SELECTION OF MACHINERY FOR HARVEST OF RAPESEED AND OTHER GRAIN CROPS

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Abstract

Two activities for effective harvest of rapeseed and other cereals namely a) purchase or lease of equipment and proper storages and b) correct control and management of processes in the harvest, threshing, cleaning, drying and storage, are important. Since the operations have to be done in short time, in the same occasion farmers have to provide transportation, cleaning and drying of products. The experience and the results of the farm machinery test show that they can work with the desired quality. After that it remains to be solved the problem about type and quantity of the technical objects. The first step in this direction is the selection of criteria. Then it has to be described numbers of eventual situations and possible solutions, and the impact of the performance factors. For easier and faster problem solving it has to be decomposed. Additional questions like: new or used equipment, which type and width of the header is better, what type and size of threshing and separation systems, tank capacity, power are appropriate, etc., may help machinery choosing. Examples are given for combine harvesters of Claas company.

Introduction

Harvesting of agricultural production in common sense includes reaping, threshing, transportation, cleaning, drying and storage. These processes are interrelated. For example, if the harvest has to be done with a few combine harvesters with small productivity, it will take more days. Because of that part of gathered grain will be with high humidity. That's why the successful storage of production, it must be with low humidity, i.e. needs pre-drying. In general, harvesting in the short time can be done only with equipment whose total capacity is higher: self-propelled combines, cars, tractors, trailers, dryers, grain cleaning systems, sheds and storage facilities. In this case, production losses are smaller but at the same time the cost of buying and maintaining of machinery are higher. For timely, quality and cost-effective implementation of these activities it is required farmers to apply modern techniques, which to be properly adjusted for specific conditions and used most effectively. An Indicative list of equipment and its tuning for harvesting of rapeseed is shown in [25]. It is clear that the main prerequisite for the successful completion of the production year for rapes is choosing of machinery.

In the present work the answer is considered together with issues for other cultures too. The reason for such approach is that very often these machines are universal and used also for other cereals. Second, harvesting periods for some crops can be overlapped, which requires farms to have more or with more capacity harvesters, vehicles, storehouses, etc. Some specific data for harvesting period can be found in published reports in particular [29], i.e. for Romania TASK F3 - Inventory and mapping of the different agronomic practices, crops and farming calendar.

Complexity of the problem stems from the wide diversity of technique that is currently used or can be bought. On the other hand the conditions in which these machines are used are different for various particular farms. Moreover, the different production years, weather conditions, economic situations, cultivated varieties and hybrids, etc. are very dissimilar.

Typically, the following approaches for problem solving exist:

• Heuristic - based on professional knowledge, skills and experience of farmers,

• Economic - the comparison is based on the specific costs for different units, often unfortunately based on results of previous years (rather than forward-looking information),

• Technical - the choice is based on computing the expected performance (productivity, energy consumption, labor spending...) for proposed machines on the market.

The most numerous are the common recommendations, partly using heuristic procedures - those most often given in some websites [2], [7], [8], [9], [10], [11], [12], [26]. A systematic approach offers [17] and [27] As expected recommendations from manufacturers and retailers are biased, the data is selective and does not allow comparison with the most important characteristics for machinery producers. In general the tips of specialists concerned mostly evaluation of the following machines' parameters: prices, costs of fuel, labor per area, filed capacity, throughout, reliability indicators, availability of service, and facilities for work. Unfortunately, in most countries of Central and Eastern Europe there are no more authorities for research and testing of this machinery. In addition to this, its exceptional diversity also makes difficult its full assessment due to lack of time, labor and financial resources. Since economic comparisons used mainly for previous period of work, they are not sufficiently acceptable. Moreover, various farm conditions can be significantly different (agrometeological, economical, varieties, hybrids ...), which makes it impossible to apply the correct analogy.

