Experimental Investigation of the Influence of the Foreploughshare and the Disk Coulter on the Tillage Quality and the Tractor Fuel Consumption

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Abstract

Despite the fact that considerable experience has been gained so far from the use of disk coulters and foreploughshares there is not much scientific data that prove the value of these implements. In the present paper the results from an experimental study of the influence of the disk coulter and the foreploughshare on the tillage quality and the tractor fuel consumption are presented. Three series of experiments were carried out:

1. Tillage with mouldboard plough equipped with both disk coulter and foreploughshare
2. Tillage with mouldboard plough equipped with foreploughshare (without disk coulter)
3. Tillage with mouldboard plough (without disk coulter and without foreploughshare).

The results proved that when both the disk coulter and foreploughshare were used, the plant residue left on the soil surface was considerably reduced. It was also found that the influence of the disk coulter is very important for decreasing both the soil draught and the tractor fuel consumption. The overall best tillage quality was obtained when both the disk coulter and the foreploughshare were used.

[Keywords] Tillage, foreploughshare, disk coulter, fuel consumption, tillage quality

1. Introduction

Despite the fact that considerable experience has been gained so far from the use of disk coulters and foreploughshares there is not much scientific data that prove the value of these implements. The disk coulter cuts the soil in a perpendicular direction to its surface and in this way assists the plough work while at the same time preserves a clear furrow, (Goryackin 1968, Kushwaha *et al.* 1986, Tice and Hendrik 1992). The type of disk coulter depends on the type of soil, (Goryackin 1968, Nerli 1984, Nieuwenburg *et al.* 1984). The use of a proper disk coulter reduces considerably the soil drought, (Chang *et al.* 1998, Natsis *et al.* 1999).

The foreploughshare is placed before each ploughshare, cuts and moves a surface soil slice towards the bottom of the previous plough furrow which is then covered completely by the corresponding ploughshare, (Choi and Erbach 1986, Srivastava *et al.* 1993). In this way a better coverage of the weeds is achieved, (Adam and Erbach 1992, Natsis *et al.* 1999, Wise and Bourarach 1999).

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In the present paper the results from an experimental study of the influence of the disk coulter and the foreploughshare on the tillage quality and the tractor fuel consumption are presented.

2. Materials and Methods

Three series of experiments were carried out:

1. Tillage with mouldboard plough equipped with both disk coulter and foreploughshare
2. Tillage with mouldboard plough equipped with foreploughshare (without disk coulter)
3. Tillage with mouldboard plough (without disk coulter and without foreploughshare).

Each experiment was repeated four times.

For the entire field tests a trailed mouldboard plough was used equipped with three plough bottoms, coupled to a 60 kW tractor. The experiments were conducted in a clay soil covered by a natural population of plants consisted of germinated weed seeds that were not deliberately sown. All tillage trials were performed at a depth of 26-30 cm. The soil draught was measured by a tillage force dynamometer.

The number of plants per unit soil surface was measured before and after each tillage trial. Also after each tillage trial was measured the number of plants and the soil depth in which they were found. In doing so, immediately after a tillage trial a vertical soil cut was prepared at selected locations, then the soil was removed from an area of one m^2 in sequences of 10 cm depth (up to a maximum depth of 30 cm) and the number of plant weeds in each soil volume (of 1 m^2 by 10 cm depth) could be measured. In this way the percentage of the weeds' pieces at the depths of 0-10 cm, 10-20 cm and 20-30 cm could be determined in each of the three series of experiments.

During each tillage trial, soil samples were collected from the soil surface and dry-sieved using sieves of 15, 10 and 5 cm mesh openings so that to measure the number of soil clods per unit surface. Also, during each tillage trial, the tractor fuel consumption was measured. The soil water content was measured at several positions in a diagonal direction of the soil field and its average value was found to be 18.5%.

3. Results and discussion

In the following tables the average values of the four experimental trials are given. It can be seen in Tables 1 and 2 that the use of the disk coulter and foreploughshare has a significant influence on the number of the weeds' pieces that are covered by the soil. More specifically, when both the disk coulter and foreploughshare are used the number of weeds' pieces remained on the soil surface is 2.4%, (see Table 1) while when the foreploughshare is used and no disk coulter then this percentage was found to be 5%. On the contrary when no foreploughshare and no disk are used then the weeds' percentage increases to 35.9 % relative to the initial weeds' value, (see Table 1).

Table 1. Influence of the disk coulter and the foreploughshare on the weeds' coverage

Operation	Number of weeds' pieces per m^2 at the soil surface		
	Before the operation	After the operation	% after the operation
Disk coulter and foreploughshare	620	15	2.4
Foreploughshare and no disk coulter	578	32	5.5
No foreploughshare and no disk coulter	512	184	35.9

In Table 2 is presented the number of weeds and the corresponding soil depth that were found during all operations. In Table 2 can be seen that when no foreploughshare and no disk coulter are used a small percentage of the weeds (21.7%) is placed at the depth of 20-30 cm while when both the foreploughshare and the disk coulter or the foreploughshare are used these percentages are 86.8 και 79.2 respectively.

