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ORAL PRESENTATIONS

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Determination of Percent Crop Residue Cover by Drone and Image Processing Method in Wheat Field After Harvesting*

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Abstract: Crop residue management is very important to control soil erosion. Leaving crop residue on the soil surface before and during planting provides very good cover for the soil. Measuring percent crop residue cover is an essential step in improving knowledge about the adoption and impact of conservation tillage. This study aimed at determining the percent crop residue cover using drone and image processing method in wheat field after harvesting. Measurements were performed during in August-October 2017. Line transect method was used as a reference method to control the results obtained from drone and ImageJ image processing method. In order to determine the percent crop residue cover using drone and ImageJ image processing, photographs were taken with a digital camera of the drone from various places of a field (A, B, C parcels) covered with wheat surface residues. The crop residue covers of A, B and C parcels were ≤ 30%, 30-60% and ≥ 60%, respectively. Wooden frame of size 1x1 m was used to determine sampling areas. During the tests, the flight height of the drone was 1.5 m. The captured digital photos were transferred to the computer and converted to JPEG format. Digital photos were analyzed using the ImageJ image processing software. In the line transect method, the square-shaped areas with a dimension of 10.6 x 10.6 m with a diagonal length of 15 m were marked on field surface. A measuring tape was then laid across the field surface at an angle of 45 degrees along a 15 m long diagonal. Intersecting points with crop surface residues at 30 cm intervals along the single edge of the measuring tape were counted. The percent crop residue cover was calculated by multiplying the number of intersecting points by the total number of slices and multiplying the value by 100. At the end of study, the mean values of percent crop residue cover using drone and image processing software ImageJ (Method 1) and line transect method (Method 2) were determined as 30.33% and 30.00% in A parcel, 64.55% and 57.33% in B parcel, 89.67% and %91.33 in C parcel, respectively. Variance analysis showed that the differences between the results obtained from Method 1 and Method 2 were statistically insignificant ($p>0.05$) in all parcels.

Keywords: Percent crop residue cover, drone, image processing method, ImageJ, line transect method

1.INTRODUCTION

Crop residues consist of vegetatif fragments such as stubble, stem, stalk, straw, glume, corncob, sunflower head, leave, seed pod, capsule, etc. which are remaining on the soil surface after harvesting (Dursun Göknur, 2002). They are also called mulch. There are many benefits such as prevention of erosion and soil moisture loss, increase of soil organic matter content, improvement of soil structure, increase of soil temperature and infiltration, reduction of field traffic, prevention of soil compaction, reduction of fuel consumption and weed control (Dickey et al., 1986; Aase and Tanaka, 1991; Daughtry et al., 1997; Rice, 2002; Bannari et al., 2006; Al-Kaisi and Hanna, 2009; MABC, 2015; Dursun 2015; UNL, 2016; Dursun et al., 2017).

Tillage methods according to the percent crop residue cover remaining on the soil surface after soil cultivation and planting are categorised into three main groups: conventional tillage (<15%), reduced tillage (15-30%) and conservation tillage (≥ 30%) (Dursun, 2015). Crop residue management provides a means for limiting both soil particle detachment and removal from the field. Vegetatif residues protect the soil from impact by dissipating the energy of the raindrops (Al-Kaisi and Hanna 2009). Residue left on the soil surface or crop residue management is the primary erosion control method (Shelton et al., 1995). The first step of crop residue management is to determine the percent crop residue cover (Dursun et al., 2017).

Various estimation and measurement methods are used to determine the percent crop residue cover (Daughtry, 2001; Dursun Göknur, 2002; Daughtry et al., 2006; Dursun et al., 2017). These methods are consisted of interviewee estimation, enumerator estimation visiting the field, interviewee with visual-aid without visiting the field, enumerator with visual-aid visiting the field, the photo comparison method, the calculation method, meter stick method, line transect method, laser scanning measurement method, estimating crop residue cover by blue fluorescence imaging, spectral reflectance measurement method, remote sensing method, field picture collected with a digital camera and analyzed with image processing method, field picture collected with a drone and analyzed with image processing method (Laflen et al., 1981; Dickey and Havlin, 1985; Hickman and Schoenberger, 1989; Corak et al., 1993; McMurtrey et al., 1993; Shelton et al., 1995; Daughtry et al., 1997; Streck et al., 2002; Al-Kaisi and Hanna, 2009; Presley, 2013; Zheng et al., 2014; Kosmowski et al., 2016; Dursun et al., 2017).

