements in travel and lateral directions, respectively. The positive axis of these directions is shown in Figure 6. The reason that the order of the equation was chosen as 10 was to properly indicate the soil displacement behavior during the tillage. Lower orders might not be able to show this behavior whilst higher orders would require more equation parameters complicating the interpretation of the equation.

$$x = a_1 y^{10} + a_2 y^9 + a_3 y^8 + a_4 y^7 + a_5 y^6 + a_6 y^5 + a_7 y^4 + a_8 y^3 + a_9 y^2 + a_{10} y^1 + a_{11} \quad (1)$$

RESULTS AND DISCUSSION

Soil displacement in front of the sweep on a camera's captured frame and on a schematic view is illustrated in Figure 7. As shown in the figure, the pin at the center of the sweep path (black pin) was thrown the widest. Furthermore, the soil bubble movement in front of the sweep was detected by yellow and red pins. Table 1 shows average and maximum lateral displacements of the pins. The measured lateral displacement ranged from -167 to +71 mm due to the displacements of the pins according to the direction shown in Figure 6.

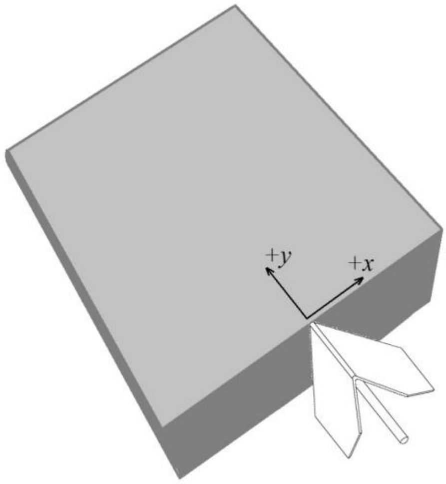

Figure 6. The axis of x and y directions in the modeling of soil displacement.

The soil lateral displacements were recorded for both inward (+x) and outward (-x) directions, relative to the initial location of each pin on the soil surface. After averaging the values at all the lateral locations, the net values of soil displacement were oriented to the center of the sweep path in most cases. Similar results have been obtained in the studies of soil movement from sweeps by Rahman *et al*. (2005) and Gürsoy *et al*. (2017). It should be noted that defining the axes in these studies is a bit different with what is defined in the present study. Several studies have shown that inward displacements are associated with soil backfilling, which is desired for seeding (Gürsoy *et al*., 2017).

Gürsoy *et al*. (2017) have reported that the displacement will be reduced with an increase in sweep width at the soil surface.

Table 1. Average and maximum lateral displacements of the pins.

	-x direction		+x direction	
	Average	Maximum	Average	Maximum
Red	46	58	2	4
Yellow	4	8	42	71
Blue	15	27	36	63
Green	7	16	22	41
Black	93	167	5	9

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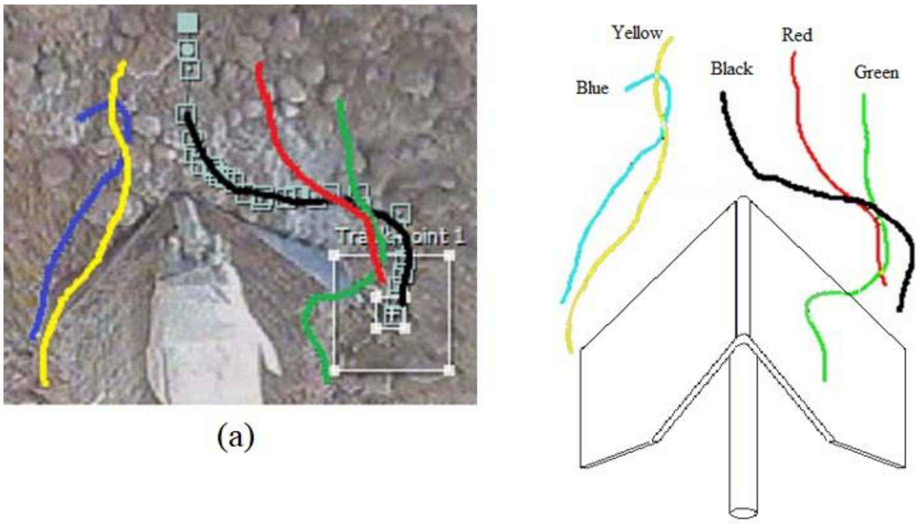

(a) (b)

Figure 7. Soil displacement in front of the sweep: (a) On a camera's captured frame and (b) On a schematic view.

