PRODUCTION TESTS OF A SEED DRILL CPH 2000 FOR DIRECT SOWING / *ESSAIS AU CHAMP D'UN SEMOIR CPH 2000 POUR LE SEMIS DIRECT*

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ABSTRACT

Under production conditions it was carried out a test with a drill CPH 2000 for direct seeding. It was evaluated the quality of the drill work and the economical evaluation was done. Obtained results showed that the average value of the practical depth of seeding was of 50.0±2.85 mm and, of practical rate of seed sowing was of 94.0±0.5 seed/m. Economical evaluation of the drill use indicates reduction in fuel and lubricants consumption per hectare of about 20.0 %, in comparison with traditional technology. These results show that this type of drill can be recommended for wide use in agricultural farms.

RESUME

L'essai d'un semoir CPH 2000 pour semis direct a été effectué dans les conditions de production. La qualité du travail du semoir a été évaluée et l'évaluation économique a été faite. Les résultats obtenus ont montré que la valeur moyenne de la profondeur pratique de l'ensemencement était de 50,0±2,85 mm et que le rendement pratique de semis était de 94,0±0,5 grains/m. L'évaluation économique de l'utilisation du semoir indique une réduction par hectare de la consommation en carburant et en lubrifiant d'environ 20,0% par rapport à la technologie traditionnelle. Ces résultats montrent que ce type de semoir peut être recommandé pour une large utilisation dans les fermes agricoles.

INTRODUCTION

World experience of agriculture proved that deep annual tillage of the soil does not only bring benefits, but also causes irreparable harm, strengthening erosion processes *(Sysolin et al, 2008; Kosolap et al, 2010; Kuksa, 2008*). When the human influence on the soil became much more tangible, intensified, agriculture faced the problem of rapid soils degradation and a sharp decrease in their fertility (*Lihochvor, 2006; Novatski et al, 2007*).

Over the past hundred years, black earth soils have lost more than half of their potential fertility (humus, nutrient reserves, structure and other properties) (*Panichev, 2007; Skuryatin et al, 2008*). These phenomena are caused by large plowing of lands, widespread use of plowing, high intensity of tillage and insignificant return of organic matter to soil. This problem can be solved with the help of the latest soil-protective energy, resource- and moisture-saving technologies (*Anderson 1997, Carr et al, 2007, Endres et al, 2007*).

The cost of agricultural products depends on the choice of technological operations and technical means for their implementation *(Warouma, et al, 2010).*

According to traditional (classical) technology, a huge amount of resources are spent on tillage: fuel and lubricants, fleet of machinery, working time, fertilizers, as a result, water and wind erosions increased, the content of organic matter in the soil decreased and, on the whole, environmental condition got worse *(Markovskaya et al, 200; Medvedev 2003; Medvedev et al, 2004; Makurina et al, 2014*).

The traditional technology of growing crops based on the use of plowing and which is a significant consumer of energy resources (which largely affects the cost price of products) has already exhausted itself due to the continuous degradation of soils and huge energy intensity. It has been established that 50% of energy and 25% of labour costs of field mechanized works' total volume account for such a soil treatment system *(Marchenko et al, 2009; Sysolin P.V., 2001).*

Analysis of experimental research results and theoretical developments of the last decade determines two possible ways for the further development of intensive agricultural technologies. The defining feature of both is the desire to reduce spending and cost of production. This can be achieved through the creation of a resource-saving technology, or the introduction of direct seeding technology based on chemicalization and sowing on the minimum prepared field surface.

Recently, in order to save fuel and labour costs, it is recommended to use combined till-plant aggregates more widely *(Gaidenko et al, 2014; Oleg, 2012; Salo et al, 2010)*.

The creation of combined till-plant machines is caused by high demands on the quality of pre-sowing tillage and the need to reduce the time gap between tillage and seed sowing. Today, the market offers a large number of combined machines with different types of tools (*Kravchuk et al, 2004, Gaidenko, 2013*).

Analyzing the economic indicators of various technologies of soil cultivation and sowing, we can conclude that the transition to energy-saving technologies will provide economy of fuel from 13 to 87% compared to the traditional ones. Significant in this case is also a reduction in labour costs *(Ivanishin et al, 2006)*. Direct seeding improves significantly soil lift and saves about 50% of the passage (*Chervet et al, 2007*). Specialized equipment is essential for successful direct seeding. But, for marketing purposes, dealers and manufacturers of agricultural machinery give sometimes fake information on the technical and operational performance of their products (*Warouma et al, 2010*). That's why it's important to test the performance of these machines.