Drone is unmanned aircraft or unmanned aerial vehicle that can be remotely controlled. Essentially, drone is flying robot. Drones are used for different purposes such as crop spraying, fertilizing, planting, irrigation, soil and field analysis, health assessment, yield estimation, crop monitoring, weeds detection, monitoring of surface flows, mapping and surveying etc. in agriculture (CEMA, 2016; Kosmowski et al., 2016; McKinnon, 2016). Drones can provide real time imagery and sensor data from fields which cannot be quickly accessed on foot or by vehicle (Malveaux et al., 2014).
In this research, it is aimed to determine the percent crop residue cover by using field picture collected with a drone and analyzed with image processing method in the field condition after wheat harvesting.

2.MATERIALS AND METHODS

The research took place in Ankara University Faculty of Agriculture Haymana Research & Experimental Farm in August and October 2017. The field is covered with surface residues of wheat and soil type is clay. The average stubble height is 19 cm.

Measurements were performed at low (A), medium (B) and high (C) percent crop residue cover of parcels. The crop residue covers of A, B and C parcels were ≤ 30%, 30-60% and ≥ 90%, respectively. Each parcel was divided into 3 sub-parcel.

In drone and image processing method, DJI Phantom 3 Pro drone was used to capture aerial pictures of the surveyed field. Drone has 4 propellers. The maximum flight time is approximate 23 min. The maximum speed is 16 m s^{-1}. The resolution of the drone's camera is 4000x3000 pixels.

ImageJ image analysis program was utilized to evaluate the digital photos. ImageJ supports 8-bit, 16-bit and 32-bit (real) grayscale images and 8-bit and 32-bit color images. It can read many image formats including TIFF, GIF, JPEG, BMP, etc. ImageJ is an open source image processing program. This program was designed for scientific.

In the method drone and ImageJ, the boundaries of the areas to be measured was determined by a wooden frame of 1x1 m square. No measurements were made from areas of flooded lands, drought, soil compaction, insect and weed damage (Eck and Brown, 2004). The digital camera of drone was used to capture aerial pictures of the surveyed fields designated by frame. Field picture was taken by drone at a 1.5 m altitude. The average wind speed was measured as 2 m s^{-1}. Three picture was taken in each sub-parcel. Digital images in JPEG format transferred to the computer have been converted to 8 bit-gray color format in ImageJ. It is then ready to be processed by the Threshold button from the Process menu in the program interface. As a result of this process, soil and crop residues are separated from each other. From the Analyze menu, the List command is given using the Histogram option. Depending on the pixel numbers in the black and white colors, the image of the percent crop residue cover on the screen was obtained as a chart (Dursun et al., 2017).

In the research, the line transect method was used to compare the results wich was taken drone image processing method. In the line transect method, squared areas with a size of 10.6 x 10.6 m and a diagonal length of 15 m were marked by the piling of the piles on the corners of each parcel. A strip meter was stretched at diagonally in field surface such as an angle of 45 degrees along the 15 m long diagonal (Dickey et al., 1986; Shelton and Jasa, 2009). It was counted the number of marks that intersect a piece of residue at 30 cm intervals along the single edge of the strip meter. The percent crop residue cover was calculated by dividing the number of intersecting points by the total number of divisions (50 piece) (Laflen et al., 1981; Al-Kaisi and Hanna, 2009; Anonim, 2015; Dursun et al., 2017).
The one-way analysis of variance (ANOVA) were applied to the values obtained from the research. SPSS software package program was used in statistical computations (Lowry, 2018).

3.RESULTS AND DISCUSSION

The averages of percent crop residue cover obtained at the measurements in parcel A (≤ 30%) were given in Table 1. The results of the one-way analysis of variance (ANOVA) were given in Table 2. According to Table 2, it can be say that the difference between the methods was statistically insignificant ($p > 0.05$).

