COMPARISON OF MOWING MACHINES USED BY AGRICULTURAL MACHINERY FOR SMALL SCALE FARMING

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Machines used for small-scale farming become very popular under Czech Republic conditions and new types of mowing machines using different work principles have been appearing on a market. The comparison of the three types of these machines is described in this paper. The VARI system of small scale farming mechanisation, produced by MEPOL Libice company, was used for our measurements. The machines, using cutter bar mower and two drums mower were investigated in 1996, the machines using cutter bar mower and one drum mower were compared and evaluated next year. The fields were chosen very responsibly to ensure similar work conditions for all three measured machines. To minimise the influence of field conditions in 1996 and 1997, the cutter bar mower was used like standard scale measure in both years. All experiments were carried out under defined procedure. The quality of work was acceptable for all three compared machines, the capacity of work was higher for cutter bar mower, and the rotary drum mowers had always about two times higher energy consumption in an equal work conditions in comparison with cutter bar mower.

agricultural engineering; small scale farming mechanisation; mowing machines; quality of work

INTRODUCTION

Nowadays, machines used for small-scale farming become very popular under Czech Republic conditions. The new types of mowing machines using different work principles have been appearing on a market. The comparison of three types of the machines and their operating under field conditions is carried out in this article.

MATERIAL AND METHODS

The VARI system of small scale farming mechanisation, produced by MEPOL Libice company, was used for our measurements. This system can be consisted of many parts: engine unit (JM4-003), gear box driving wheels (DSK-315), cutter bar mower for middle cut (AZS-345), cutting adapter using two drums (BS-600), cutting adapter using one drum (RZS-69) and others. Three machines, consisting of above listed spare parts, were compared. First one, mowing machine presents engine unit, gear box and cutter bar mower (AZS-345). Second one, mowing machine presents the similar engine unit and the cutting adapter using two drums (BS-600). Third one, in the machine was used similar engine unit combined with one drum (RZS-69) cutting adapter as well. The main technical characteristics for all these three machines are shown in Table I.

The following parameters were compared for all three machines:

a) crop parameters: density, average height, humidity;

b) work quality parameters: the stubble length, work period, visual control of the stubble;

c) efficiency parameters: energy consumption, work capacity.

Since energy consumption measurement was one of the aims of our work that was necessary to prepare an engine unit. The preparation was made by petrol tank replacement (original petrol tank used by manufacturer) with a new calibrated petrol tank. This new machine configuration enabled to find out the fuel consumption of each three machines. The engine unit was partly new and it was adjusted according to manufacturer's recommendation. New sharp knives were used for all the three types of machines.

All experiments were carried out in following procedures:

1) The stubble length was set up to 28 mm for all three machines under laboratory conditions.
2) The length of trial course was set up to 60 m.
3) The petrol level in tank was provided.
4) The machine was spaced 1 m in front of measured course.
5) The time necessary for the passing the trial course was measured.
6) The engine was switched off just after trial course passing and the new petrol level was measured.
7) After each trial course passing by machine five samples of stubble were picked up from area of 10 x 10 cm. Stubble length and density were obtained from these samples for each passage of the machine.

The measurements were carried out during two years, 1996 and 1997. The machines AZS 345 and BS 600 were compared and evaluated in 1996. The AZS-345 (the same machine like in 1996) and RZS 69 were compared and evaluated next year.

RESULTS

Characteristic of the measured fields

Three machines comparisons require knowledge of crop characterising values (crop density, type of crop, crop height, and crop humidity) and their similarity on all the measured fields. The fields were chosen very responsibly to ensure similar work conditions for all three measured machines. Unfortunately, field conditions of the year 1996 were different from the year 1997. It was caused by different weather conditions in those two years. In 1996 the weather conditions were better for grass growth (frequent rain in spring) and the crop yield was higher than in 1997. The average stubble density (number of stubble per dm^2) was 137 in 1996; and 95 in 1997 only. The meadow grass with average height about 0.38 meters and humidity about 85% was on all fields. It is evident that the most important difference among fields was crop density. The crop density can influence work quality and energy consumption of measured machines. To minimise the influence, the cutter bar mower AZS-345 was used like standard scale measure in both years.