Table 2. Influence of the disk coulter and the foreploughshare on the position of the weeds in the soil

Weeds' soil depth (cm)	Number of weeds (%) relative to their total number		
	Foreploughshare and disk coulter	Foreploughshare only	No foreploughshare and no disk coulter
At soil soirface	2.4	5.5	35.9
0 – 10	4.0	6.9	19.0
10 – 20	6.8	8.4	23.4
20 – 30	86.8	79.2	21.7

In Fig. 1, can be seen typical soil draught graphs as measured during the field trials. The average draught values of these trials and the overall results of the effect of using foreploughshare and/or disk coulter on soil draught and tractor fuel consumption are summarised in Table 3. In Table 3 can be seen that if the measured soil draught, when no disk coulter and no foreplougshare were used is considered as 100 units, then the soil draught measured at the presence of the foreploughshare was 116.4 units while when both the disk coulter and the foreploughshare were used the soil draught was found to be 113.3 units. It can be seen in Table 3 that when both the disk coulter and the foreploughshare is used the soil draught is less than the corresponding soil drought when only the foreploughshare is used and no disk coulter. This can be explained by the fact that the disk coulter reduces the soil resistance by pre-cutting the soil while when no disk coulter is used the soil is cut by the edge of the mouldboard and thus more draught is required. The fuel consumption was found to vary (see Table 3) in a way similar to the soil draught as was expected. These results reveal the importance of the disk coulter in reducing the soil draught and the fuel consumption.

