THE INFLUENCE OF CASE IH COMBINE HARVESTER'S STRAW AND HUSK DISTRIBUTOR DESIGN CHANGES ON DISTRIBUTION QUALITY

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Nowadays, conservation tillage technologies play an important role in plant production all around the world. The Czech Republic conditions are not an exception. Conservation technologies application brings some risks. To minimise these risks, it is necessary to ensure distribution of straw, husk and other plant remains as evenly as possible. Crushing and distribution of straw appears to be no problem during harvest, when modern types of combine harvesters are used. Unfortunately, the distribution of husk and other small remains are non-uniform very often. Similar situation is, if axial combine harvesters Case IH are exploited. If a design change realised by protraction of distributor's driving shaft length to 200 mm is applied, then the distribution of husk and other small remains is much better, too. The distribution of straw is good in the same time as well. If a design change realised by additional distributing metal sheet vane mounted on a lower side of plate and flicker straw, then the distribution of husk and small remains is better as well, but not so much. Problems with crushed straw distribution can be expected in a field with a higher crop yield.

agricultural engineering; straw crushing; conservation tillage; husk distribution

INTRODUCTION

Nowadays, conservation tillage technologies play an important role in plant production all around the world. The Czech Republic conditions are not an exception. The clue of these technologies is to reduce soil tillage depth to the necessary minimum. But in these case plant remains are not completely defrayed into soil. It can be said that ploughing like a traditional soil tillage operation is not used.

Economic conditions of our agriculture cause many changes in the structure of plant production. The number of agricultural farms without animal production has been increasing. The area with a grain growing is becoming larger in plant production as well. The utilisation of straw and other plant remains appears to be a problem. On the other hand, straw is very good and important source of organic matter, which can be used for organic fertilising etc. (Angers et al., 1993; Watts, Dexter, 1997). It is very useful to search out a method that returns straw and other organic matter into soil. The simplest method is to crush and distribute straw with other remains evenly on a surface during harvest.

Unfortunately, fertilisation by straw brings some risks. To minimise risks it is necessary to ensure distribution of straw, husk and other plant remains as evenly as possible (Johnson, 1988; Ball, Robertson, 1990). Combine harvester plays very important role in material distribution of course. The quality of straw crushing and straw, husk and other remains distribution depends on many factors. First of all, there are design and technical conditions of straw crusher and distributor and weather conditions.

MATERIAL AND METHOD

Crushing mechanism of combine harvester must ensure adequate crush of straw (90% of pieces must be less than 80 mm of length). The crushed straw and other organic remains (husk, weed seeds, grain losses) must be evenly distributed along the working width of the machine. Crushing and distribution of straw appears to be no problem during harvest when modern types of combine harvesters are used. Unfortunately, the distribution of husk and other small remains are non-uniform very often. New machines are equipped with husk distributors in case of customer request from that reason.

CASE IH Company's axial combine harvesters use different design of straw crushing mechanism. It is caused by different threshing technology process of these machines in comparison with tangential combine harvesters. Tangential combine harvesters' crushing mechanism is mounted behind a straw walker and crushed straw is distributed toward ground surface by routing plates. On the contrary, crushing drum used by axial combine harvester is working like refuse drum of axial threshing mechanism of the machine, too. Crushed straw is then transported to two plates and flicker distributors.

Measurements were taken with CASE IH 2188 combine harvester during the harvesting season 1999. They proved that the quality of crushing and distributing of straw is convenient from the point of view of conservation tillage. Unfortunately, it is not possible to say about a quality of husk and other remains distribution. The husk and other small particles remained in short row in centre of machine's working width still. Therefore, an effort has been appearing now to change the design of plate and flicker distributors from that reason. The main subject of this article is objective comparison of influence of two types distributor's design changes to quality of husk and other small remains distribution.

First change of design was protraction of distributor's driving shaft length to 200 mm. The distributor's rotation level was placed down using this design change and therefore it was possible to distribute the husk and other remains from cleaning mechanism with a support of crushed straw distributors as well.

The second observed change of design was the use of additional distributing metal sheet vane mounted on a lower side of plate and flicker straw. Additional distributing vanes can improve the husk distribution as well.