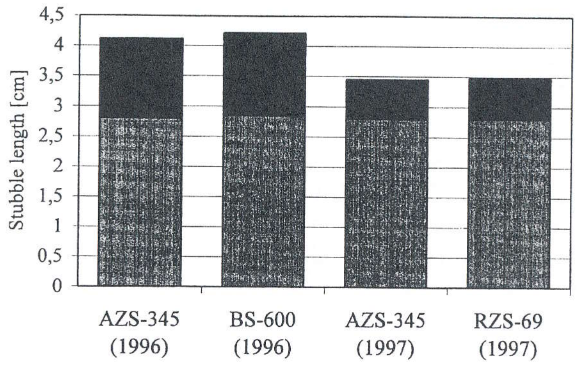
Quality of work

The most important work quality value was the stubble length. The average stubble length was calculated from five samples obtained after course passing by machine. The stubble length was longer in any case than the one set up under laboratory conditions. The average stubble length for all measured machines is given in Fig. 1. It is evident that the stubble length was adequate for all measured machines. The difference between stubble length for the machines measured in 1996 from those in1997 can be explained by the stubble density. The stubble density of grass in 1996 was higher; the stubble length was higher for both measured machines in this year, too.

The good quality of work was proved also by the visual control of the stubble for all three machines investigated. But it is necessary to remark that all the measured machines have been operating under optimal work conditions. The disadvantage of one drum machine (RZS-69) was its worse field tracking. The main disadvantage of drum mower BS 600 (two drums) was the small pieces of grass flying away and around the mowing mechanism during cutting. The main disadvantage of cycle bar mower (AZS-345) were the vibrations of handrails.

Capacity of work

It is commonly known (B ř e č k a , B e r n á š e k , 1988; C o l z a n i , 1983), that the mowers employing impact cutting principle (i.e. rotary drum and disc

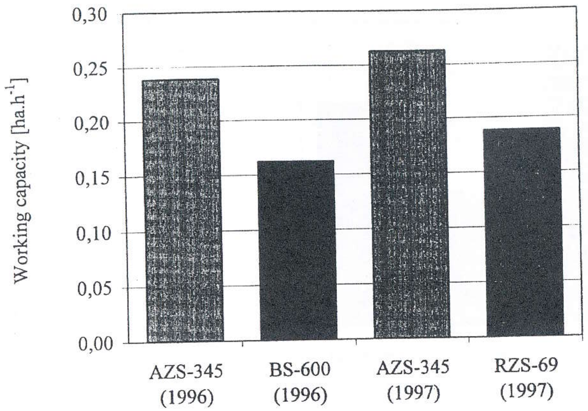


1. Stubble length for the measured machines

I. The technical characteristics of measured machines

Type of the machine	Cutter bar mower AZS-345	Drum mower BS-600	Drum mower RZS-69
Engine	type: JM4-003 volume: 133 cm^3 power: 3.75 kW max. speed: 4700 rpm	similar	similar
Working width (m)	0.92	0.715	0.68
Number of knives	12	6 (3 per drum)	3
Number of fingers	17	–	–
Number of drums	–	2	1
Drum diameter (m)	–	0.38	0.68
Forward speed at 4700 rpm ($m.s^{-1}$)	0.875	0.847	0.91
Set cutting high (mm)	28	28.5	28
Cutting speed at 4700 rpm ($m.s^{-1}$)	2.17 (average)	91.1 (max.)	50.7 (max.)

mowers, flail mowers) have about two times higher work capacity than the mowers using shear cutting principle (i. e. cutter bar mowers). This prediction of work capacity was not confirmed by our measurements. The higher work capacity was measured for the cutter bar mower AZS-345. It was caused by cutting width of this mower (see Table I) combined with the comparable forward speed with other measured machines. The work conditions were adequate for this type of the machine in all cases. No problems were found out with cutter bar jamming by the just cut grass etc. during measurement procedures. The technological idle times were not observed. For this reason,



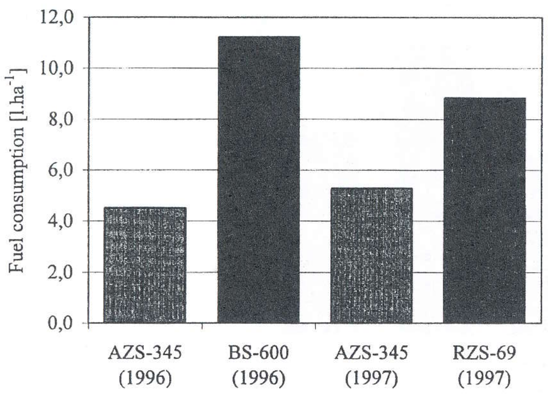
2. Working capacity of the measured machines

the longer cutting width with comparable forward speed for the AZS-345 must give the higher working capacity. The comparison of the working capacity of all the three machines is in Fig. 2.