This can be attributed to the fact that soil flowing around a wider sweep had a lower speed because of soil-tool adhesion and soil-tool friction. Furthermore, the measurement of soil displacement is carried out on soil surface in this study. It seems that by increasing the depth, the soil displacement will be reduced (Gürsoy *et al*., 2017), so, soil movement is maximum in the zero depth.

Regression curves fitted on the path of the soil movement are illustrated in Figure 8. Table 2 shows the parameters of the regression model fitted to the soil paths. Since the fitted model was a 10-th order polynomial curve, 11 parameters are determined for each model in Table 2. Travel speed and width of the sweep affect the fitted model parameters. Providing such regression model can be useful for studying the behavior of soil lateral displacement in each moment having the forward travel of the sweep. Average and maximum soil displacements can be easily determined using these models. Furthermore, function extremum, maximum, and minimum of these models in the domain of sweep travel distance can result in maximum and minimum soil displacement during the tillage operation. The parameters of the fitted model presented in Table 2 have some physical implications. In a regression model, the sensitivity of the output variable to the changes of the input variable significantly increases by increasing the higher order parameters of the model. As shown in Table 2, the higher order parameters of the fitted model to the path of the black pin (a_n, n =

Table 2. Parameters of the fitted regression model to the soil paths.

	$a_1\times 10^{-20}$	$a_2\times 10^{-17}$	$a_3\times 10^{-14}$	$a_4\times 10^{-12}$	$a_5\times 10^{-10}$	$a_6\times 10^{-7}$	$a_7\times 10^{-6}$	$a_8\times 10^{-4}$	$a_9\times 10^{-2}$	$a_{10}\times 10^{-1}$	a_{11}
Red	-2.98	10.9	-14.3	98.1	-408	109	-1900	2150	-1506	5905	-9747
Yellow	2.76	-5.32	4.40	-20.3	57.6	-10.4	117	80.6	32.3	-65.9	51.3
Blue	73.8	-107	67.9	-245	552	-81.2	781	-480	178	-354	282
Green	20.0	-17.5	5.63	-6.81	-2.15	1.15	-4.66	-5.90	2.99	161	12.8
Black	-418	462	-213	533	-781	68.2	-350	92.3	-10.2	39.7	216

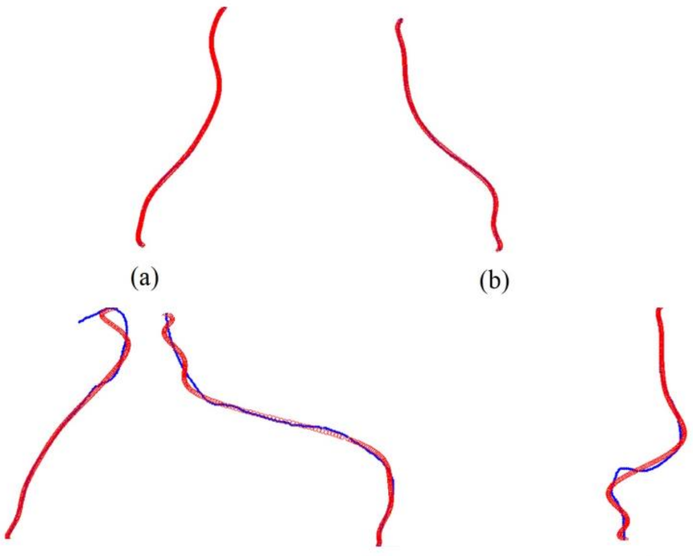

Figure 8. Regression curves (red) fitted on the path of the soil movement (blue) for: (a) Yellow, (b) Red, (c) Blue, (d) Black, and (e) Green pins.

1,…, 5) are high compared to other models, which reveals the significant lateral displacement of the black pin. This result is in line with the findings brought in Table 1.

Larger lateral soil displacement causes rougher soil surface, which is considered poorer performance for a tillage operation. Smoother soil surface favors a better seeding result, as it will most likely give a more uniform seeding depth. Large lateral displacement also causes several other problems. Larger soil displacement also implies high tractor power requirement based on energy conservation laws. The source of the kinetic energy of moving soil particles is provided from the impact of the sweep, which is powered by the tractor in a farm. One problem is "soil stepping", that is the phenomenon of tool throwing soil into the furrows created by adjacent tools (Hasimu and Chen, 2014). In the case of seeding operation, soil stepping will result in uneven seeding depths, which will negatively affect the uniformity of plant emergence. Another problem is that soil stepping, in the case of post-emergence weeding operations, may damage the plants by burying them in soil. Based on these facts, the small sweep, S153, had advantages.