The measurements were carried out during harvest of a winter wheat in any case. Unfortunately it was not possible to ensure the measurement for every tested machine on one field. The difference of field yields and of growth conditions can influence done measurements partly. The measured parameters were obtained under practical conditions of the following procedure:

1) Measuring canvas (width of 500 mm and corresponding length with working width of combine harvester) was installed between front and rear axle of the machine at the beginning of newly harvested row.
2) The canvas was moved together with working machine up to the moment when working speed and condition has become normal (app. 20 m). After the moment the canvas was quickly placed on the ground.
3) Crushing straw, husk and other remains have been falling down on the canvas after combine harvester's passing.
4) Material on canvas was crossly divided after each 500 mm. Each sample was put into bag and ticketed. Each measurement was repeated three times for every tested design change of the machine.
5) Samples were processed under the laboratory conditions. The first step – each sample was weighed.
6) Crushed straw and husk with other small remains were grouped in two parts by laboratory sieve cleaner with circular holes. The holes were 10 mm in diameter.
7) Crushed straw and husk with other small remains was weighed separately for each sample.

It was possible to find out a crushed straw's percentage and husk with other small remains' percentage. The values were obtained along the whole working width of combine harvester by the described procedure.

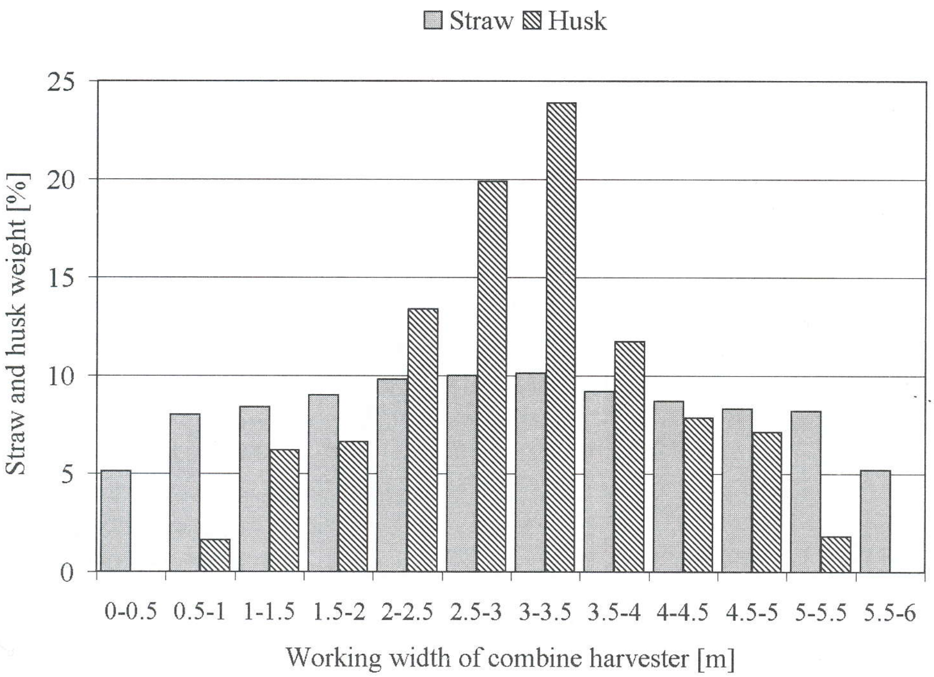
RESULTS AND DISCUSSION

As it was discussed above, the combine harvester CASE IH 2188 without design changes was measured in 1999 (K v í z , 2000). The measurement results are shown in Fig. 1. The values presented in the column chart were calculated under the following procedure. Average weight of crushed straw and husk with other small remains was calculated from every sample. Weight was calculated from three corresponding measurements by arithmetic average. Weights were calculated like percentage value because of better arranging of the chart. It was decided to use Christiansen's coefficient (C_u) like criteria for evaluation of distribution uniformity. The coefficient is calculated using the following formula:

$$C_u = 100 \cdot \left[1 - \left(\sum_{i=1}^{n} |i_{si} - i_m| / n \cdot i_m\right)\right] \quad [\%]$$

where: i_{si} – weight of i sample (g)
i_m – arithmetic mean of i_{si} values (g)
n – number of samples

Christiansen's coefficient calculates percentage deviation of each carried out i-measurement from arithmetic



1. Column chart of straw, husk and small remains distribution uniformity for not designedly changed CASE IH 2188 combine harvester

average of all measurements. When deviations are small (good uniformity of distribution), coefficient value is going up to 100% and vice versa. The coefficient is accepted by various standards (ASAE 1983, ČSN 11 0046) and is frequently used to evaluate water distribution uniformity of irrigators (for example) (R ů ž i č k a , 1992).