As regards to technical comparisons, they are based on empirical and theoretical relationships, fundamental to the performance of threshing, grain cleaning, drying and transport processes [5], [19], [20], [23]. For example calculations for harvesters refer to the width of cutterbar, combine reel, winch, auger, band conveyor, threshing and cleansing devices. Calculation of vehicles productivity is based on the speed and carrying capacity. In practice, the optimal speed is chosen such that the losses do not exceed the limit. For combine harvesters from former Soviet Union acceptable losses are 1 to 1.5%, for other countries – 2%. Respectively grain storage facilities define size of structures, conveyors, fans, equipment for the production of heat and cold. For the last two groups of objects calculations are much simpler and more accurate. Therefore, below we propose an approach and sequence for machinery selection only for harvesting.

Procedure selection of equipment for grain harvesting

Because of requisite to make decisions often under conditions of risk and uncertainty, with no or little information, first we need to specify criteria for achieving the desired result as in [Off]. For example some farmers prefer Minimax criterion (Savage criterion of regret). It can ensure the least possible losses. The particular criterion choice is a matter of the decision-maker discretion.

However, regardless of the selection criterion, it is desirable first in detail to be described the number of possible situations (conditions that will show the effectiveness of the decision).

It is imperative to be given information about crops' areas, yields, respectively grain and straw. After that the need of equipment is determined by the time of harvesting. This includes the start and end of the process, the amount of working days and hours, number of shifts per day and the duration of each shift. The relationship between the length of the harvesting period and the number of working days is given by the ratio of meteorological conditions (numerical value to 1). Data of timeliness loss factors (coefficients) is based on statistics from the closest agrometeorological stations can be found for example in [16]. More accurate determination of possibilities (working days) can be made based on objective parameters such as temperature and humidity of soils, rainfall, information in phenological cards, etc. Thus the results will provide not only average values, but also random variables. According to working hours in 24 hours they are determined by the technological requirements of the process and personnel provision for work in two or three shifts. For example, rape seed harvesting is has to be done when there is desired grain moisture in order to limit grain losses. The availability of good natural lighting can also be important if you do not use autopilots or laser guidance of harvesters. Deadlines for work should guarantee optimal balance between loss of production (due to an extension of time to work on the one hand) and the cost of buying and maintaining harvesters and workers paying (on other hand) - [16]. The numerical values are determined by timeliness loss factor. We should not forget that shorter harvesting periods will worsen the effects of seasonal work. The quantitative performance indicators hove to ensure appropriate quality. For example, combine speed (affecting the productivity of harvesters) and the speed of the threshing apparatus must ensure not exceeded acceptable grain loss (indeed different value for different countries). To avoid overlapping of time to harvest, as between those of wheat, barley and rape seed, it is recommended to select appropriate periods for sowing and length of growing period for the crop.

Thus, by simple calculations based on time resources (days, number of shifts and their duration), the amount of work (e.g, in areas) may in advance approximately to be determined the required number of specific brands, models and modifications of harvesters based on their performance.

This information should be summarized in a number of possible solutions. Simple harvest has to be described by type and numbers of harvesters. Moreover every decision needs to be presented by final set of indicators such as cost, fuel and labor expenditure, to ensure the safety and reliability of the process. These data are the basis for the comparison and selection of the most appropriate machinery. Unfortunately, in the prospects of the machines' field capacity (if available) is technical, i.e. without considering the shift time factor. In fact, effective time coefficient of combines depends on the coordination of interactions between harvesting, transport and storage (organizational and technical solutions) and varies between 0,60 and 0,85. Generally, the technical capabilities shall be presented by the field capacity (productivity) and fuel consumption per unit of harvested production or area. Such norms, as there are a long established, are for machinery usually long time in use. Thus determination of new machinery performance is a problem and obstacle for objective evaluation and comparison of different agricultural machines. Besides the difficulties in describing the huge numbers of possible situations and possible solutions, there are problems in modeling the influence of various factors (conditions and decisions) on the values of the criteria, i.e. goals.

A feasible solution to improve the suggested solutions is a segmentation of a task into subtasks and narrowing the number of possible situations and possible solutions. Below are listed some of these actions by answering specific questions.