CONCLUSIONS

In this study, soil displacements resulting from a sweep was measured for a loam soil in a soil bin. A model of soil lateral displacement was developed using regression curves fitted from a sequence of soil displacements in a video recorded from the top view of tillage operation.

This study initiated a new investigation by using colored pins as model tracers to monitor soil displacement. Five pins with different colors were placed at the soil surface with a certain order in front of the sweep, and pins movements were tracked for 10 seconds from the moment they were in touch with the sweep using a camera. The limitation of the method presented in this study might be in measurements of the displacement of soil particles in soil depth.

The soil bubble during the tillage operation was observed using image processing. Measurement results showed that lateral displacements decreased from the center of sweep path to the edges along the lateral direction. A polynomial equation was then fitted to the path of each pin. The extremum of these equations indicated the highest soil displacement in the paths.

Since higher lateral soil displacement causes rougher soil surface, more energy consumption, and soil stepping (Zhang *et al*., 2004), the method presented in this study can be used in designing problems to improve soil lateral displacements during tillage operation.

REFERENCES

1. Barr, J. B. and Fielke, J. M. 2016. Discrete Element Modelling of Narrow Point Openers to Improve Soil Disturbance Characteristics of No-Till Seeding Systems. Paper No. 162460906, *In 2016 ASABE Annual International Meeting* , 17-20 July 2016, Florida, USA, PP. 1-14.
2. Bogunovic, I. and Kisic, I. 2017. Compaction of a Clay Loam Soil in Pannonian Region of Croatia under Different Tillage Systems. *J. Agr. Sci. Tech.,* **19:** 475-486.
3. Gürsoy, S., Chen, Y. and Li, B. 2017. Measurement and Modelling of Soil Displacement from Sweeps with Different Cutting Widths. *Biosyst. Eng.,* **161(1):** 1-13.
4. Hasimu, A. and Chen, Y. 2014. Soil Disturbance and Draft Force of Selected Seed Openers. *Soil Till. Res.,* **140(1):** 48-54.
5. Hemmat, A. 2009. Reduction in Primary Tillage Depth and Secondary Tillage Intensity for Irrigated Canola Production in a Loam Soil in Central Iran. *J. Agr. Sci. Tech.,* **11**: 275-288.
6. Kushwaha, R. L. and Shen, J. 1995. Finite Element Analysis of the Dynamic Interaction between Soil and Tillage Tool. *T. ASAE,* **38(5):** 1315-1319.
7. Lindstrom, M. J., Nelson, W. W., Schumacher, T. E. and Lemme, G. D. 1990. Soil Movement by Tillage as Affected by Slope. *Soil Till. Res.,* **17(3-4):** 255-264.
8. Liu, J., Chen, Y. and Kushwaha, R. L. 2010. Effect of Tillage Speed and Straw Length on Soil and Straw Movement by a Sweep. *Soil Till. Res.,* **109(1):** 9-17.
9. Liu, J. and Kushwaha, R. L. 2006. Modeling of Soil Profile Produced by a Single Sweep Tool. *CIGR J.,* **8(1):** 1-13.
10. Novák, P., Hůla, J. and Kumhálová, J. 2016. Translocation of Soil Particles at Different Speed of Tillers. *In Proceedings of 6th International Conference Trends in Agricultural Engineering,* 7-9 September 2016, Czech Republic, PP. 433-437.
11. Rahman, S., Chen, Y., and Lobb, D. 2005. Soil Movement Resulting from Sweep Type Liquid Manure Injection Tools. *Biosyst. Eng.,* **91 (3)**:379-392.
12. Sharifat, K. and Kushwaha, R. L. 1997. Soil Translocation by Two Tillage Tools. *Can. Agr. Eng.,* **39(2):** 77-84.
13. Sharifat, K. and Kushwaha, R. L. 1999. Lateral Soil Movement by Tillage Tools. Paper No. 991003, *In 1999 ASAE Annual International Meeting,* 18-21 July 1999, Ontario, Canada, PP. 1-8.
14. Sharifat, K. and Kushwaha, R. L. 2000. Modeling Soil Movement by Tillage Tools. *Can. Agr. Eng.,* **42(4):** 165-172.
15. Sibbesen, E., Andersen, C. E., Andersen, S., and Flensted-Jensen, M. 1985. Soil Movement in Long-Term Field Experiments as a Result of Cultivations. I. A Model for Approximating Soil Movement in One Horizontal Dimension by Repeated Tillage. *Exp. Agr.,* **21(2):** 101-107.
16. Solhjou, A., Fielke, J. M. and Desbiolles, J. M. 2012. Soil Translocation by Narrow Openers with Various Rake Angles. *Biosyst. Eng.,* **112(1):** 65-73.
17. Solhjou, A., Desbiolles, J. M. and Fielke, J. M. 2013. Soil Translocation by Barrow Openers with Various Blade Face Geometries. *Biosyst. Eng.,* **114(3):** 259-266.
18. Solhjou, A., Fielke, J. M., Desbiolles, J. M. and Saunders, C. 2014. Soil translocation by Narrow Openers with Various Bent Leg Geometries. *Biosyst. Eng.,* **127(1):** 41-49.
19. Tollner, E. W., Verma, B. P. and Cheshire, J. M. 1987. Observing Soil-Tool Interactions and Soil Organisms Using X-Ray Computer Tomography. *T. ASAE,* **30(6):** 1605-1610.
20. Ucgul, M., Saunders, C. and Fielke, J. M. 2017a. Discrete Element Modelling of Tillage Forces and Soil Movement of a One-Third Scale Mouldboard Plough. *Biosyst. Eng.,* **155(1):** 44-54.
21. Ucgul, M., Saunders, C. and Fielke, J. M. 2017b. Discrete Element Modelling of Top Soil Burial Using a Full Scale Mouldboard