The chart (Fig. 1) approved that crushed straw is distributed with good uniformity without any design changes. In the centre of row the weight of 10% of material is loaded. The value declines from the centre to both sides of row, but not dramatically. Good distribution of straw is done by coefficient C_u = 86.3%. It is no problem with the straw distribution uniformity here.

On the other hand, when husk and other small remains are evaluated, the situation is very different. In that case, it is possible to see the weight of 20% of the material in the centre of working row. From the centre to sides of row the percentage of material decline very quickly. It is not even possible to find out any material on left and right edge of row. In this case a value of Christiansen coefficient C_u is 29% only. As it results from these measurements, the distribution of husk and other small remains is very non-uniform and it can cause the problems with conservation tillage technologies.

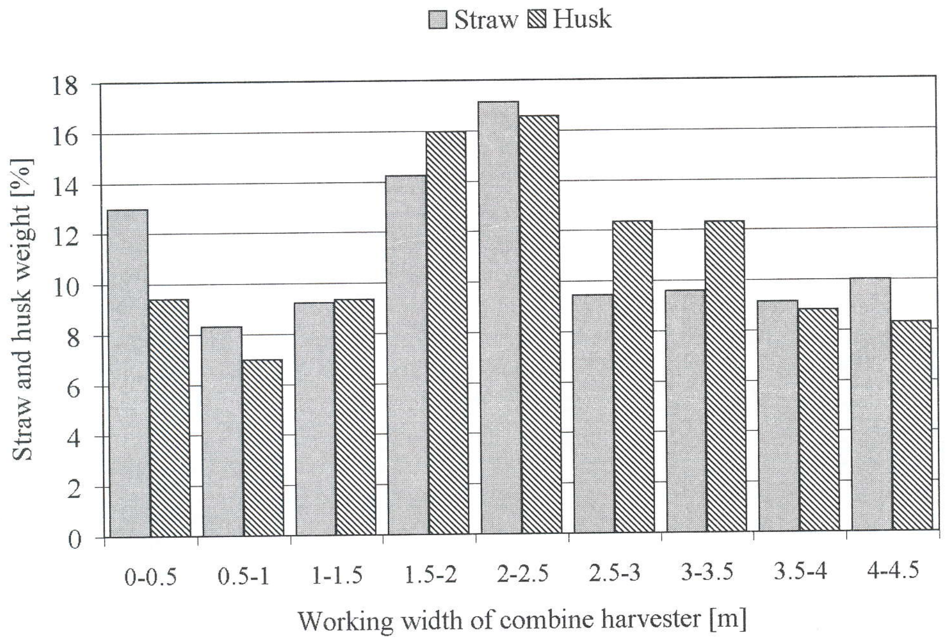
The measurements carried out with a straw distributor modified by first design change presented these consequences (Fig. 2). It is clear from column chart that crushed straw was distributed with good uniformity as well. In this case the value of C_u = 78% is a little smaller for straw, but it is still acceptable. Husk and other small remains are distributed much better with this design change. The weight of 16% of material is loaded in centre of row; amount of material declines from the centre to edges of row also, but not quickly. On the left and right edge of row it is still possible to find out the weight of 10% of material. The value of C_u = 74.6% is too much better than C_u = 29% achieved by the first measurements. The straw uniformity is almost similar as husk and other small remains. It is possible to suppose that a lower level rotation of plate and flicker distributors (mentioned above) allow distribute straw, husk and other small remains together.

The measurements carried out with a straw distributor modified by the second design changes presented that straw, husk and other small material are distributed in the whole working width of a combine harvester, but not ideally (Fig. 3). Material weight is rannging from 20 to 25% in the centre of working row (on the left and right edges of row it is possible to find out about 3% of material weight only). This is too much. Coefficient C_u is for straw 45.2% and for small remains 53.9%. Small remains are distributed better than the machines without design changes. There is an interesting worst distribution of crushed straw here. It was probably caused that the measurements of the type of design change were carried out in a field with higher crop yield. Nevertheless, it is possible to say that this very easy design changes can cause better distribution of small material particles.

