EVALUATION OF WORKING QUALITY OF COULTER SETS DESTINED FOR DIRECT DRILLING

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Introduction

Lowering of energy consumption at soil cultivation is achieved most often through improving construction of tillage implements and machines and also through introducing new technologies being reckoned among so called „minimal soil cultivation". The extreme form of the former is direct drilling. Measures done within this technology are limited to destroying weeds and forecrop residues with the chemical methods and also to drilling carried out with special seeder. The seeder destined to direct drilling is equipped with coulter sets which make possible to put seeds into uncultivated soil. The units most often consist of coulter and cutting disc. Task of the coulter is to cut the stubble and pre-loose the narrow strip of soil next to a furrow. The coulter forms the furrow and put seeds into it. There are most often used the sets consisting of a double disc coulter and a cutting disc. In order to obtain the proper seeding depth the set must be loaded with great vertical force. This load may be lowered as the coulter with positive cutting angle is employed but at the same time the risk of gathering up crop residues and soil occurs. This phenomenon results in high unevenness of seeding depth, clogging delivery tubes or insufficient covering of seeds. In the light of the above the need of working up and experimental verification of such coulter sets which at proper functioning will warrant minimization of load in the vertical plane. The field tests aimed for determining the effects of some chosen coulter units used at direct drilling on mean cohesive soil, have been carried out.

Materials and methods

During the tests prototype elements as well as taken from serially produced seeders (sets a and b) were used. Disks of the double disk coulter were 325 mm in the diameter and the angle between them was 15^{o}. The diameter of flat cutting disc was 450 mm. The diameter, working width and amplitude of wavy cutting disk were 420, 45 and 170 mm respectively. The prototype elements (Fig. 1) were worked out on the base of theoretical speculations and literature.

As independent variables the coulter sets in the following combinations of elements were taken:

a) - a double disc coulter and a flat cutting disc,
b) - a double disc coulter and a wavy cutting disc,
c) - a duckfoot coulter and a flat cutting disc,
d) - a duckfoot coulter and a wavy cutting disc,
e) - an asymmetric disc coulter.

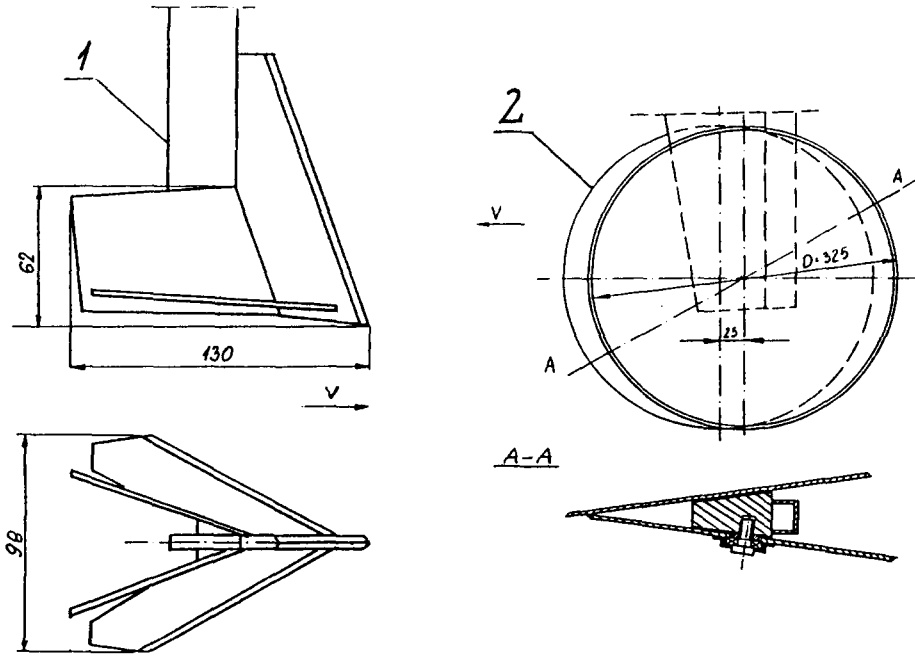

Fig. 1. Prototype elements: 1-a duckfoot coulter, 2-an asymetric double disc coulter

The aim of the tests performed was to solve the following problems:

1. What are the values of the vertical component of a draft force for prototype elements in comparison with typical ones?
2. What are the values of seeding depth unevenness after using the peculiar coulter sets?
3. How the type of a coulter set affects on bulk density and porosity of soil covering seeds in the furrow ?
4. Does the type of used coulter sets influence yield of some chosen plants ?