Buy or rent machines?

Farmers or managers have to make rent-or-buy decisions using either a risk-assessment or a cost-comparison approach. First is risk approach and if not applicable they discard it. After that they can determine main financial indices by cost comparison. A short description of such procedure is given below [32].

Step 1**:** Get basic cost information: Technical information; Purchase cost; Expected life; Expected use in hours per year; Monthly rentals per year; Monthly rental rate; Pickup/delivery per rental.

Step 2**:** Determine cost to own: Depreciation; Capital cost; Overhead; Overhaul parts and labor; Subtotal; Less resale value; Total cost to own.

Step 3**:** Cost to operate: Labor; Parts; Lube; Tires; Total.

Step 4**:** Cost to rent: Rental fees; Pickup and delivery charges; Total to rent;

Step 5**:** Compare costs to buy or rent: Total cost to own; Total cost to operate; Subtotal cost to buy; Total cost to rent.

New or used machines?

The first difference is in the scope and duration of the guarantees. Usually new machinery (of course not just appeared on the market) offers new and advanced technological solution. Used equipment in most cases can be repaired and serviced technically by the presence of relevant services and skilled workers. Sometimes, however, it shows more hidden defects, it is necessary to change the oil, bearings, belts, etc. If a long time has expired from the finish of its production, perhaps there will be no warranty for spare parts. For used equipment can be obtained and relevant information about its reliability, though mostly subjective. More considerations for selection or use of the new technique offer [8]. After all, the decision should be based on expected costs and performance for the intended service life.

We have to take into account also that often farmers prefer new equipment as funding is easier for projects supported by the European Union. It is also known that there are five principle ways to acquire a new or used/second hand machines: Contract Purchase, Operating Lease, Lease

Purchase, Hire Purchase, and Finance Lease. The choice of one of this ways may materially change the effect of machinery efficiency. In addition another possible way of providing mechanized harvesting is a lease of machines and workers together.

Pulled or self-propelled machines?

As a rule pulled agricultural aggregates have greater total weight (tractor + machine with own carrier), longer transmission route from engine to working tools ...). Moreover, most of these machines are with small filed capacity. Self-propelled harvesters can open cutting road in the crop, as a road for vehicles for gathered grain. They have greater maneuverability; their turning area is smaller, turning path and relative time - shorter. The location of the cabin allows better control over the harvesting process.

Disadvantages of self-propelled combines are associated with their higher price and lower annual use. The answer of the above question must be specific to the list of crops, relative areas and expected yields. Some additional considerations for the use of motorless harvesters can be found in [1].

What header is better?

The header has to guarantee a right cutting height, acceptable losses. For typical harvesters' throughout, a maximal combine speed (for example 2,2 m/s – [15] can determine the biggest header working width. Using of another machine type, i.e. stripper header [3] or height cut [28] allows to reduce entering crop and to increases harvester filed capacity. In such case straw fro the high stubble must be collected additionally or mulched and threw across the field, i.e. increased cost and time.

A sample. A farm cultivated four crops in the following rotation: wheat, maize, rapeseed, sunflower. The corresponding minimum, average and maximum yields are: 2,2/3,6/6,3; 3,0/5,5/12,0; 1,2/2,4/3,8; 0,9/1,9/3,1 t/ha. Their residues to product ratios RPR (straw to grain) are: 1,0/1,2/1,3; 1,0/1,1/1,2; 1,3/1,5/1,7; 0,9/1,0/1,1. The permissible speeds are: 1,67; 2,22; 1,53; 2,78 m/s. The last values have to be specified for each headers model and modification.

A minimum header operational width B has to be

$B \geq q_{max} / [V * q_з * (1 + RPR)]$,

Where q_{max} is harvesters throughout, kg/s,

V – permissible speed, m/s,

$q_з$ – minimal grain yield, kg/m².

For combines Claas Avero 160 and 240 $q_{max} \approx 3{,}8$ kg/s, Tucano 320 and 330 ≈ 6,1 kg/s.

