RESEARCH IN STRIP TILLAGE MACHINE ROW CLEANER TECHNOLOGY PROCESS

Egidijus Sarauskis[1], Kristina Vaitauskiene[1], Kestutis Romaneckas[1], Antanas Sakalauskas[1], Algirdas Jasinskas[1], Vidmantas Butkus[1], Davut Karayel[2], Zita Kriauciuniene[1]
[1]Aleksandras Stulginskis University, Lithuania; [2]Akdeniz University, Turkey
egidijus.sarauskis@asu.lt, kristina.vaitauskiene@asu.lt, kestas.romaneckas@asu.lt, zita.kriauciuniene@asu.lt

Abstract. Lately the strip tillage system has been gaining increasing popularity in the world; it tills only the individual strips of soil in which the crops will be sown, not the entire soil surface. Strip tillage is a combination of the traditional and no tillage systems with the inherent advantages of both systems. This article presents the results of experimental studies that summarize the strip tillage machine row cleaner technical parameters on strip formation and cleaning off crop residues. The research has shown that using the strip tillage system for wide row crops the disc attack angle of the seed distributer should not be greater than 15º, and the distance between the centre of the seed distributer discs should not exceed 120 mm. Machine working speed has a strong influence on cleaning off crop residues. In order for the crop residues not to be cleaned off too far, the working speed should not be greater than 9 km·h^{-1}.

Keywords: strip tillage, row cleaners, crop residues, working speed, attack angle.

Introduction

Every year the no tillage strip tillage system gains popularity: the soil is only tilled where it will be sowed and the rest is left undisturbed [1; 2]. Strip tillage is a minimum tillage system consisting of no tillage and conventional full tillage systems. This tillage system is designed to grow crops with wide row spacing, such as corn, sugar beets, sunflowers, etc. [1]. The main advantages of strip tillage determining the popularity of these systems are cost reduction and environmental friendliness. Strip tillage reduces energy consumption because only one part of the soil is tilled, also undisturbed soil is protected from erosion [1; 2]. Between tillage strips, in the row spaces remaining from the last harvest crop residues and upright stubble even after strong precipitation hold water well enough, it is absorbed by the crop residues and the soil [3]. In addition, crop residues between the tilled strips keep the soil moisture and prevent it from easy evaporating. Tilled soil warms up faster than not tilled [4], which is very important to ensure favourable conditions for seed germination. One of the most important factors is that strip tillage, compared to conventional tillage, allows reducing the costs of agricultural production. Scientists [4; 5] performed experimental investigations and determined that strip tillage system use for corn and sugar beet crops yields a harvest similar to that observed in conventional tillage system. Strip tillage working time and fuel costs are lower.

Strip tillage technology usually cultivates soil between 100 and 300 mm wide with a tillage depth of 80 to 200 mm [6]. The width of the strips and the distances between them depend on what crops will be grown. Strip width is a very important tillage parameter, which may affect not only the crop but also the tractor fuel consumption. Experimental studies conducted in Turkey found that increasing the strip width from 225 to 375 mm average sunflower seed yield increased from 3.9 to 4.4 t·ha^{-1}. However, when the tractor fuel consumption was assessed, it was estimated that 225 mm strip widths require less fuel. When the strip width is increased to 375 mm, the tractor fuel consumption expenses increase by an average of 2.5 l·ha^{-1} [7].

Strip tillage technology is important in many ways, one of the most important being the cleaning off of crop residues, which affects proper seedbed preparation in accordance with the agro-technical requirements. The most commonly used are various forms of disc row cleaners. Strip tillage machine row cleaner discs can be installed behind the disc coulter that slices through the soil. However, in this case, 4 % more of crop residues may be inserted in the soil [8].

Scientists state that the row cleaner discs need gaps between them of 5-20 mm, because two discs at an angle get clogged with straw and get pushed up to the top [9].

Strip tillage technology is just beginning to be researched in Lithuania. There is a lack of experimental and fundamental research to prove what strip tillage machine work is most appropriate for Lithuanian soil and climate conditions. In addition, it is not yet known what the main technical

parameters of the working parts should be to ensure a quality tillage process that would require the lowest energy costs and would be the most environmentally friendly.

