ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Grain Harvesting Mechanization: Disadvantages and Prospects.

Evgeniy Ivanovich Trubilin*, Gennady Georgievich Maslov, Roman Olegovich Evglevsky, and Valery Pavlovich Lavrentyev.

Kuban State Agrarian University named after I.T. Trubilin, Kalinina str., 13, Krasnodar, 350044, Russia

ABSTRACT

The state of grain harvesting technologies in the Kuban region was analyzed, the advantages and disadvantages of various technological schemes of combine harvesters, their negative impact on soil compaction and spraying and on grain trauma were noted. Means of harvesting processes the complexity of work performing during harvesting and grain quality improving were indicated.
Keywords: harvester grain yield, straw, chaff, Thrasher, soil, energy intensity, productivity, fuel cost, quality of cleaning.

Corresponding author

INTRODUCTION

Harvesting is the most important final stage of grain production. Harvesting processes account for about half of all costs. In this regard, it is very important to improve all technological operations related to grain harvesting.

Grain economy is the most profitable type of activity, and in the main directions of agro-industrial complex strategy development until 2020 it is given the main importance. But it is necessary not only further increase in production and maintenance of exports (about 15 million tons of grain) but also its fundamental quality improvement. It is clearly seen in the example of wheat, where the content of gluten decreases. The share of strong wheat with gluten content above 28% is no more than 0.5% of commodity resources [1, p. 120]. In its commodity part, the share of wheat of grade 3 also declines. About 80% of shipments for export are wheat of the fourth - fifth grade [1, p. 120], which significantly reduces its competitiveness on the world market. According to some literary sources, Russian grain is not in high demand abroad [2, p. 6]. Negative aspects of harvesting include crop losses. Grain crushing, taking into account transportation, is almost 10%, which is 2-4 times higher than permissible. Actual harvesting time exceeds the normative 4-5 times, due to which the grain losses are 10-13 kg for 1 ton of crops. The flow and process rhythmicity are disrupted, as well as the harvesting complexity and basic post-harvesting works [3, p. 4]. The use of harvesting metal-intensive and expensive self-propelled combine harvesters raises the cost of grain, reduces the soil fertility due to re-consolidation.

All that is said shows not only the need to improve the grain harvesting technology but also a sharp (at times) increase in labor productivity and all types of costs reducing. Our task is to offer these directions through innovative technologies [4, p. 2071] and intellectual engineering [5, p. 47-51].

MATERIAL AND METHODS

The theory of operations research, dispersion analysis, experimental data approximation and mathematical statistics were used in technologies. Analysis of field experiments was carried out according to the method of B.A. Dospekhov (Moscow, 1979).

RESULTS AND DISCUSSION

Considering serious technological shortcomings of grain crops harvesting, our suggestions for their improving are as follows.

The main thing in the innovative development of grain harvesting technologies is the use of "neveika" and multifunctional harvesting units, optimization and strict observance of the harvesting schedule, rational mode of grain transportation from harvesters, and the use of intelligent mechanization tools for high-quality technical support of the harvesting complex field work. Go to "neveika" is vital indeed, since combine harvesters have already exhausted themselves and further improvement will again require already high engine power, a large number of combines that reduce the soil fertility. In addition, the use of self-propelled combines leads to the work complexity disruption, harvesting time delaying, soil moisture loss and a decrease in the future harvest.