Results are 5,3/8,5; 2,8/4,6; 8,2/13,2; 9/14,5.

For Claas harvesters there are following headers [31]:

For Avero and for Tucano model/width, m, are

C660/6,66; C600/6,07; C540/5,46/C490/4,92/C430/4,32; C370/3,71; V600/6,07; V540/5,46;

C750/7,60; C900/9,12; V540/5,46; V600/6,07; V660/6,68; V750/7,60; V900/9,12; V1050/10,67; V1200/11,97.

There are also folding cutterbars C540/5,46 and C450/4,55;

SUNSPEED 16-70 for 16 rows and 70 cm row width; 12-75 respectively for 12 and 75; 12-70 respectively for 12 and 70 for sunflower,

CONSPEED for 4, 5, 6, 8 or 12 rows for maize,

rapeseed table as header extension.

A Bulgarian producer [21] offer headers for maize and sunflower – ХПС-4/2,8; ХПС-6/4,2; ХПС-8/5.6; ПС-8/5,6; ПС-12/8,4.

According to results for maize harvesting are suitable CONSPEED for 4 or 6 rows, ХПС-4, ХПС-6 for sunflower – SUNFLOWER 16-70, for wheat - C540 or C750; V540 or V750, dor rapeseed header extension produced by Claas, [21], [22], [31]. Of course all smaller headers can be included in number of eventual decisions.

With what kind of dividers?

The choice depends on the harvested crop. Especially a rape seed harvesting without active field dividers, leads to significant losses. As a rule active dividers are more suitable for lodged plants too.

With or without header extension?

Using of special headers for rape seed or upgrading of conventional cutterbars by rape seed table and active dividers allows grain losses to be reduced by up to 30%. This is an important action because conventional header losses are usually up to 3 times more than in threshing apparatus. If farmer have to harvest two crops in different time in one day, the header must be with variable characteristics. For example, the Vario header can be use for rape seed in the morning and the evening and in the other time of the same 24 hours – for harvesting of barley. Of course such a header is more expensive. Otherwise an extension for rape seed first should be removed and then for other crop harvest mount again. That means more time and efforts. Obviously row crops require different type of harvester. For example there are headers for maize, for sunflower, and for these two plants in one machine. A choice in such situation is the answer of question universal or specialized machine.

Which type of threshing and separator units are adequate?

There are same principle recommendations [5]:

- One-cylinder threshing devices with straw walker are more popular because of their simplicity, easy maintenance, and high reliability of the process,
- Two- or three-cylinder threshing devices with straw walker can provide throughout, less grain losses, grain with higher quality, especially for more difficult threshing crops,
- Axial threshing and separator units have high throughout, low grain losses, good grain quality for dry and short-length crops (less than 1,2 m), high yield, and low-weed fields [14]. At the same time fuel expenditure is higher by 30%. Because of crushing of grain and straw mass before axial-flow threshing grain is additional damage.
- What is the throughout?

There are standards described technological requirements for harvest, i.e. [4]. For states from former Soviet Union harvesters throughout must be determine for wheat with grain to straw ratio 1:1,5, grain losses less than 1,5%, grain crushing less than 0,5%, weeds less than 5%, and yield 400 kg/da. For harvesters from West Europe and North America an acceptable performance are characterizes by grain losses after threshing and separation units 2%, yield 1000 kg/da, and grain to straw ratio 1:0,5-1:0,7. Such results are possible for height cut harvest. Usually technical information about harvesters from West Europe and North America does not include data about throughout, so the comparison is very difficult. Another problem is that for different crops and their condition (grain to straw ratio, moisture, amount of weeds, yield) one or other harvester system can determines their throughout. Such systems are header, threshing and separation units. A particular decision for such situation is individual adjustment of each system.

Especially threshing and separation units' throughout can be estimated approximately as is shown in [10], [20], [23]. Such information can be found in [15] too.

Which engine power is better?