The aim of this work is to determine the strip tillage machine disc row cleaner technical parameters regarding strip formation and cleaning off crop residues.

Materials and methods

Experimental research was carried out in medium loam soil in Pasvalys district in 2014. Experimental studies were carried out with a strip tillage machine, which consisted of two equal sections capable of cultivating two separate strips on the soil surface. The main object of this experimental study was row cleaner discs that are installed on the front of the strip tillage machine (Fig. 1) for cleaning off crop residues that do not clog up other machine working parts. Serrated row cleaners composed of two discs were used in the examination. Both discs had the same diameter (340 mm) and number of teeth 14.

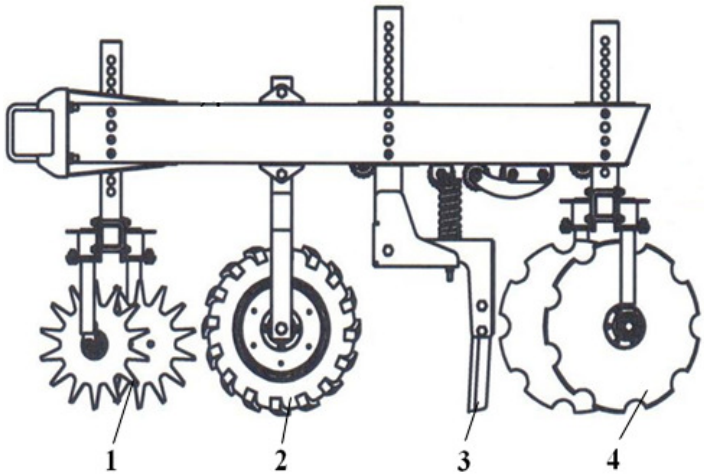

Fig. 1. **Strip-tillage equipment:** 1 – row cleaners, 2 – supporting wheel, 3 – coulter, 4 – discs

The experimental research was carried out by changing the experimental machine row cleaner disc attack angle α with the driving direction (α = 10.0º, α = 15.0º and α = 22.5º), the gap L between the row cleaner disc centres (L = 105 mm, L = 120 mm ir L = 135 mm), and working speed (5 km·h^{-1}, 7 km·h^{-1}, 9 km·h^{-1}, 11 km·h^{-1}). No-till spring wheat stubble was selected to determine the experimental strip tillage machine working parameters, wherein the upper soil layer (0-50 mm) humidity was 13 % and hardness about 1.0 MPa. Soil hardness and humidity were measured by an Eijkelkamp Penetrologger.

Performing the research the row cleaner discs crossed through the crop residue covered surface of the soil. The row cleaner discs stuck in the soil spinning on their axles; disturbed the soil surface and cleaned crop residues off beyond the edge of the strip. The experimental research has shown that the distance row cleaner discs cast crop residues from the centre of the strip, depending on the working speed of the machine, row cleaner disc attack angle, and the distance between the centres of the row cleaner discs. Also, according to the above-mentioned row cleaner disc parameters the strip width of disturbed and undisturbed soil was determined. All investigations were replicated 5 times.

The experimental research data were processed using the analysis of variance method, estimating least significant differences LSD_{05} at the 95 % probability level [10].

Results and discussion

The research established that for the strip tillage machines working at an identical speed of 5 km·h^{-1} the strip width is strongly influenced by the row cleaner disc technical parameters. As the distance (L) between the centres of the discs increases it gives the impact on the surface of the soil and hence wider strips are formed (Fig. 2). As the distance L increased from 105 to 135 mm, the strip width increased on average from 1.7 % to 4.7 %. The higher the attack angle of the disc, the lower the strip width dependence on the distance L.