Plough under Field Conditions. *Biosyst. Eng.*, **160(1):** 140-153.

22. Zhang, J. H., Lobb, D. A., Li, Y. and Liu, G. C. 2004. Assessment of Tillage Translocation and Tillage Erosion by Hoeing on the Steep Land in Hilly Areas of Sichuan, China. *Soil Till. Res.*, **75(2):** 99-107.
23. Znova, L., Melander, B., Lisowski, A., Klonowski, J., Chlebowski, J., Edwards, G. T., Kirkegaard Nielsen, S. and Green, O. 2017. A New Hoe Share Design for Weed Control: Measurements of Soil Movement and Draught Forces during Operation. *Acta Agr. Scand. B - S. P.*, **68(2):** 139-148.

مدل‌سازی جابجائی خاک بر اثر خاکورزی پنجه‌غازی به کمک پردازش تصویر

ج. مساح، ح. اعتضادی، ب. آزادگان، و س. ر. حسن بیگی

چکیده

مطالعه جابجایی ذرات خاک به هنگام عبور یک تیغه خاکورزی می‌تواند منجر به طراحی هندسی مناسب ابزار خاکورز شده و بنابراین، انرژی مورد نیاز برای خاکورزی را کاهش دهد. در این تحقیق، جابجایی خاک بر اثر حرکت یک تیغه پنجه‌غازی متداول اندازه‌گیری و مدل‌سازی شده است. تیغه پنجه‌غازی دارای عرض برشی برابر با ۱۵۰ میلی‌متر بود و عملیات خاکورزی آن در شرایط آزمایشگاهی و در خاک لومی با رطوبت ۵.۵٪ (بر پایه خشک) در عمق کاری ۵۰ میلی‌متر و سرعت پیشروی ۰/۱۳۳ متر بر ثانیه مورد مطالعه قرار گرفت. پنج نشانه با رنگ‌های مختلف در سطح خاک با یک نظم خاص در مسیر پیشروی تیغه پنجه‌غازی قرار داده شد تا بتوان برهم‌کنش خاک-ادوات را مدل کرد. مسیر حرکت نشانه‌ها به مدت ۱۰ ثانیه از لحظه برخورد با تیغه به کمک یک دوربین CCTV نصب شده در بالای تیغه ردیابی شدند. نتایج تجربی نشان داد که بیشترین جابجایی‌ها در اطراف مرکز مسیر تیغه بود و با دورتر شدن از مرکز تیغه کاهش می‌یافت. جابه‌جایی جانبی اندازه‌گیری شده بین ۱۶۷- تا ۷۱+ میلی‌متر بود. همچنین، یک معادله چندجمله‌ای به مسیر حرکت هر یک از نشانه‌ها برازش شد. نقطه اکسترمم این معادلات نشان‌دهنده بیشترین میزان جابجایی خاک در مسیر حرکت نشانه‌ها بود. روش ارائه شده در این تحقیق می‌تواند در مسائل طراحی ادوات خاکورزی به منظور مطالعه اثر تیغه‌های پنجه‌غازی با هندسه‌های مختلف بر روی جابه‌جائی خاک در طی عملیات خاکورزی مورد استفاده قرار گیرد.

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