It is known, that needed power is a sum of power loss due to wheelslip, power for rolling resistance force, for overcoming of slopes, for drive of conveyors, threshing and separation units, for straw chopper, and eventually for drawbar force. Therefore, a larger cutterbar and higher speed will require more summary power. This means that the maximum engine power is relevant to maximal harvester speed. Certainly, other devices like dividers, mulchers need additional power. Also sometimes (very seldom) engine has to provide power for trailers, balers, drills, pulled by combine.

A few powerful harvesters or more but with less power?

Work with small number of harvesters can reduce salary for operators (if their payment is a function only of time expending). Moreover as a rule a few combines costs less than one with the same summary capacity. Besides, little harvesters in more situations provide higher technological and technical reliability. They are also maneuverable, total grain in their bunkers is less, i.e. they expend less fuel.

Which volume of grain hoper is better?

Often combines with the same throughout and similar power are completed with different bunker volume. In general, it is recommended this volume to be equal or aliquot to vehicles carrying capacity. That means in case of renewal of combine fleet, it is good new machines to have such grain hoper volume as replaced.

With or without compensators?

It means a device, which offsets or counterbalances a destabilizing factor such like bad correlation between harvesters and vehicles capacity. Sometimes it is a combi-trailer, pulled in field by tractors and on roads - by cars. At other times it can be large field bins (partly or fully mobile) where combines unload gathered grain. These volumes between harvesters and transport are especially useful in case of farm and transport machines with different capacity, moving at different speeds. Admittedly each real decision must to take into account roads' type (field, with asphalt or others), their width, slope rate, turning radius, permissible speed, distances between field and storages, etc. For example in case of high slope road, hopper can reduce combine lateral stability.

Is a swath pairing device necessary?

In Bulgaria such a device is good only for little yield crops. Creation a swath from two neighbor moves in one allows better engine power using, especially in case of the second phase of two-phase (swath) harvesting, window pickup and straw baling.

With or without header trailer?

Usually moving of grain harvesters in plains with header width less than 6 m can be realized without header trailer. The folding header eliminates the need for fitting and removing the cutterbar. Using of such cutterbar allows short time readjustment from transport to harvest and back. Narrow roads and paths as well as dense traffic frequently increase the time required for transporting the combine and reduce its output per day. Unfortunately this type of header is too expensive and with relatively small width. Obviously farmers have to accept regulations for moving of large self-propelled machines. Using of header trailer is recommended if roads are narrow than 6 m, the cutterbars are with constant area and the trailer price are not so high.

With or without straw chopper?

First each farmer has to decide what is better: to collect the crop residues or to spread then on field. If there is enough straw yield it will be good to be gathered. Evidently the fact is there a market for baled or no pressed straw determines growers' decision. Second step in answering above question is selecting of mounted to harvester or pulled by tractor chopper. Often it is better to chop straw in one field move. Thus is saving fuel and time. However such problem solution needs combine with higher engine power. A factor with opposite effect when a height cut harvesting is practiced is increasing of postharvest cost. The main cause of this is necessity of more power for combine engine. Similar questions concern using of baler or trailer in an aggregate with harvester.

With or without extras, accessories or facilities?

Today all producers and sellers offer a lot and diversified combine harvesters extras. More of them make harvesting easier, improve quality and increase productivity.

A few examples. CRUISE PILOT provides automatic forward travel control. It guarantees optimum utilization of the entire cutterbar width, higher precision covering the area, high functional safety, also in the store house and when working at night. LASER PILOT is an electro-optical guidance system. It uses pulses of light to scan between the crop and stubble and guide harvester automatically along the crop edge. GPS PILOT leads combine too, but using global positioning system signals. AUTO CONTOUR controls the ground pressure. Electronic sensors record the hydraulic pressure in the system and react quickly, adapting the cutterbar perfectly to the terrain. A combine with such device considerable eases work load, particularly when using large cutterbar widths, at night, in the storehouse, on slopes and on rocky grounds. Other accessories gather information like Yield mapping, Qantimetr, Moisture meter.