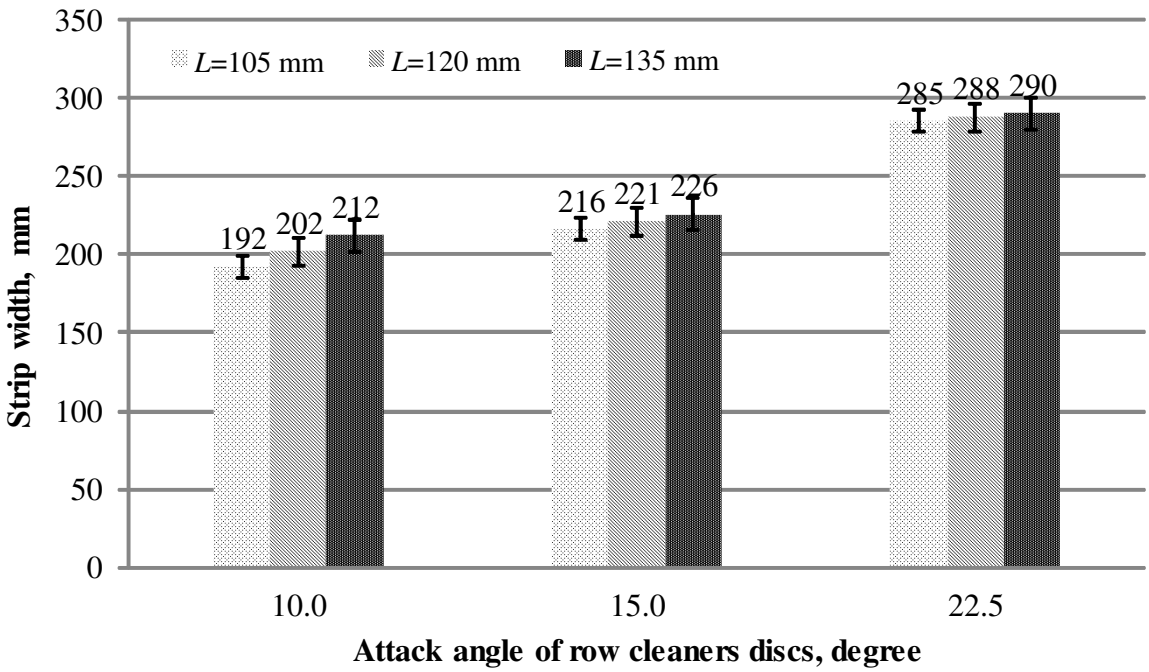

Fig. 2. **Strip width dependence on technical parameters of the row cleaner**

Another very important technical parameter is the row cleaner disc attack angle (α), which indicates the disc position relative to the driving direction. When the attack angle is 10.0º, the strip width averaged about 202 mm. When the attack angle increased from 10.0º to 15.0º, the average strip width increased by about 20 mm. Increasing the angle of attack further, from 10.0º to 22.5º, the average strip width increased significantly by about 86 mm. Wide strips means that more soil surface will be affected by machine working parts, and at the same time benefits of sustainable agriculture technology will be reduced: soil protection from erosion, reduction of fertile layer soil leaching, water conservation, etc. In addition, greater strip width tilling means higher energy consumption.

In order for the tillage technological process to be executed smoothly, it is necessary for the tilled soil surface part (in our case the strip) to be free of crop residues of the last harvest. The main purpose of the row cleaner discs is to clean the strip area of straw, stems and crop residues, etc., so that they do not interfere with coulters and other working part functions. The row cleaning quality depends on the technical machine parameters of the row cleaner and technological modes. The experimental research has shown the influence of different attack angles and machine speeds, and different gaps between the centres of the discs (L) on cleaning off crop residues.

In the first case, the distance L between the centres of the row cleaner discs was set at 105 mm. Studies have shown that both the row cleaner attack angle (α) and the working speed of the machine have a strong impact on cleaned off crop residues falling distance from the centre of the strip. When the attack angle is 10.0º, the cleaned off crop residues distance from the centre of the strip, depending on the working speed, ranged from 208 to 252 mm (Fig. 3). Increasing the angle of attack further, from 10.0º to 22.5º, cleaned off crop residues fell even further from the centre of the strip.