We offer to complete multifunctional aggregates (MFA) on the basis of trailed non-motorized tractors or hinged on mobile energy equipment of combines. The latter are only harvesting machines, performing mowing of grain, threshing, collecting and unloading the cast heap, as well as chopping and spreading the straw. These functions are the same for both trailed and mounted combine harvesters. In addition, as part of such an MFA, there should be either a lumber box, a disc harrow, or a seed drill for direct sowing for the simultaneous grain harvesting of other harvesting complex works [6, p. 4]. Synthesis of proposed MFA will eliminate combine harvesting disadvantages. It seems to us that the MFA on the basis of a trailed combine harvester with a tractor energy part will be much more efficient than on the basis of a self-propelled four-wheel-drive combine harvester. As the production inspection of trailed combine harvesters in Canada shows [7, p. 38], working on "neveika" method, they significantly exceed self-propelled harvesters using conventional technology, providing an economic effect of 80$ per 1 hectare of harvesting area [7, p. 40]. Trailed harvester can be equipped with an adapter for the grain on the vine. In this case, the effectiveness of MFA increases. The problem of "neveika" heap clearing professionally that wasn't solved by scientific and design organizations for many years has been successfully solved in recent years in Canada [7]. As the production test shows [7], the trailed combine requires only 120 kW of tractor engine power. For a self-propelled combine harvester with a rotary and classical scheme of a threshing-separating device, the required engine power is much higher (Fig. 1a and b).

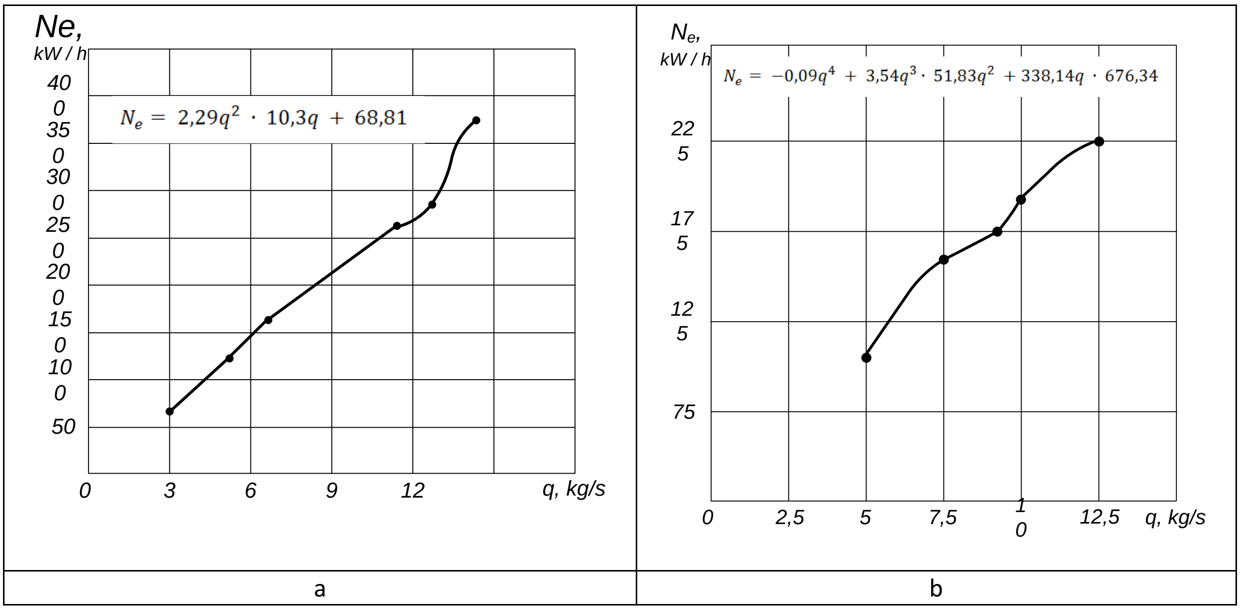

Figure 1: Combine harvester engine power dependence on constructive schemes TSD: a - rotary; b - classical

With any method of harvesting, we prefer a rotary combine modification. Rotary combine harvesters have higher technological efficiency due to the high specific threshing capacity (8 kg / m · m) and much smaller grain crushing, not exceeding 0.6%. Application of tooth working elements of a rotor instead of grooved whips on threshing drums proposed by the North-Western NIIMAC, St. Petersburg) [8, p. 43], allowed to reduce a degree of grain trauma, energy consumption of threshing and fuel consumption, due to the impact of the grinding and combing action of the threshing device on the threshed crop, which increased the capacity of the combine by 20-25%, and reduced grain losses. Thus, the rotary TSDhigh efficiency due to the corrugated pests modernization and further reduction of grain losses, increasing the capacity of the combine, reducing the energy intensity and the degree of grain microdamagewas confirmed once again.