It is evident (Fig. 2) that the machine AZS-345 has the higher working capacity (discussed above). The smallest working capacity was found out at the two-drum mower BS-600. The one drum mower RZS-69 had the smaller working width but was used with the higher forward speed. The result of comparison is the second position from the point of view of working capacity from all machines.

Energy consumption

According to many authors' (O'Dogherty, Gale, 1986, 1991; Persson, 1987; Tuck et al., 1991) measurements, the mowers using impact-cutting principle have relatively high power requirements (10 to 12 $kW.m^{-1}$) in comparison with the mowers employing shear cutting principle (1 to 4 $kW.m^{-1}$). This prediction of energy consumption was confirmed by our measurements, too. The rotary drum mowers (BS-600 and RZS-69) had always higher fuel consumption in equal work conditions. It is evident from the obtained values. It is possible to declare that one litre of the fuel can be used for cutting about 0.21 ha by cutter bar mower AZS-345, about 0.11 ha by RZS-69 and about 0.086 ha by BS-600 only. It is two times lower value for rotary mowers. This difference is very important and it confirms prediction. From this point of view, the cutter bar mower is definitely better solution. The fuel consumption for one hectare of cutting area is seen in Fig. 3 for all the three machines measured.



3. Fuel consumption of the measured machines

DISCUSSION

The principal objective of the work described in this paper was to examine the behaviour of the three different mowing machines used by the small scale farming mechanisation.

The high attention was devoted to selection of fields used for measurements. We wanted to minimise the differences among fields by managing similar working conditions for all machines. This intention was possible to accomplish in the same year only. Since the experiments were carried out during two years, in both years the machine AZS-345 was used like standard scale measure. The results from all measurements were comparable in this case.

From the point of work quality it is possible to say, that the quality was good for all measured machines. This is maybe also due to using of the new sharp knives in all cases. It is necessary to remark that rotary drums machines (BS-600 and RZS-69) have better precondition to work under worst working conditions (older, high and thick grass) than the cutter bar mower (AZS-345).

Small pieces of grass flying away and around the mowing mechanism during cutting of the rotary drum mowers are unpleasant for machine operator. This happens, first of all, at two drum mower (BS-600). Vibrations on hand rails of the machine using cutter bar mower adapter (AZS-345) are unpleasant for machine operator as well. The field tracking was good for the machines AZS-345 and BS-600; worst was for the machine using one drum (RZS-69). This is maybe due to worst field tracking by only one drum and to design of the machine also. The wheels are in back of the machine and for this reason the drum cannot react to small inequality of the ground of the field during cutting immediately.

The working capacity was the best for cutter bar mower (AZS-345) due to its higher working width and comparable forward speed with other tested machines. Other reason can be optimal working conditions for this type of the machine in all cases. The smaller working capacity was found out at the two drum rotary mowers (BS-600). This was due to the smallest forward speed from the tested machines (see Tab. I). The rotary mower using one drum (RZS-69) has the smallest working width, but the higher forward speed. Their working capacity was between these two machines.

The energy consumption was (it confirms the prediction very well) about two times higher for the mowing machines using rotary drums. According to many authors, it is due to the work principle of these machines (impact-cutting principle). The high fuel consumption is the main disadvantage of these machines. The high fuel consumption maybe has relationship with smaller work capacity of these machines in comparison with cutter bar mower. If the engine power output is available for the adapter cutter bar mower AZS-345, for these rotary adapters can be better to use the engine with higher power output. If the engine with small power output is used, the main part of the power output is to consume for the no load power input of rotary cutting mechanism and here is no reserve of power input. The working capacity is smaller in this case, the fuel consumption higher and finally, the operation of machine is more expensive. It is necessary to take into account, that the easier driving of the machine for operator is paid by more expensive operation of the machines using rotary drums.