To receive answers for these questions formulated as research problems experimental tests were carried out. They were performed in Agricultural Test Station Ostoja, on gray brown soil belonging to good wheat complex. Soil in the layer with thickness 10 cm on average had 1.4% of humus and 13% of fine particles. Soil reaction pH in KCl was 5.1.

In the main part of the test, using investigated coulter sets, two year exact experiment was planned. The method of randomized blocks in three repetitions was used. The area of plots was 42 m^2. Into uncultivated after gathering forecrop, soil five species of plant were sown. Corn, horse-bean and sunflower were cultivated in main yield after no good wheat had been gathered for green tops. Field pea and yellow lupin were cultivated as stubble aftercrop after gathering barley for grain. All coulter sets co-worked with the same seeder during sowing. Vegetation conditions for peculiar plants were identical; the same fertilization and crop cultivation were applied.

The values of a vertical component of the draft force for the coulter sets were measured while stubble aftercrop was being sown. For this purpose a two-ring strain dynamometer was employed. In order to amplificate and shape electrical signals the measuring bridge of UM 131 type was used. Moreover, the signals were registered with the aid of the magnetic register of 7001 Bruel-Kjaer type. Soil moisture during measuring was 11.3 %.

Seeding depth, porosity and bulk density of soil covering seeds in a furrow were measured directly after sowing. Unevenness of seeding depth was determined with the device to cutting off soil layers. Soil was screened through a screen having sieve mesh diameter 2 mm and next separated seeds were counted. Bulk density of soil was determined by the oven-dry method but porosity by Zawadzki method.

Number of plants per the area unit was determined directly before gathering of peculiar species. For plant counting a frame 0.35 m^2 in area was used. Picking was manual. Plants were picked from the area of 10 m^2 and next dried and weighted. Obtained results were subjected to statistical analysis.

Results and discussion

The values of the vertical component of draft force for sets with prototype coulters were lower than for units with typical ones (Fig. 2.). There was also determined that using of the wavy cutting disc, in the place of the flat one, resulted in lowering of the draft force. Differences between the values of the vertical component of the draft force for tested sets were small at shallow sowing growing considerably as working depth increases. The largest values of measured