As a result of our research, we obtained combine harvestersengine powerdependenceswith rotary and classical TSD, the combine weight on its capacity, and also the qualitative indices of their work in the field of " Kuban" farm of KubSAU on harvesting new varieties of winter wheat "Grom" and "Olson", and their dependence on combine TORUM-740 productivity change.

Our investigations establish the combine harvester engine power dependence on a threshing separating device (TSD) through put. They are obtained on the basis of data approximation for rotary (Figure 1a), and the classical (Figure 1b) design diagrams.

Rotary harvester mass dependence on its throughput was also obtained (Fig. 2).

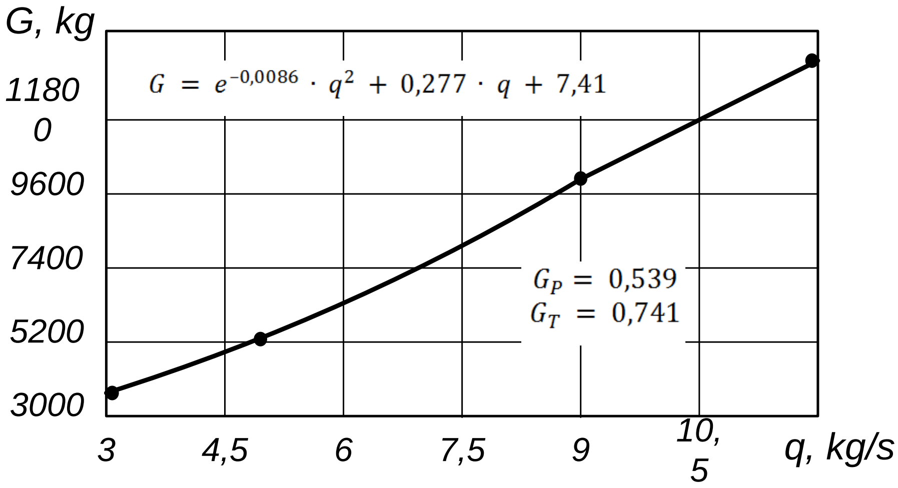

Figure 2: Combine harvester mass dependence on its threshing machine capacity (rotor modification)

The obtained dependences are expressed by polynomials of the second degree. Their adequacy is confirmed by the Fisher criterion with a calculated value 0.75 lower than the tabulated 0.77 for the TSD classical scheme and, correspondingly, 0.66 and 0.80 for the rotary one.

When testing the combine harvester TORUM-740 on harvesting winter wheat of Olkhon variety in 2017, the dependence of grain losses on this combine harvester productivity was obtained (Figure 3).