Unfortunately they do not work every time effectively. For example GPS PILOT performance depends of the quality of GPS data. Some times in Bulgaria it is a problem to have good signals. Another problem is their high price. An agronomist can collect needed for harvesting information for a little cost and in addition to make and implement relative decisions. Some of the systems are interchangeable and there is no need to buy all of them. All extras as a rule are options for customers. Therefore farmers shouldn't make decision to buy one or other harvester only based on preliminary information. It is often promotional and it is not included in the base model price.

Below some samples of information about particular harvester, as a support for decision making are given. For example Claas company offers a system of grain harvesters – figure 1.

Each model name is a hyper text and this allows fast cross-reference to additional facts, including technical one. Unfortunately more of information is only in text and picture format. It gives no more than an overview of the specific model. There is only one data in numbers about harvester output. It is in t/h and i.e. doesn't take into account ratio of idle to total time. Instead of this for shown models are given icons presented threshing and separation units.

More specific information is acceptable in chapter Technical information publication or in some publications, i.e. [15]. Part of values for base harvesters indicators are presented in table 1.

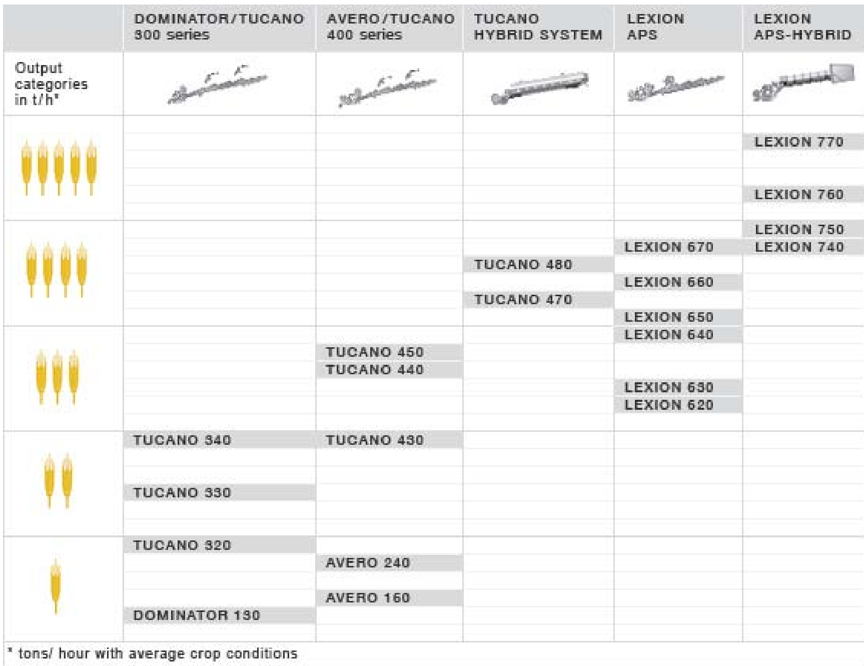

Figure 1. Base harvesters indicators of Claas company according to http://www.claas.com/cl-pw/en/products/combines/_startpage/start,bpSite=51524.html

APS is Accelerated Pre-Separation Threshing System

Table 1.

Main technical data for some Claas company grain harvesters according to [15]

Company series, model or modification	Width of header, m	Engine power, kW	Width of threshing cylinder, mm	Diameter of cylinder/ angle of coverage/ deck length, m	Length of separators, m/area of separators m²	Area of sieves, m²	Throughout, kg/S	Filed capacity, t/h	Grain hopper volume, m³	Weight without header, kg
Dominator										
150	3,05-6,09	104	1060		3900/4,1	3	3,8	5,5	4	7620
140	3,05	89	1060	450/117/470	3900/4,1	3	3,8	5,5	3,2	7320
130	3,05-4,6	92	1060		3900/4,1	3	3,8	5,5	3,2	7320