Therefore, in the conditions of each farm, specialists must clearly determine which technology and with which set of agricultural machines the maximum profit will be achieved with minimal financial and energy costs. The aim of this work was to reduce the production cost of plant growing by rational acquisition and efficient use of agricultural park from modern agricultural machines for agrarian formations.

MATERIALS AND METHODS

The test was carried out in 2016 at the State Enterprise "Experimental farm "Elitne" at the Kirovograd state agricultural experimental station of the National Academy of Agrarian Sciences of Ukraine.

The equipment used in traditional plowing is composed of units: tractor T-150 and cultivator 2KPS-4; tractor MTZ-80/82 and seeder CZ-3, 6; tractor MTZ-80/82 and rollers 3KKSH.

The mechanical seed drill CPH 2000 of direct seeding with an operating width of 6.0 m was aggregated with the tractor Case Puma 195 (Fig. 1).

Fig. 1 - Mechanical seed drill CPH 2000 for direct seeding (No-Till) aggregated with a tractor Case Puma195

The mechanical seed drill CP 2000 for direct seeding consists of:

- batteries of disc knives with 34 pieces, staggered at a distance of 17.78 cm from each other, which contributes to self-cleaning from plant residues. The pressure of the knives on the soil is 203 kg, which is sufficient to ensure cutting of plant residues, soil and formation of furrow up to 15.24 cm in depth (Fig.2,a);

a) *b)*

Fig. 2 - The components of the mechanical seed drill CPH 2000 for direct seeding with the tractor Case Puma 195: battery of disc knives (a), mechanical seed drill (b)

- mechanical seed drill with 34 double-disc openers, which have an operating stroke of 27.94 cm and provide a seeding depth up to 8.9 cm, in the range of opener pressure on the soil from 45.36 to 63.05 kg. The bunker consists of 2 compartments for seeds and fertilizers; the capacity is respectively 1691.5 and 540 litres. The length and height of the seed drill are 6.0 and 2.49 m, respectively, with a mass of 4715 kg (Fig. 2, b).

For the unit, the working speed, as provided by the manufacturer, was 10 ± 0.5 km/h.

When carrying out production tests, the unit performed a technological operation – sowing of cereals (winter wheat) with the simultaneous application of granulated mineral fertilizers and packing the crops on the field after pre-sowing cultivation.

The established rate of seed sowing was 200 kg/ha, fertilizers – 61 kg/ha. The established depth of seeding was – 50 ± 0.5 mm.

Determination of moisture and hardness of the soil was carried out in accordance with GOST 20915-75 "Agricultural machinery. Methods for determining the conditions of tests", respectively, humidity was done by thermo-mass method and hardness – with a hardness tester. During the operation of the unit, a rectilinear mode of movement was selected with loop pear-shaped turns in a circle (Fig. 3).

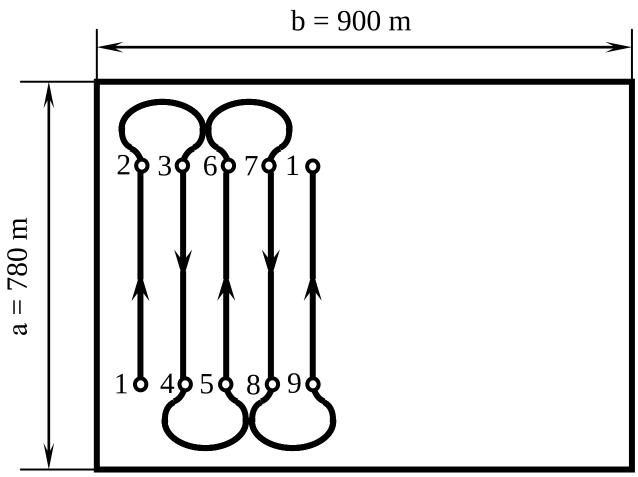

Fig. 3 - Scheme of the accounting area and movement of the unit

During the work it was done a periodical control of the operation's main parameters of the unit under investigation (engine speed, the slip of driving wheels; the working speed of the aggregate, the value of the engine load index), the values of which were fixed from the control panel of the tractor.

The operational and technological evaluation of machine-tractor aggregates was carried out in accordance with GOST 24055-88, while determining (*Gritsishin et al, 1992*):

- productivity per hour of operational time (W_{on}), ha/h:

$$W_{on} = W / (T_1 + T_2) \quad (1)$$

where W is the volume of a performed work, ha;

T_1 – the time for which the machine performs the main work (sowing), hour;

T_2 – the time for which the machine performs additional work (turn, loading of seeds, etc.), hour.