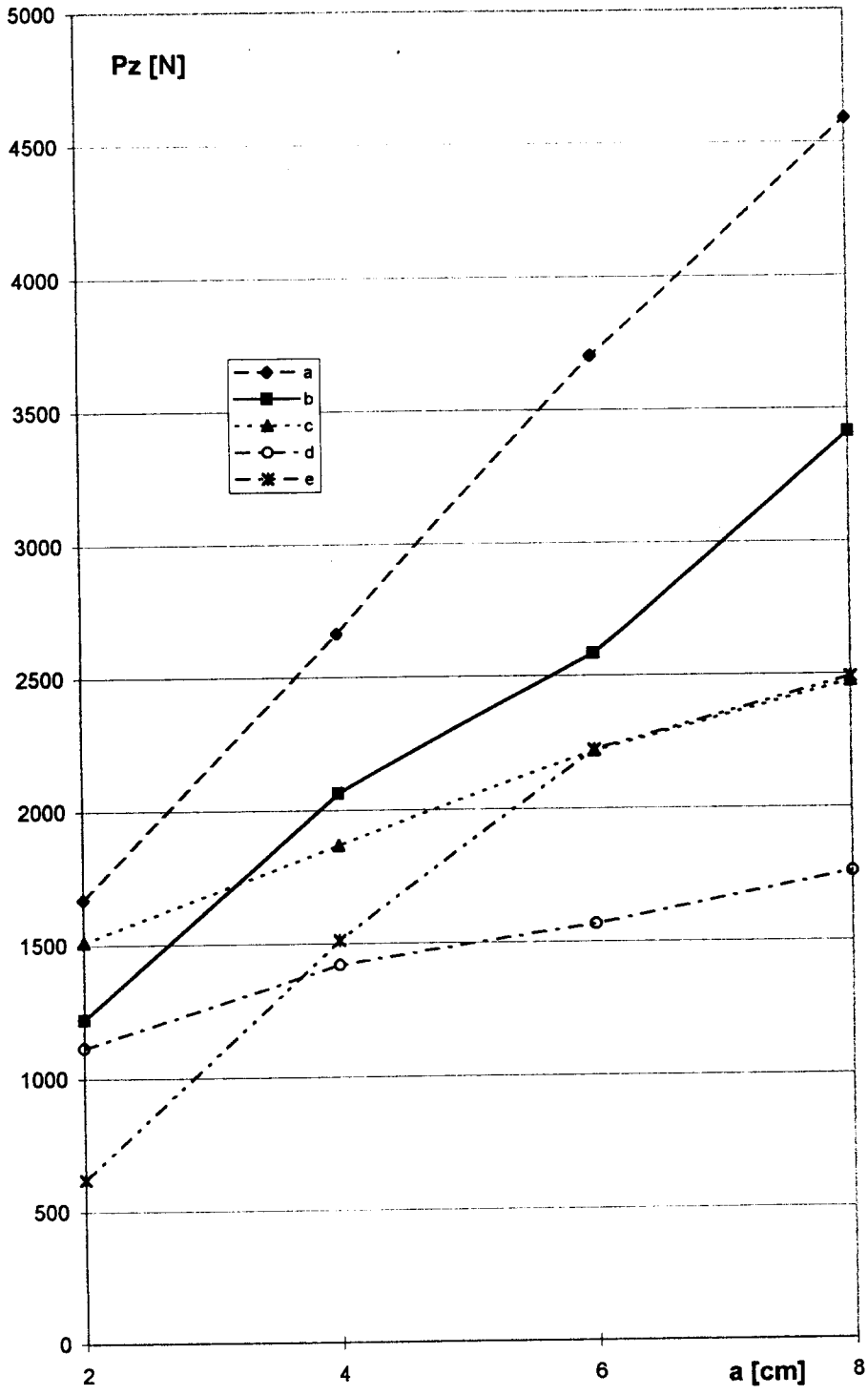

Fig. 2. The values of the vertical component (Pz) of the draft force against seeding depth (a)

force were determined for the following sets, in sequence: a double disc coulter with the flat cutting disc, a double disc coulter with the wavy cutting disc, an asymmetric disc coulter and finally for a duckfoot coulter with the wavy cutting disc.

There was especially important relation between the values of vertical components of the draft force for sets equipped with prototype and typical elements while working at larger depths. The value of vertical force, in regard for the way the sets are loaded, affects indirectly total mass of a seeder. At working depth of 8 cm, the value of a vertical component of the draft force for the typical set consisting of double disc coulter and the flat cutting disc, was 4591 N. An asymmetric double disc coulter reached mentioned depth after loading with force of 2491 N. In sequence, the unit consisting of a duckfoot coulter and the wavy cutting disc only after it was loaded with force of 2475 N. The values of force are relatively 53.9÷54.2% of the vertical component of the draft force of the mentioned previously typical set.

The values of the vertical component for the sets with prototype parts were lowered due to constructional solutions. A duckfoot coulter plunged itself into soil and within the range of 2÷8 cm it worked without, necessary at other coulters load. The vertical force, acting in the opposite direction, caused loading the cutting disc co-working with this coulter. The value of the force indispensable to maintaining working depth of the set was the sum of the vertical components of draft forces both of the coulter and the cutting disc. There is no a cutting disc in the set of an asymmetric double disc coulter. Its role is carried out by the disc coulter which is put forward.

Unevenness of seeding depth changed within the range of 6.3÷35.8 %. The largest values of this index were at seeding depth of 2 cm (Table 1). Seeds were put into soil more precisely by coulters co-working with the wavy cutting disc than by these same coulters co-working with the flat one. There also was determined that a duckfoot coulter sowed seeds with lower unevenness than the double disc coulter. The work of an asymmetric double coulter resulted in lower unevenness of seeding depth in comparison with the work of coulter co-working with the flat cutting disc.

As the result of direct drilling the physical properties of soil in the uppermost layer undergone major changes. Before experiments bulk density of soil in the layer 0÷10 cm was 1560 $kg*m^{-3}$, and the values of total, capillary and non-capillary porosity were relatively 40.4, 37.0 and 3.4%. The lowest soil loosing in a furrow was obtained after an asymmetric double disc coulter was used - soil bulk density lowered to the value of 1430 $kg*m^{-3}$. After working passage of

coulters co-working with the flat cutting disc soil bulk density in a furrow lowered its value to 1350÷1390 kg*m^{-3} but in the case of coulters co-working with the wavy cutting disc to the value of 1080÷1250 kg*m^{-3} (Table 2).