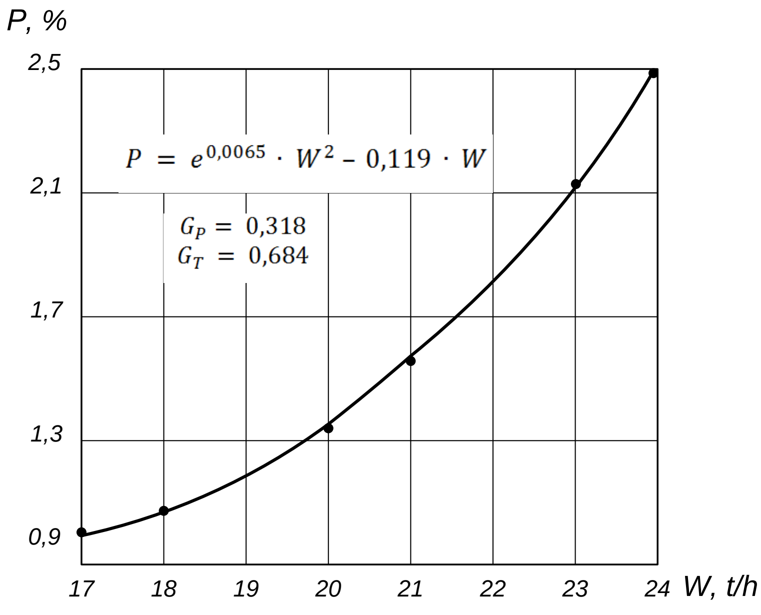

Figure 3: Grain yield losses dependence on combine harvester TORUM-740 capacity

The studies were carried out at a grain yield of 7.2 tons per hectare in 2017. The combine harvester met agricultural requirements for all harvesting quality indicators. The grain losses amounted to 1.3% of the crop, without taking into account losses from grain crushing and spraying.

The main advantage of rotary TSD is a significant grain trauma reduction. According to our research results (table 1) for all qualitative indicators, the combine harvester TORUM-740 of the Rostselmash plant with a rotary TSD provided advantage comparing to the classic thresher Tucano-480.

Table 1: Combine harvesters work quality indicators with different designs of TSDs

Indicator names	Combine Harvester TORUM-740 with rotary TSD	Combine Harvester Tucano-480 with Classical TSD
Travel speed, km / h	4,8	4,3
Cutting width of a header, m	6,8	7,2
Cutting height of wheat, cm	17,6	19,2
Standard deviation, ± cm	2,4	2,7
Variation coefficient, %	12,1	14,1
Combine productivity, t / h	21,2	20,1
Grain losses after threshing,%:	1,04	1,34
Including spraying	0,04	0,34
Loss of grain at the cutter bar,%	0,2	–
Total losses for the combine harvester,%	1,24	1,34
Quality of grain from the combine harvester,%		
–whole grain	99,62	96,6
– crushed grain	0,38	3,4
–basic grain and grain impurity	99,6	99,8
– weed admixture	0,4	0,2

The results of our research on grain quality after threshing with rotary TSD (TORUM-740 combineharvester) and classical TSD (combine harvester Tucano-480) also show a significant advantage of a rotary modification both in 2016 and in 2017 (Tables 2 and 3).

A significant difference of grain micro damage between TORUM-740 and Tucano-480 combine harvesters (Table 2), including the grain germ, takes place because of grain trauma. Thus, grain micro damage by Tucano-480 combine amounted to 29.5%, but TORUM-740 - only 21.2%, including germ damage, respectively, 11.4% and 7.6%. All this is reflected in the next harvest due to the billet threshing apparatus.

Grain quality indicators, both of "Thunder" (table 3) and "Olkhon" (Table 4) are also more preferable for the rotary modification combine harvester. It is clearly seen in both total virtuosity and protein content, even in the total mass of samples taken during harvesting before fractionation (14.24 percent - Tucano-480 and 17.81% -TORUM-740). Raw gluten content in the grain as a percentage, in DCO units, to the quality group prior to the sample fractionation relates the grain to the third quality class (Table 4). However, after the sample fractionation in the largest of them, after descending from the sieves with elongated holes of 3 × 20 mm, the gluten content increased to 31.12% and the grain class increased by 1 unit (from 3 to 2).