- productivity per hour of shift time of work (W_{cm}), ha/h:

$$W_{cm} = W / (T_1 + T_2 + T_3 + T_{41} + T_5 + T_6 + T_7) \quad (2)$$

where T_3 – time for machine maintenance, preparation for work, hour;

T_{41} - time for elimination of technological malfunctions, hour;

T_5 - time for rest, hour;

T_6 - time for free movement, hour;

T_7 - time for testing the machine, hour.

- productivity per hour of operating time (W_{ek}), ha/h:

$$W_{ek} = W / (T_1 + T_2 + T_3 + T_{41} + T_5 + T_6 + T_7 + T_{42}) \quad (3)$$

where T_{42} – the time to eliminate technical problems, hour.

The investigated coefficients were determined by such formulas (*Listopad et al, 1986*):

- use of driving time:

$$K_d = T_1 / (T_1 + T_2) \quad (4)$$

- technological services:

$$K_1 = T_1 / (T_1 + T_3) \quad (5)$$

- reliability of the technological process:

$$K_2 = T_1 / (T_1 + T_{41}) \quad (6)$$

- reliability of the technical process:

$$K_3 = T_1 / (T_1 + T_{42}) \quad (7)$$

The evaluation of the quality of the drill's work was done in accordance with OST 70.5-1.82 for the following indicators: the correspondence of actual seeding depth to the specified depth; the deviation of the actual rate of seed sowing from the preset one; straightness of longitudinal rows.

The depth of seed sowing was determined by their direct arrangement in a row on the day of sowing. For this purpose, three survey sites with a length of 1 m and a width of two passes of the planter were planned. The distance between the counting sites along the aggregate course was 10 m. The number of measurements was 100.

To determine the practical rate of seed sowing, the sowing machines poured a certain number of seeds with the expectation that it would be enough for several passes of the drill. The rest of the seeds were selected and weighed. By the difference in the weight of the seeds that was covered, and the residues, the amount of seeds actually sown was determined.

The straightness of the longitudinal rows was determined in three rows 25 m long, disposed diagonally. On each of the repetitions of the experiment, the distance from the centre line of the row to the centre of the plants was measured. The centre line was found by placing the cord in the centre of the rows.

To compare the two technologies, the indicators such as costs of time, costs of fuel, labor and lubricants were determined.

RESULTS

- **Results**

The location of the test had the following characteristics: precursor – annual grasses; number of standing plant residues from 0.3 to 0.5 pcs/m^2; average diameter of plant residues from 3 to 5 mm; the average length of standing plant remains is 0.18-0.12 m; weight of plant residues up to 10 g/m^2; the relief of the field surface is a plateau levelled, the slope is up to 1°.

The moisture content in the layer from 0 to 5 cm was 8.6%, from 5 to 10 cm – 12.73%. The average moisture content of the sowing soil was 10.66%.

The soil hardness value in the layer from 0 to 5 cm was 2.45 kg/cm^2, in the layer from 5 to 10 cm – 2.73 kg/cm^2. The average value of the hardness of the soil seed layer was 2.59 kg/cm^2.

During the operating movement of the unit, the parameters studied had the following numerical values: engine speed 2043 ± 35 rpm, the slip of driving wheels– 4.86 ± 1%; the operating speed of the unit was 8.64 ± 0.55 km/h (Table 1). Since the tractor, which was part of the seeding unit, passed the running-in period, the value of the engine load index was in the range from 75 to 80%.

Table 1

Values of the studied parameters during the operating movement of the unit

№	Parameter	Repetition							Average value
		1	2	3	4	5	6	7	
1	**Engine rotational frequency, rpm**	2060	2070	2000	2040	2060	2050	2020	2043±35
2	**Slip of driving wheels,%**	4	5	5	6	5	4	5	4.86±1
3	**Operating speed of the machine, km/h**	8.5	8.5	9.5	8.1	8.5	9	8.4	8.64±0.55

When the drill was working on the processed soil, due to the growth of the rolling resistance coefficient, it was self-deepening.

The results of the duration cycles of unit work are shown in Table 2.