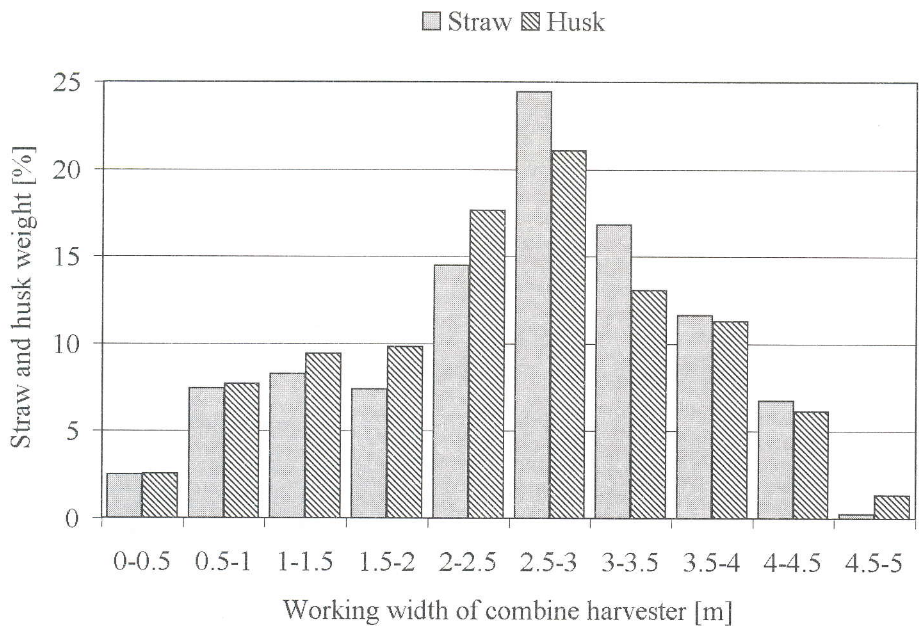
CONCLUSION

The main subject of the paper is to evaluate the impact of different types of straw and husk distributors design changes. Owners of CASE IH combine harvesters can apply these changes to increase a quality of work. It results from our measurements that the quality of husk and small remains distribution is poor with not designed changed machines. It can cause problems with conservation tillage technologies. Nevertheless, the quality of straw crushing and distribution is good, the problems can be expected in most cases from that reason.

If a design change realised by protraction of distributor's driving shaft length to 200 mm is applied, then the



2. Column chart of straw and husk and small remains distribution uniformity for CASE IH 1688 combine harvester with protracted distributor's driving shaft length



3. Column chart of straw and husk and small remains distribution uniformity for CASE IH 2188 combine harvester with additional distributing metal sheet

distribution of husk and other small remains is much better. The distribution of straw is good in the same time as well. This simple design change can be recommended from the point of view of our measurement results. There is one possible design disadvantage here. The bearings of distributor's driving shafts will be highly stressed in comparison with the designedly not changed machines.

If a design change realised by additional distributing metal sheet vane mounted on a lower side of plate and flicker straw, then the distribution of husk and small remains is better as well, but not so much. Problems with crushed straw distribution can be expected in a field with a higher crop yield. But the problems are possible to expect with the designedly not changed machines as well. The main advantage of the solution is its technical simplicity.

We would like to carry out another similar measurements in near future. It might be interesting to find out a relationship between distribution uniformity of straw, husk, small remains and crop yield as well as influence of another harvested crop to distribution quality.

REFERENCES

ANGERS, D. A. – N'DAYEGAMIZE, A. – COTÉ, D.: Tillage-induced differences in organic matter of particle-size fractions and microbial biomass. Soil Sci. Soc. Am. J., *57*, 1993: 512–516.

BALL, B. C. – ROBERTSON, E. A. G.: Straw incorporation and tillage methods: straw decomposition, denitrification and growth and yield of winter barley. J. Agr. Eng. Res., 1990: 223–243.

JOHNSON, R. R.: Soil engaging tool effects on surface residue and roughness with chisel-type implements. Soil Sci. Soc. Am. J., *52*, 1988: 237–243.

KVÍZ, Z.: Kvalita práce drtiče a rozmetadla slámy sklízecích mlátiček firmy CASE IH (The quality of work of straw crusher and distributor of CASE IH combine harvesters). [Graduation thesis.] Czech University of Agriculture, Prague, 2000. 70 p.

RŮŽIČKA, M.: Rovnoměrnost intenzity postřiku závlahového postřikovače (Uniformity of intensity of spraying of irrigation sprayer). Pedologie a Meliorace, *28*, 1992: 145–151.

WATTS, C. V. – DEXTER, A. R.: The influence of organic matter in reducing the destabilisation of soil by simulated tillage. Soil Till. Res., *42*, 1997: 235–275.