Table 2: Mass of 1000 grains wheat grains micro damage by various TSD (wheat grade "Grom")

Options	Grains mass of 1000 grains, g	Grains micro damages, %	
		Total	Including germ
Seeds from combine harvester with rotary TSD (TORUV-740)	47,46	21,2	7,6
Seeds from combine harvester with beet TSD (Tucano-480)	47,36	29,5	11,4
Seeds from the farm «Kuban» KubSAU for sowing in 2016 from the bur	47,27	25,3	9,3
HCP_{05}	0,9	0,2	1,0

Table 3: Winter wheat grain quality indicators of the grade "Grom" after harvest ripening (12.10.2016)

Options	Grain humidity, %	Grain nature, g/dm^3	Total glassy, c. u.	Protein content, %	Gluten content, %	Gluten quality		Grain class
						GDM (un.)	Group	
Seeds from combine	11,1	824	54,2	12,4	18,1	74,1	1	4

harvester with rotary TSD (TORUV-740)								
Seeds from combine harvester with beet MSU (Tucano-480)	11,4	822	51,2	11,4	15,3	77,7	1	5
Seeds from the Farm «Kuban» KubSAU for sowing in 2016 from the bur	11,8	824	53,5	12,4	17,2	76,2	1	5
HCP_{05}	0,2	2,4	2,6	0,2	0,3	4,3		

As the data in Table 4 show, the difference in the content of raw gluten and protein in Olkhon grains harvested by different combine harvesters is significant both in grain in general before calibration and in grain fractions. This difference between Tucano and Torum combine harvesters is due to the influence of grain microcracks during harvesting. The grain nature indicators, total vitreousity, raw gluten quantity allow to determinethe class of wheat of Olkhon variety, as a whole as a result of harvesting by different combine harvesters, and by grain fractions (Table 4).

Table 4: Harvesting wheat of Olkhon variety effect by combine harvesters Tucano and Torum on wheat class (2017)

Grain fractions	Grain quality indicators								
	Grain humidity, %	Nature, g/dm³	Total vitrification, %	Protein, %	Raw gluten				Class of grain
					%	GDM units	Quality group	Characteristic	
Combine harvester Tucano-480									
Before fractionation	10,10	824	69,7	14,24	23,21	52,3	I	good	3
3,0/20	10,10	840	74,2	15,62	25,84	54,8	I	good	3
2,5/20	10,15	832	70,1	14,38	23,80	52,6	I	good	3
2,2/20	9,91	785	67,5	13,42	19,48	53,9	I	good	4
1,7/20	9,66	736	58,5	10,42	16,04	38,9	I I	sat, strong	5
HCP_{05}	0,04	6	1,3	0,83	0,40	–	–	–	–
Combine harvester TORUM-740									
Before fractionation	10,49	824	81,9	17,81	26,63	58,90	I	good	3
3,0/20	10,34	845	85,2	19,68	31,12	65,00	I	good	2
2,5/20	10,63	828	82,4	17,86	26,40	59,80	I	good	3
2,2/20	9,99	782	77,2	14,785	21,56	44,80	I	good	4
1,7/20	9,76	731	67,4	14,39	20,20	43,09	I	good	4
HCP_{05}	0,12	7,2	2,7	0,56	0,84	–	–	–	–

Seed germination after rotary TSD also significantly increases.

Considering great advantages of the rotary TSD, only a rotary combine of TORUM type should be included in the multifunctional harvesting unit (TSD), and in the variant of a grain heap harvesting with a stubble on the vine - the combing adapter of KubSAU [9] construction with the heap cleaning at the base [7]. Reducing grain traumatization by rotary TSD provides additional economic effect. We obtained the losses cost of wheat grain yield dependence on the values of its macro and microdamage:

$$Cp = Z \cdot U \cdot (0{,}012\ Dp + 0{,}0001\ Mp)$$

Cp - is the cost of crop losses dependence on the value of its macro and micro damage, rubles / ha;
U - grain yield, t / ha;
Z –grain purchasing price, rub / t;
Dp - size of grain crushing during harvesting (macro damage), %;
Mp - the value of microdamage of grain during harvesting, %.