Machine working speeds have a significant impact on cleaned off crop residues final placement. It was determined that if the working speed is increased from 5 to 11 km·h^{-1}, cleaned off crop residues fall 44 mm further away (when α = 10.0º), 100 mm (when α = 15.0º), and 114 mm (when α = 22.5º).

As the distance L between the centres of the row cleaner discs increased to 120 mm, it was found that the cleaned off crop residues distance from the centre of the strip increased the most in the case where the attack angle was α = 22.5º (Fig. 4). At other attack angles an increase was also observed, but not as great. As in the previous studies, so in this case, crop residues fell farthest from the centre of the strip when the working speed was 11 km·h^{-1}.

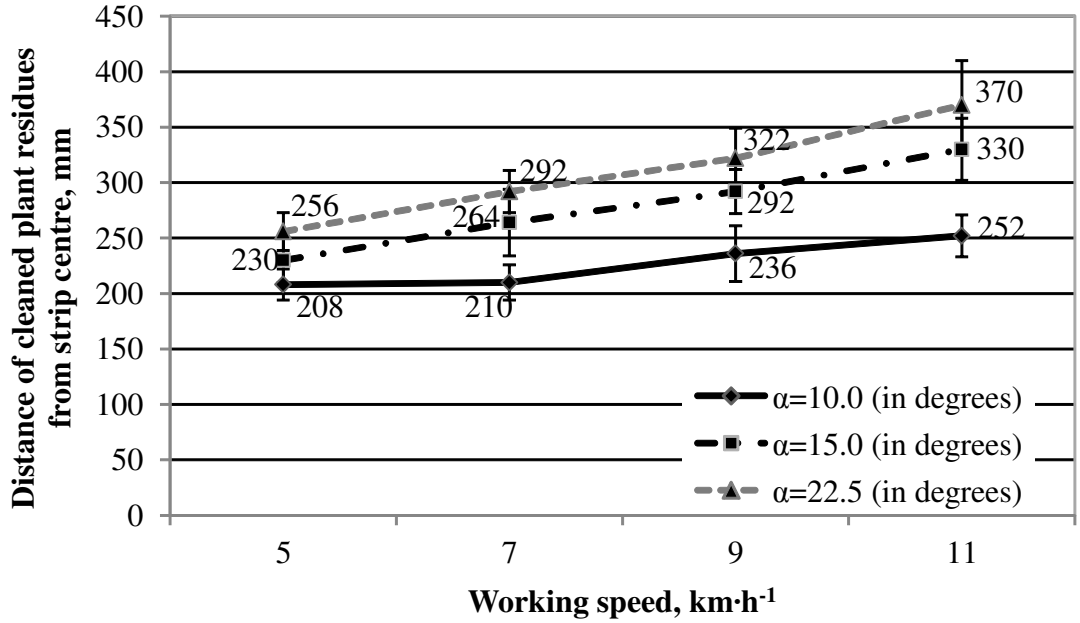

Fig. 3. **Working speed and row cleaner attack angle influence on the cleaned off crop residues distance from the centre of the strip, where *L* = 105 mm**

As the distance between the centres of the row cleaner discs was increased further (*L* = 135 mm), it was found that the cleaned off crop residues distance from the centre of the strip increased the most. When the attack angle is $\alpha = 22.5^{o}$, the greatest cleaned off crop residues distances of all were determined (Fig. 5). At 11 km·h^{-1} working speed crop residues fell up to 812 mm away. This distance is clearly too large, because the crops are often grown in wide rows of 500, 600, or 750 mm row spacing. This would mean that the crop residues from one strip could be flung all the way to another strip. Preferably the crop residues are flung no further than the middle of the strip.