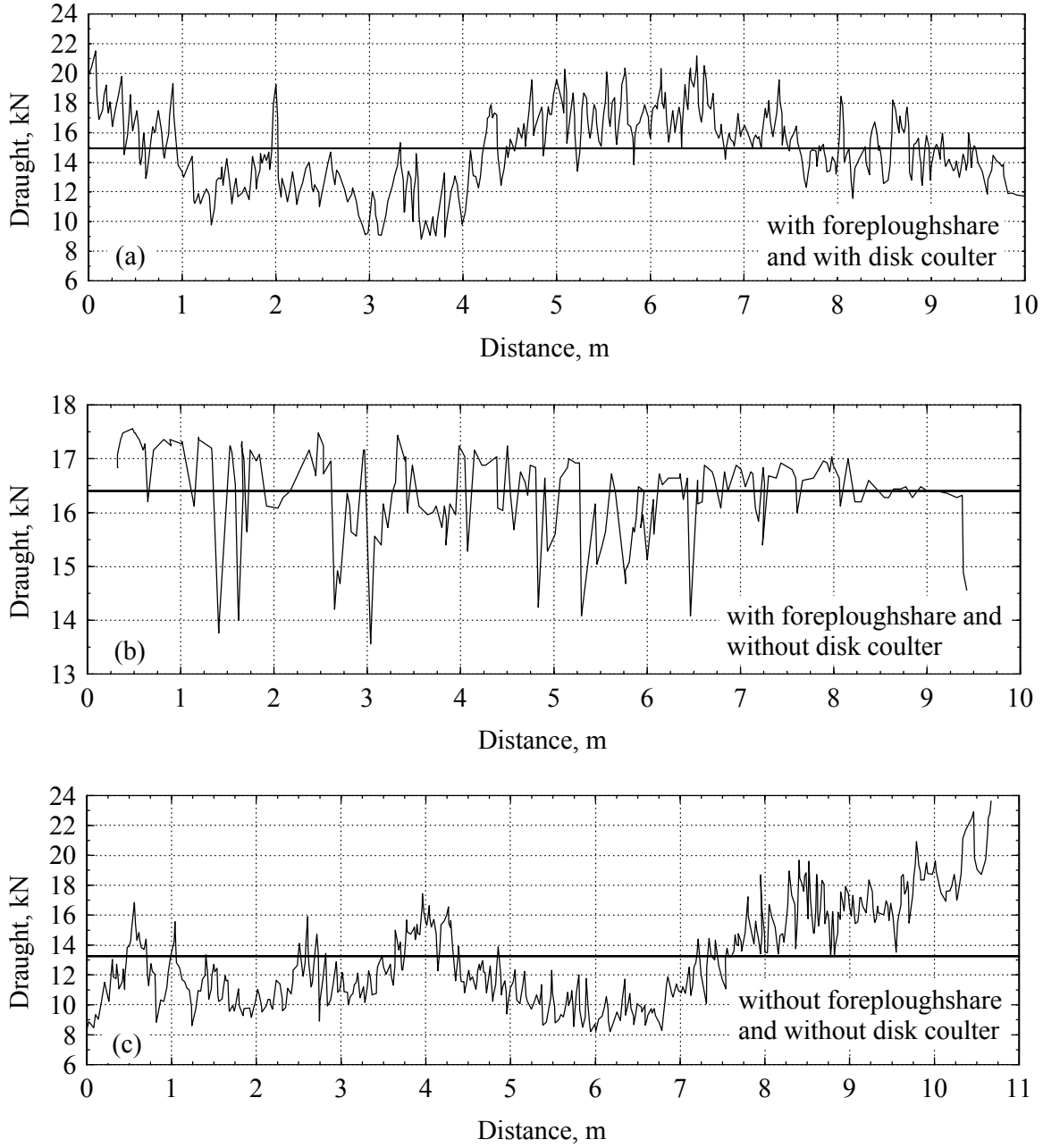

Fig.1. Measured soil draught for the three cases examined (a) with foreploughshare and with disk coulter, (b) with foreploughshare and without disk coulter and (c) without foreploughshare and without disk coulter. The lines parallel to the x-axis represent the average soil draught value over the considered length

Table 3. Influence of the foreploughshare and disk coulter on the soil draught

Operation	Tillage depth (cm)	Operation width (m)	Soil draught (kN)	Fuel consumption (*l*/ha)
Disk coulter and foreploughshare	27.8	1.02	14.9	37.0
Foreploughshare and no disk coulter	28.0	1.04	16.4	40.9
No foreploughshare and no disk coulter	27.2	1.03	13.3	33.5

In Table 4 is presented the number and size of soil clods during all operations where can be seen that the clods size category larger than 15 cm does not appear at all when both foreploughshare and disk coulter are used. This means that when both foreploughshare and disk coulter are used fewer operations following the tillage for the preparation of the seed bed would be required and hence the fuel saving would be high.

Table 4. Influence of the forploughshare and the disk coulter on the number and the size of soil clods

Operation	Number of soil clods to the total number of soil clods (%)			
	>15 cm	15 - 10 cm	10 - 5 cm.	< 5 cm
Disk coulter and foreploughshare	0	5.0	14.0	81.0
Foreploughshare and no disk coulter	1.5	4.6	13.8	80.1
No foreploughshare and no disk coulter	4.2	4.0	18.8	73.0

4. Conclusions

Despite the fact that the use of the foreploughshare and disk coulter increases the soil draught, it was experimentally confirmed that for the preparation of the seed bed additional operations can be avoided such as second tillage and/or spraying. Overall the work quality is considerably improved when both the foreploughshare and disk coulter are used. Thus the use of both the foreploughshare and disk coulter are highly recommended.

References

1. Goryackin V. P. 1968. *Collected works in three volumes.* Translated from Russian. Edited by N.D. Luchinskii.
2. Kushwaha R., Vaishnav A., Zoerb G. 1986. Soil bin evaluation of disc coulters under no till crop residue conditions. *Transactions of the ASAE*, 29(1), 40-44.
3. Tice E. and Hendrick J. 1992. Disc coulter operating characteristics. *Transactions of the ASAE*, 35(1), 3-10.
4. Nerli N. *Dynamics of the disk harrow.* Pisa 1930, Translated: Jerusalem,1984 .
5. Nieuwenburg P.IJ.J., Speelman L., Wensik H.E. 1992. An evaluation of some disk coulter designs. *Journal of Agricultural Engineering Research*, 51, 67-80.

6. Natsis A., Papadakis G., Pitsilis I. 1999. The influence of soil type, soil water and share sharpness of a mouldboard plough on energy consumption, rate of work and tillage quality. *Journal of Agricultural Engineering Research*, 72, 171-176.
7. Chang, Cheu-Shang, Correa W.A. Jr., Coelho A.R.C.M. 1998. Draft resistance and energy consumption for moldboard plow penetration. *In Proc. International conference on agricultural engineering AgEng Oslo* 1998, Paper no 98-A-086.
8. Srivastava A. K., Goering C. E., Rohrbach R. P. 1993. *Engineering Principles of agricultural machines*. Published by the ASAE.
9. Choi C., and Erbach D., 1986. Cornstalk residue shearing by rolling coulters. *Transactions of the ASAE*, 29(6), 1530-1535.
10. Weise G. and Bourarach E.H. Tillage Machinery. In *CIGR Handbook of Agricultural Engineering 1999*. Volume III. Plant Production Engineering, pp 184-217.
11. Adam K.M., Erbach D.C. 1992. Secondary tillage tool effect on soil aggregation. *Transactions of the ASAE*, 35(6), 1771-1775.