Table 1. The values of unevenness of sowing depth (%)

Coulter set	Unevenness of seeding depth (%) at working depth:			
	2 cm	4 cm	6 cm	8 cm
a	35.8	11.9	16.7	14.4
b	16.3	13.8	12.2	7.5
c	23.9	11.9	10.2	10.0
d	12.7	9.6	6.3	6.5
e	9.7	13.6	20.2	9.1

The work of all coulter sets caused increasing total and non-capillary porosity and decreasing capillary porosity of soil. Non-capillary porosity increased in the highest degree after sets equipped with wavy cutting discs were used - i.e. in 23.9÷25.8%. The sets equipped with flat ones caused increasing non-capillary porosity by 12.7% but an asymmetric double disc by 8.4%. The sets with wavy cutting discs caused decreasing the value of capillary porosity by 7.6 to 12.3%, the sets with flat cutting discs - by 5÷6.4% and the work of an asymmetric double disc coulter resulted in decreasing the value of capillary porosity by 3.5% only.

Table 2. The values of bulk density So (kg*m^{-3}), total porosity Po (%), capillary porosity Pk (%) and non-capillary porosity Pn (%)

Coulter set	So	Po	Pk	Pn
a	1390	46.7	30.6	16.1
b	1250	52.0	24.7	27.3
c	1350	48.1	32.0	16.1
d	1080	58.6	29.4	29.2
e	1430	45.3	33.5	11.8

Tabela 3. The results of mesauring number of plants per area unit (No.*m^{-2}) and dry mass yield (t*ha^{-1}) of cultivated plants

Plant	Coulter set	Number of plants	Dry mass yield
Corn	a	9.9	9.43
	b	10.7	9.47
	c	11.4	9.44
	d	11.8	9.59
	e	10.8	9.34
$LSD_{0.05}$		n.d.	n.d.
Sunflower	a	10.4	8.27
	b	12.0	8.53
	c	10.8	8.20
	d	12.2	8.48
	e	11.2	8.44
$LSD_{0.05}$		0.38	n.d.
Horse-bean	a	40.0	3.35
	b	42.4	3.35
	c	39.4	3.51
	d	41.9	3.62
	e	40.3	3.38
$LSD_{0.05}$		n.d.	n.d.
Field pea	a	81.3	1.27
	b	86.3	1.53
	c	81.8	1.44
	d	85.1	1.55
	e	81.9	1.41
$LSD_{0.05}$		1.82	0.13
Yellow lupine	a	67.0	1.08
	b	70.3	1.13
	c	68.6	1.03
	d	71.7	1.10
	e	68.2	1.05
$LSD_{0.05}$		1.12	n.d.

$LSD_{0.05}$ - least significance difference at confidence level 0.05;

n.d. - non-significance differences

Statistical analysis of results obtained in both agrotechnical seasons indicate differences of number of plants per area unit and yield some cultivated plants.

Substantial differences between number of plants of sunflower. field pea and yellow lupine were obtained for both years when the experiment was carried out (Table 3). The higher values of this number for mentioned plants were when sowing was executed by sets equipped with wavy cutting discs.

For both years substantialy lower yield of field pea was obtained when sowing was realized by sets of double disc coulter and the flat cutting disc. At the same time yield of field pea was higher when sowing was done by sets with wavy cutting discs than sowing was executed by the asymetric double disc coulter.

Conclusions

1. Coulter sets (c.d.e) equipped with prototype parts may be applied to direct drilling on medium-cohesive soil. The vertical component of draft for these sets was lower than for sets built of typical parts.
2. The degree of change of some chosen soil properties depended on the type of coulter set used. The highest changes in the values of bulk density and porosity of soil occured when the coulter sets (b.d) with wavy cutting discs were used. These sets gave at the same time the lowest unevenness of seeding depth.
3. Statistical analysis of results in both agrotechnical seasons indicated differences of number of plants per area unit and yield of some cultivated plants: essentialy higher values of this ratio for sunflower. field pea and yellow lupine and also larger yield of field pea were attained when the drilling was realized by sets with wavy cutting discs.

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