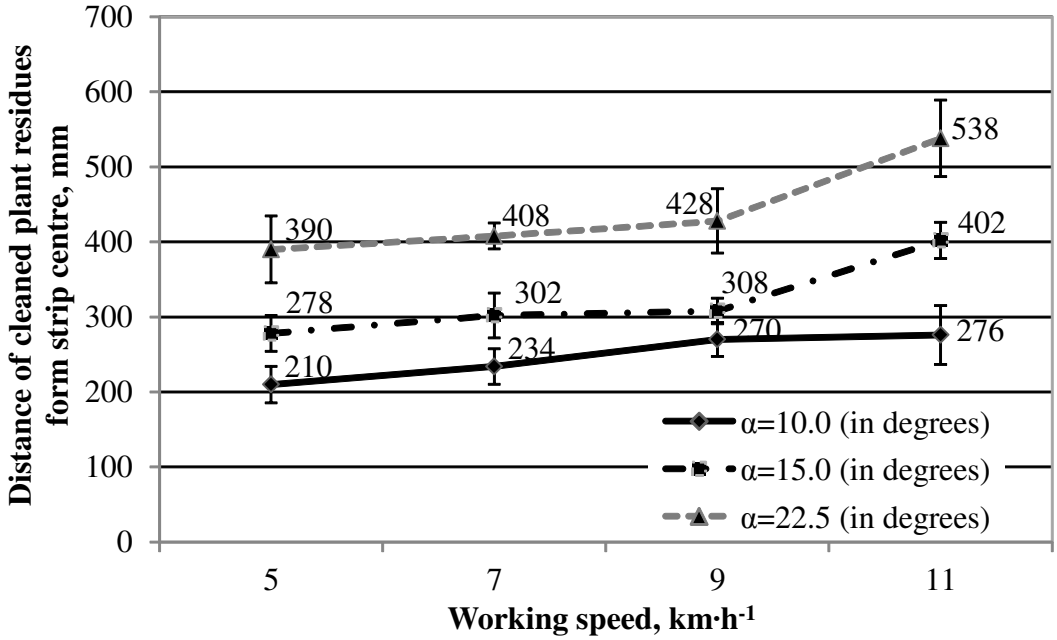

Fig. 4. **Working speed and row cleaner attack angle influence on the cleaned off crop residues distance from the centre of the strip, where *L* = 120 mm**

In summary of the experimental results, it can be stated that the strip width and cleaned off crop residues distance from the centre of the strip are significantly influenced by the technical parameters and row cleaner strip tillage machine working speeds. The most suitable attack angles for the technical

process are α = 10º and α = 15º, the distances from tarp row cleaner disc centres are L = 105 mm and L = 120 mm, and the working speed is from 5 to 9 km·h^{-1}.