Proposed MFAs can be based on self-propelled, trailed and mounted combine harvesters. In the latter version, a mobile power-generating device of MES-450 type Polesset (Belarus) is used, on the front canopy of which a grain harvester of KZR-12 type is hung, and on the rear one there is a tool, depending on the type of work: stubble peeling, soil loosening by a combined unit, direct sowing of intermediate cultures by a seeder of direct sowing, straw pressing. The grain heap can be unloaded into a bunker on an energy source, into a tractor trailer connected to a grain harvesting machine [9], or in a nearby transport vehicle. When using a self-propelled or trailed combine harvester as part of the MFA, one of the above mentioned agricultural machines is aggregated behind the combine by means of a specially developed damper device. For a self-propelled combine harvester there is one more requirment. It is options with drive rear axle.

The structure of the MFA park for each agricultural enterprise (trailed, mounted, self-propelled) depends on harvesting conditions, yield and most importantly taking into account the ecology requirements, productivity, minimum crop losses and costs.

CONCLUSION

The state of grain harvesting technologies requires significant improvement in labor productivity, grain quality, lower costs and technological impact on the soil by heavy harvesting equipment that can be achieved through multifunctional harvesting units (MFAs) combining grain harvesting operations and a number of basic accompanying operations (loosening of soil, direct sowing of intermediate crops, straw pressing, etc.) for one pass of machines across the field. Such complex work will reduce labor and money costs, and scientifically based parameters of combine harvesters mass, engine power, threshing-separating devices (TSD) will reduce crop losses, energy intensity and grain quality improvement. The use of light trailed (non-motor) combines with cereals threshing by the method of «neveika» and heaps separation at the hospital, in addition to these advantages, it reduces harmful effect on soil over-consolidation and spraying. The economic effect of using «neveika» from the experience of Canada [7] is about 80$ on 1 hectare of harvesting area.

REFERENCES

[1] Krasnoshchekov, N.V. Innovative development of agricultural production in Russia. - M.: FSSE "Rosinformagrotekh", 2009. – p. 388.
[2] Russian grain is not in high demand on the world market / Expert magazine "Chief Agronomist", No. 11, 2009. –p. 6.
[3] Blednykh, V. V. [and others] Modern combine harvesters: state, trends and development concept. Testbook / CHSAU. - Chelyabinsk, 1998. –p. 70 .
[4] Parameters optimization for multifunctional aggregates in plant growing mechanization. Maslov G.G., Trubilin E.I., Truflyak E.V. Research Magazine of Pharmaceutical, Biological and Chemical Sciences. 2016. T. 7. № 3. p. 1919-1926.
[5] Maslov, G.G., Zhurii, I.A. Perspective compositions of machine-tractor aggregates for combining operations. / Tractors and agricultural machinery. No 2. 2017. - p. 47-51.
[6] Maslov, G.G. Grain crops complex harvesting perspectives: monograph / G.G. Maslov, A.V. Palapin, N.A. Rinas. : Kuban State Agrarian University. - Krasnodar, 2014. – p. 87 .
[7] Heyderbrecht, and. P. Canadian technology for harvesting crops. / Engineering and equipment for c. № 4. 2006. - p. 38-40.
[8] Lipovsky, M. I. Rotary combine harvester quality improving. / Agricultural machinery and technology. № 2. 2014. - p. 43.
[9] Grain harvesting machine / Invention patent RUS No. 2305395. Pub. 10.09.2007. Authors: Tarasenko B.F., Maslov G.G., Medovnik A.N., Sidorenko S.M.

ISSN: 0975-8585

[10] Development of marble beef technology / Ruslan Omarov, Ivan Gorlov, Vladislav Zakotin, Sergei Shlykov// 16th International Scientific Conference ENGINEERING FOR RURAL DEVELOPMENT Proceedings. 2017; Volume 16, pp. 956-959.

[11] Modern methods for food safety / Ruslan Omarov, Alexander Agarkov, Evgeny Rastovarov, Sergei Shlykov// 16th International Scientific Conference ENGINEERING FOR RURAL DEVELOPMENT Proceedings. 2017; Volume 16, pp. 960-963.