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Vliv úprav rozmetadla slámy u sklízecích mlátiček CASE IH na kvalitu rozhozu.

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V posledních letech se ve světě i u nás v rostlinné produkci stále více prosazují technologie předseťové přípravy půdy, pro které se vžil název půdoochranné technologie nebo také technologie mělkého zpracování půdy. Lze se setkat i s názvem minimalizační nebo bezorebné zpracování půdy.

Podstata všech těchto technologií spočívá v omezování hloubky zpracovávané vrstvy půdy na nezbytné minimum. Využívání bezorebných technologií však s sebou přináší také některá rizika. Nedochází například k úplnému zapravení rostlinných zbytků do půdy. Velké množství plev a úhrabků, nashromážděných na povrchu pole při sklizni, může negativně ovlivnit vzcházení výdrolu, což způsobuje problémy především v následně pěstovaných porostech ozimé řepky a ozimých obilovin. Velké množství organických zbytků na povrchu půdy také působí jako přirozená ochrana pro hlodavce.

Sláma je přitom bohatým zdrojem organických látek nutných k udržení půdní úrodnosti i při nedostatku statkových hnojiv (Angers et al., 1993; Watts, Dexter, 1997). Je proto velice rozumné slámu do půdy nějakým způsobem vrátit. Asi nejjednodušší je slámu již při sklizni rozdrtit a spolu s ostatními rostlinnými zbytky rovnoměrně rozptýlit po pozemku.

Podle autorů Johnson (1988) a Ball, Robertson (1990) lze všechny tyto negativní vlivy odstranit nebo minimalizovat již při sklizni předplodiny a také následnou volbou vhodných postupů a strojů pro podmítku, předseťovou přípravu půdy a setí.

Velice důležitou úlohu hraje sklízecí mlátička. Ta musí zajistit, aby sláma byla dostatečně rozdrcena (90 % částic má být menších než 8 cm) a jak sláma, tak další organické zbytky (především plevy a úhrabky) byly rovnoměrně rozptýleny po celé šířce sklízecí mlátičky. Moderní sklízecí mlátičky těmto požadavkům vyhovují, pokud jde o drcení a rozptyl slámy. Problematický je ale rozptyl plev a úhrabků — u strojů, které jsou vybaveny pouze drtičem slámy, zůstávají ve velké vrstvě v řádku za mlátičkou. Podobná situace je také u axiálních sklízecích mlátiček firmy Case IH (obr. 1) (Kvíz, 2000). Technologický proces drcení a rozhozu slámy je u axiálních sklízecích mlátiček řešen tak, že vlastní drtič je umístěn hned za axiálním mláticím a separačním ústrojím a pracuje rovněž jako odmítací buben. Podrcená sláma pak dopadá na rozmetací kotouče. Z tohoto důvodu se objevily snahy o úpravu rozmetadla slámy těchto strojů tak, aby se rozmetání plev a úhrabků zlepšilo.

Jestliže se použije úprava spočívající v prodloužení hřídelí pohonu rozmetacích kotoučů o 20 cm, situace s rozhozem plev a úhrabků se podstatně zlepší. Tuto poměrně jednoduchou úpravu lze na základě výsledků našich měření doporučit (obr. 2). Určitá nevýhoda tohoto řešení je technického charakteru. Spočívá v tom, že ložiska uložení hřídelí pohonu jsou během práce stroje více namáhána z důvodů změny polohy těžiště rozmetacích kotoučů, což se samozřejmě posune dále od ložisek poháněcích hřídelí.

Jestliže se použije druhá úprava, spočívající v namontování dalších rozmetacích lopatek také na spodní stranu rozmetacích kotoučů, situace se také zlepší, i když ne tolik jako při použití předchozí úpravy (obr. 3). Na výnosných pozemcích může nastat komplikace s rozhozem slámy. To je ale možné předpokládat i na stroji bez úprav. Výhodou tohoto řešení však je, že je velice jednoduché. V případě potřeby je lze uskutečnit i s poměrně skromným technickým vybavením.

Nedostatkem námi provedených měření je, že nebylo možno zajistit jejich uskutečnění na stejném pozemku. Z toho důvodu chceme podobná měření ještě zopakovat pokud možno na výnosnějších porostech. Sledován bude rovněž vliv úprav na vzcházivost následné plodiny. Zajímavá by také mohla být měření sledující kvalitu rozmetání slámy v závislosti na jejím výnosu.

zemědělská technika; drcení slámy; konzervační zpracování půdy; rozhoz plev

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