Table 2

Duration of cycles

№	№ of a position	Duration of cycle (min) with:	Repetition			Average value on repetitions (min)
			I	II	III	
1	1-2	Operating stroke	6	6	5	5.40
2	2-3	Turn	2	1	2	1.40
3	3-4	Operating stroke	5	6	6	5.40
4	4-5	Turn	2	2	2	2.0
5	5-6	Operating stroke	6	6	5	5.40
6	6-7	Turn	2	2	2	2.0
7	7-8	Operating stroke	5	6	5	5.20
8	8-9	Turn	1	2	2	1.40
9	9-10	Operating stroke	6	5	5	5.20

Thus, the average operating time of the unit was 5 minutes 32 seconds, of a turn – 1 minute 50 seconds, of the operating cycle – 7 min. 22 seconds. The structure of the operation cycles of the unit during the studied period is shown in Fig. 4.

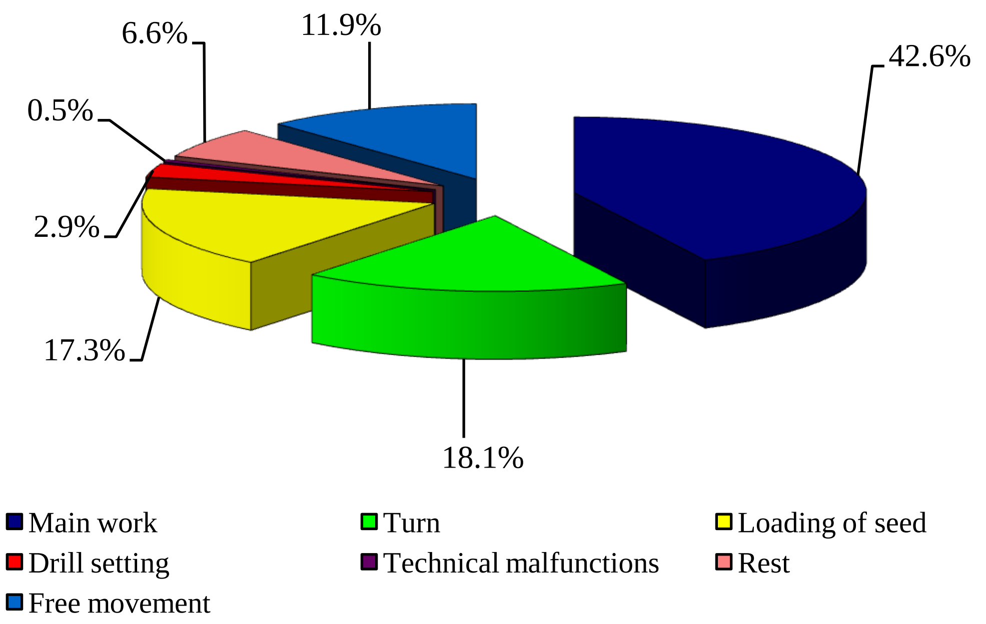

Fig. 4 - Structure of operation cycles of the unit during the period under study

When the indicators of the unit performance were calculated, it was found that within the range of changes in the duration of the operating stroke from 5 min up to 6 min, the value of work productivity varied from 4.6 to 5.5 ha/h. It was established that with an average value of the unit operating stroke duration of 5 min 32 s, the work productivity value per hour of the main time was 4.69 hectares.

The productivity of operative time per hour was 2.56 hectares, variable time – 2.01 hectares, operational – 1.99 hectares.

The investigated coefficients had the following values: use of the movement time 0.7; technological maintenance 0.94; reliability of the technological process 0.99; reliability of the technical process 1; the specific fuel consumption was 7.6 l/ha. According to the results of the researches, the seeding depth value ranged from 47.6 to 53.3 mm. The average seeding depth value was 50 ± 2.85 mm (Table 3).

Table 3

Results of seeding depth measurements

Indicator	Average value on repetitions			Average value of an experiment, mm
	I	II	III	
Depth of seeding, mm	53.3	47.6	49.2	50.0±2.85

According to the results of the researches, the value of actual seed sowing ranged from 93.4 to 94.4 pcs/m. The average value of the actual seed sowing was 94.0 ± 0.5 pcs/m. The deviation of the actual seed sowing from the preset rate ranged from 1.9 to 2.9%. The average value of seed sowing deviation was 2.3 ± 0.5% (Table 4).

Table 4

Results of determination of seed sowing practical rate

Indicator	Average value on repetitions			Average value of an experiment, pcs/m
	I	II	III	
Seed sowing practical rate, pcs/m	94.2	94.4	93.4	94.0±0,5
Deviation from the preset rate, %	–2.1	–1.9	–2.9	–2.3±0,5

According to the results of the researches, the value of the longitudinal rows straightness fluctuated within ± 5 mm.