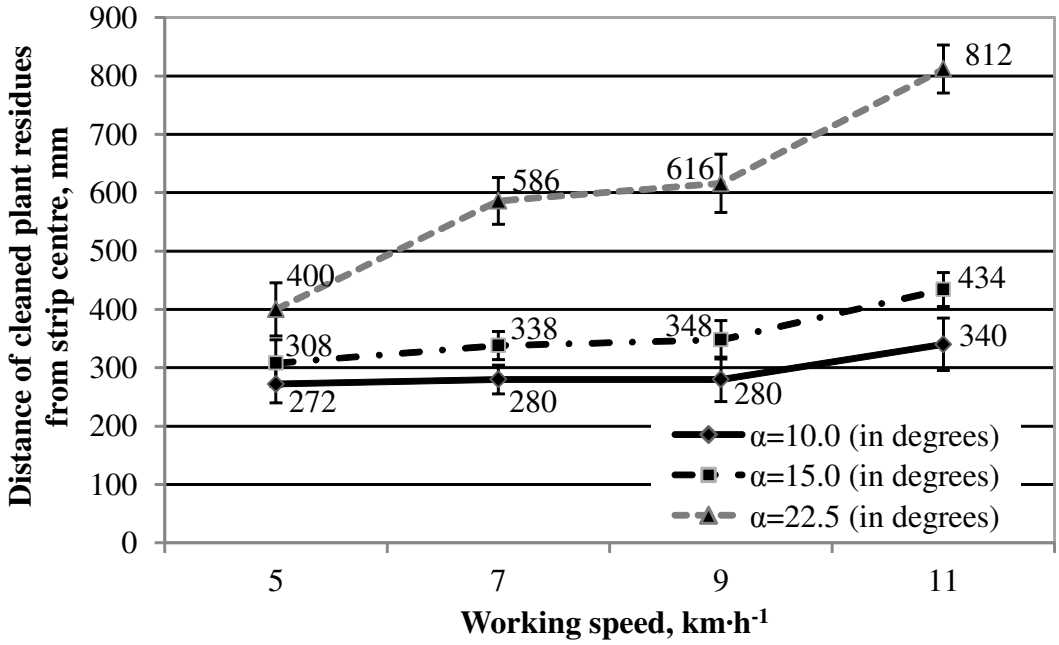

Fig. 5. **Working speed and row cleaner attack angle influence on the cleaned off crop residues distance from the centre of the strip, where L = 135 mm**

Conclusions

1. The strip width depends on the technical parameters of the strip tillage machine working parts. When the row cleaner disc attack angles are switched from α = 10.0º to α = 22.5º and the gaps between the disc centres are increased from L = 105 mm to L = 135 mm, the strip width increased from 192 to 290 mm.
2. Row cleaner disc attack angles and the gaps between the disc centres have a strong impact on the distance of the cleaned off crop residues falling from the centre of the strip. Strip tillage technology is important for growing wide row crops, the row cleaner disc attack angle should not be greater than 15º, and the distance between the disc centres should not exceed 120 mm.
3. Increasing the strip tillage machine working speed greatly increases the distance of cleaned off crop residues falling from the centre of the strip. When the working speed is 11 km·h^{-1}, the cleaned off crop residue distance is too great because crop residues can fall onto parallel strips. To avoid this the working speed should be limited to 9 km·h^{-1}.

References

1. Nowatzki J., Endres G., DeJong-Hughes J., Aakre D. Strip till for field crop production: Equipment-Production-Economics. North Dakota State University Extention service, 2008. 8 p. [online] [28.02.2015]. Available at: http://www.ag.ndsu.edu/pubs/ageng/machine/ae1370.pdf.
2. Sarauskis E., Masilionyte L. Žemes dirbimo ir tiesiogines sejos derinys (Combination of tillage and no-tillage). Mano ukis, vol. 6, 2012, pp. 70-75. (in Lithuanian).
3. Jabro J.D., Stevens W.B., Iversen W.M., Evants R.G. Bulk density, water content, and hydraulic properties of a sandy loam soil following conventional or strip tillage. Applied Engineering in Agriculture, vol. 27(5), 2011, pp. 59-69.
4. Evans R.G., Stevens W.B., Iversen W.M. Development of strip tillage on sprinkler irrigated sugarbeet. Applied Engineering in Agriculture, vol. 26(1), 2010, pp. 59-69.
5. DeJong-Hughes J., Vetsch J. On-farm comparison of conservation tillage systems for corn following soybeans. University of Minnesota, 2007. 12 p.

6. Morris N.L., Miller P.C.H., Orson J.H., Froud-Williams R.J. The adoption of non-inversion tillage systems in the United Kingdom and the agronomic impact on soil, crops and environment – A review. Soil and Tillage Research, vol. 108, 2010, pp. 1-15.
7. Celic A., Altikat S., Way T. R. Strip tillage width effects on sunflower seed emergence and yield. Soil & Tillage Research, vol. 131, 2013, pp. 20-27.
8. Fallahi S., Raoufat M.H. Row-crop planter attachments in a conservation tillage system: A comparative study. Soil and Tillage Research, vol. 98, 2008, pp. 27-34.
9. Terminology for soil-engaging components for conservation-tillage planters, drills and seeders Transaction of the ASAE standarts S477, 1995, pp. 312-317.
10. Jasinskas A., Steponavičius D., Šarauskis E., Šniauka P., Vaiciukevičius E., Zinkevičius R. Zemes ukio masinu laboratoriniai darbai (Agricultural machines laboratory works), Lithuanian University of Agriculture, Akademija, Kauno r., 2010, p. 110. (In Lithuanian).