The averages of percent crop residue cover obtained at the measurements made in parcel B (% 30-60) were given in Table 3. The results of the one-way analysis of variance (ANOVA) were given in Table 4. According to Table 4, it can be say that the difference between the methods was statistically insignificant ($p > 0.05$).

Table 1. The averages and standard errors of percent crop residue cover obtained at the measurements in parcel A (%)

Method	Parcel and sub-parcels	□ ± S□
Drone + ImageJ	**A1**	32.33 ± 1.76
	A2	32.00 ± 3.46
	A3	26.67 ± 1.76
	A parcels	**30.33 ± 1.83**
Line transect	**A1**	32.00
	A2	32.00
	A3	26.00
	A parcels	**30.00 ± 2.00**

Table 2. Results of variance analysis of percents crop residue cover found in parcel A

Source of variance	Degrees of freedom	Sums of squares	Mean squares	F	P
Total	11	194.250	-		
Between parcels	2	62.000	-		
Within parcels	9	132.250	-	0.710	0.264
Treatment (Between groups)	3	60.917	20.306		
Error	6	71.333	11.889		

Table 3. The averages and standard errors of percent crop residue cover obtained at the measurements in parcel B (%)

Method	Parcel and sub-parcels	□ ± S□
Drone + ImageJ	**B1**	63.00 ± 10.26
	B2	62.33 ± 2.40
	B3	68.33 ± 12.25
	B parcels	**64.55 ± 1.90**
Line transect	**B1**	58.00
	B2	58.00
	B3	56.00
	B parcels	**57.33 ± 0.67**

Table 4. Results of variance analysis of percents crop residue cover found in parcel B

Source of variance	Degrees of freedom	Sums of squares	Mean squares	F	P
Total	11	1752.250	-		
Between parcels	2	666.500	-		
Within parcels	9	1085.750	-	0.400	0.758
Treatment (Between groups)	3	182.250	60.750		
Error	6	903.500	150.583		

The averages of percent crop residue cover obtained at the measurements made in parcel C (≥ % 90) were given in Table 5. The results of the one-way analysis of variance (ANOVA) were given in Table 6. According to Table 6, it can be say that the difference between the methods was statistically insignificant ($p>0.05$).

Table 5. The averages and standard errors of percent crop residue cover obtained at the measurements in parcel C (%)

Method	Parcel and sub-parcels	□ ± S□
Drone + ImageJ	**C1**	91.00 ± 4.04
	C2	92.33 ± 0.88
	C3	85.67 ± 4.98
	C parcels	**89.67 ± 2.03**
Line transect	**C1**	94.00
	C2	92.00
	C3	88.00
	C parcels	**91.33 ± 1.76**

Table 6. Results of variance analysis of percents crop residue cover found in parcel C

Source of variance	Degrees of freedom	Sums of squares	Mean squares	F	P
Total	11	350.917	-		
Between parcels	2	60.667	-		
Within parcels	9	290.250	-		
Treatment (Between groups)	3	80.917	26.972	0.770	0.551
Error	6	209.333	34.889		

According to the results obtained from the research, the difference between the percents crop residue cover found in parcels A, B and C is statistically insignificant. This result was confirmed by Karabacak (2007), Kosmowski et al. (2016) and Dursun et al. (2017). Karabacak (2007) found that the correlation coefficient between the values of percent crop residue cover obtained from image analysis and line transect method was 0.91 for wheat. Dursun et al. (2017) determined that the difference between the values of the percent crop residue cover obtained from ImageJ image processing program analyzing photographs which was taken with the digital camera of the smart mobile phone and line transect method is statistically insignificant in the field condition covered with wheat surface residues. Kosmowski et al. (2016) found that the difference between the values of the percent crop residue cover obtained from the image processing method analyzing photographs taken with the camera of the drone and line transect method was statistically insignificant.

4.CONCLUSION

At the end of the research, it was understood that the percent crop residue cover can besuccessfully determined with drone and ImageJ image processing program.

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