The obtained results make it possible to determine the economic efficiency of using this aggregate (Table 5).

Table 5

Economic efficiency of use of a mechanical seed drill CPH 2000 of direct seeding

Indicators	Comparison of technologies	
	Direct Sowing Technology (No-Till)	**Traditional**
Winter wheat		
Composition of the aggregates that are involved	**The Case Puma 195 tractor + seed drill CPH 2000**	**Tractor T-150 + cultivator 2KPS-4; Tractor MTZ-80/82 + seeder CZ-3,6; Tractor MTZ-80/82 + rollers 3KKSH**
Costs of time, man-hour/ha	0.99	0.76
With traditional technology,%	30.3	100
The costs of fuel and lubricants, l/ha	7.6	9.5
With traditional technology, %	-20.0	100
Labour, fuel and lubricants costs UAH*/ha	167.2	209.0
With traditional technology, %	-20.0	100

** UAH- Ukrainian Currency: 1USD = 26 UAH*

Economic evaluation of the use of this drill indicates a reduction in the cost of fuel and lubricants and total costs per a hectare by 20.0%, in comparison with the traditional technology.

- **Discussions**

According to the obtained results, the actual operating speed of the unit (8.64 ± 0.55 km/h) was less than the working speed set by the manufacturer (10 ± 0.5 km/h), this is due to the operation of the unit on the field after preliminary processing of soil, the hardness of which in the upper layers was 2.45 kg/cm^2.

According to the results of the researches, the seeding depth ranged from 47.6 to 53.3 mm. The average seeding depth was 50.0 ± 2.85 mm, which corresponds to a technologically specified value.

Also, the value of seed sowing practical rate ranged from 93.4 to 94.4 pcs/m. The average value of actual seed sowing was 94.0 ± 0.5 pcs/m, which corresponds to 198.3 kg/ha. The established rate of seed sowing on the seed drill was 203 kg/ha, which corresponds to 96.23 pcs/m. The deviation of the practical seed sowing from a given norm ranged from 1.9 to 2.9%. The average value of the seed sowing deviation was 2.3%, which does not exceed the allowable values of agrotechnical requirements (3.0%).

The value of straightness of longitudinal rows fluctuated within ± 5 mm, which does not exceed the allowable values of agrotechnical requirements ± 10 mm.

When the drill was working on the processed soil, due to the growth of the rolling resistance coefficient, it was self-deepening, which convinces the efficiency of the drill's work on unprocessed soils.

The costs of fuels and lubricants were 9.5 litres per hectare with traditional technology, and 7.6 litres per hectare with direct seeding technology (untreated soils). These figures are not confirmed with the found figures (*Salo, 2010*) when using the scarifier-drill KRU-4, where the costs of fuel and lubricants were 11.0 l/ha and using the till-plant complex for sowing cereals, where these costs were 9.9 l/ha (*Gaidenko, 2014*).

Economic evaluation of the use of this drill indicates a reduction in the costs of fuel and lubricants and total costs per hectare by 20.0%, in comparison with the traditional technology. These figures are consistent with the results (*Vanishina, 2006*), where they were in the range of 13 to 80%, but do not confirm the results (*Warouma et al, 2010*), where they are between 8.1 and 10.0% in two different fields (*Gaidenko, 2013*) and where in the implementation of major agrotechnical operations, the reduction of costs were 11.5% compared with the traditional technology.

CONCLUSIONS

The use of direct seeding technology is one of the ways to reduce costs for technological operations. In comparison with conventional tillage, the direct seeding system is characterized by the decrease in fuel consumption, in work time, in labor, in agricultural tools passages number and in tools used number.

The costs of fuels and lubricants for direct sowing and traditional technology have the order of 7.6 l/ha and 9.5 l/ha, respectively; labour costs, fuel and lubricants for direct sowing and traditional technology have the order of 167.2 UAH/ha and 209.0 UAH/ha, respectively.

The use of a mechanical seed drill for direct seeding of the CPH 2000 series, when assembling with the Case Puma 195 tractor, carrying out the technological operation – surface tillage with simultaneous sowing of winter wheat, local application of granular mineral fertilizers in a row and packing of crops, satisfies agrotechnical requirements and according to preliminary conclusions, can be recommended for widespread use in agricultural enterprises.

These results would allow developing a complex of high-productive soil-cultivating and sowing machines, and can be also used in developing typical rates of production and consumption of fuel for this unit.

It would be necessary to continue this research in the future by doing a production performance analysis to make much more complete comparison of the two technologies.

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