One fact is clear from this article. With one type of engine unit it is very difficult to build optimal machine using so different types of mowers. The designers would like to build simpler and in this case cheaper machines and this is why they must make in very cases some types of compromises.

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Porovnání žacích strojů používaných u malé mechanizace.
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V současné době se u tzv. malé nebo zahradní mechanizace můžeme setkat s různými technickými řešeními žacích strojů určených pro sečení vysoké trávy. Jedná se především o klasické prstové žací lišty, žací stroje rotační s dvojbubnovým žacím ústrojím a žací stroje rotační s jednobubnovým žacím ústrojím. Právě žací stroje jednobubnové se momentálně těší značné oblibě. Zástupce všech těchto strojů lze najít u systému malé zahradní mechanizace VARI od výrobce MEPOL Libice nad Cidlinou. Právě na nich byla uskutečněna v letech 1996 a 1997 provozní měření, která mohou sloužit pro určité porovnání těchto strojů mezi sebou. Měřenými stroji byly žací adaptér AZS-345 (žací lišta prstová polohustá), žací adaptér BS 600 (rotační žací stroj bubnový se dvěma bubny) a žací adaptér DAKR RZS-69 (rotační žací stroj bubnový s jedním bubnem).

Aby bylo zajištěno objektivní porovnání všech strojů, používala se k pohonu stejná motorová jednotka a zkoušky probíhaly vždy v jeden den na tomtéž pozemku. Protože se podmínky měření v jednotlivých letech díky rozdílnému počasí lišily, byl žací adaptér AZS-345 použit v obou letech jako srovnávací stroj. Mezi základní sledované parametry patřila kvalita práce, která se hodnotila objektivně pomocí výšky strniště a subjektivně obsluhou během provozu. Dále se sledovala výkonnost jednotlivých strojů a jejich energetická náročnost, která byla hodnocena spotřebou paliva jednotlivých strojů. Za tímto účelem byly vybaveny kalibrovanou nádrží paliva. Všechny zkoušky probíhaly podle stanoveného zkušebního postupu:

1) Výška strniště byla u všech strojů nastavena na 28 mm od rovné betonové podlahy.
2) Na zkušebním pozemku byla naměřena délka zkušební dráhy 60 m.
3) Byla zjištěna hladina paliva v kalibrované nádržce.
4) Zkoušený stroj byl spuštěn v místě jeden metr před naměřenou zkušební dráhou.
5) Byl změřen čas nutný pro ujetí zkušební dráhy.
6) Motor byl vypnut okamžitě po projetí měřeného zkušebního úseku a byla odečtena hladina paliva v kalibrované nádržce.
7) Po každém posečení měřeného úseku zkoušeným strojem bylo odebráno pět vzorků strniště z plochy 10 x 10 cm. Ze vzorků se zjišťovala délka strniště a hustota porostu.

Na základě těchto sledovaných parametrů byly jednotlivé stroje mezi sebou porovnány. Z hlediska kvality práce nebyly pozorovány podstatné rozdíly, jak je patrné z grafu (obr. 1). Další graf (obr. 2) porovnává výkonnost zkoušených strojů. Proti všem předpokladům měly rotační žací stroje menší výkonnost než žací stroj s prstovou žací lištou polohustou. Rotační žací stroje také byly energeticky mnohem náročnější než žací lišta prstová polohustá (obr. 3), což je naopak v dobrém souladu s předchozími měřeními podobného druhu. Nevýhody rotačních žacích strojů jsou pravděpodobně způsobeny také tím, že instalovaný výkon motorové jednotky nebyl

pro stroje pracující na tomto principu práce dostačující. Touto domněnkou by se vysvětlila především jejich menší výkonnost.

Z výsledků je patrné, že s jedním typem pohonné jednotky lze jen těžko vytvořit optimální sestavu se všemi uvedenými druhy žacích adaptérů. Konstruktéři se snaží postavit konstrukčně nenáročné, a proto levné strojní prvky, což mnohdy vede ke kompromisním řešením.

zemědělská technika; malá zahradní mechanizace; žací stroje; kvalita práce

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