108	4,5-6,1	163	1580		4400/7,0	5,1	7,3	10,5	7,5	10050
98	3,9-5,2	147	1320		4400/5,8	4,25	6,1	8,8	6,2	9350
Tucano										
450	3,7-9,1	102	1580	450/151/ 606	4400/7,0	5,65	8,2	11,8	9	12530
440	3,7-9,1	191	1580		4400/7,0	5,65	8,2	11,8	8,5	12400
430	3,7-9,1	177	1320		4400/5,8	4,7	6,8	9,8	7,5	12000
340	3,7-9,1	191	1580	450/117/ 470	4400/7,0	5,1	7,3	10,5	7,5	11800
330	3,7-9,1	177	1320		4400/5,8	4,25	6,1	8,8	7,5	10800
320	3,7-9,1	140	1320		4400/5,8	4,25	6,1	8,8	6,5	10700
Lexion										
410	3,9-5,4	144	1420	600/142/ 740	4400/6,25	4,4	7,9	11,4	6,3	11000
420	4,5-6,0	162	1420		4400/6,25	4,8	7,9	11,4	7,3	11800
430	4,5-6,0	191	1420		4400/6,25	4,8	7,9	11,4	7,8	11800
440	5,4-6,6	191	1700		4400/7,5	5,8	9,5	13,7	8,1	13000
450	6,0-7,5	210	1700		4400/7,5	5,8	9,5	13,7	8,6	13000
460	6,0-7,5	236	1700		4400/7,5	5,8	9,5	13,7	9,6	13000
470	6,1-7,6	240	1420		2-445/4200/	4,8	10,0-10,5	14,4-15,1	10	-
480	6,7-9,1	280	1700		2-445/4200/	5,8	11,0-12,0	15,8-17,3	10,5	14000
600	6,7-9,1	368;409	1700		2-445/4200/ 6,7	6,2	11,0-12,0	15,8-17,3	12	-
580	6,7-9,1	316;362	1700		2-445/4200/ 6,7	5,8	11,0-12,0	15,8-17,3	10,5	16500
570	6,1-7,6	290;312	1420		2-445/4200/ 3,1	4,8	10,0-10,5	14,4-15,1	10,5	15500
560	6,1-7,6	265	1700		4400/7,5	5,8	9,5	13,7	10,5	14500
550	6,1-6,7	243	1700		4400/7,5	5,8	9,5	13,7	9,6	14200
540	5,5-6,1	217	1700		4400/7,5	5,8	9,5	13,7	8,6/8,1	14100
530	4,5-6,1	217	1420		4400/6,25	4,8	7,9	11,4	8,6	13500
520	4,5-6,1	191	1420		4400/6,25	4,8	7,9	11,4	7,8	13200
510	4,5-5,5	162	1420		4400/6,25	4,8	7,9	11,4	7,3	12900

Finally, the answers of more of the questions above reduce the number of possible decisions. Then the next stage of problem solving is calculation of all indices mentioned in “Buy or rent machines?” For that is important to know filed capacity for a shift W, ha/shift

$W \approx Bm * V * Sd * \tau$,

where Bm is operational width of header,

Sd – duration of a shift,

τ - shift time factor (ratio of time without harvesting and all shift time – D, as a sample 0,7),

for whole number of possible decision.

Now it is possible to be determined the quantity of harvesters Nh:

$Nh \approx Q /(W * D * Ns)$,

Where Q is the quantity of work (area or grain for harvesting),

D – working days (as a sample 6 for wheat and rape seed, 10 for sunflower, 12 for maize),

Ns – number of shifts in 24 hours (ratio of working hours in 24 hours and Sd).

After these calculations it is promising to be used Savage or Laplace criteria (an example for the last criterion: 1 of 10 years – with minimal yield, 2 of 10 years with maximal yield, the left – with average yield).

Determination of models, modifications and numbers of other machines like cars, trailers, dryers, as storages is the next stage of farm machinery selection. General principle of such decisions is guarantee of the best interaction between all machines structures, workers, etc.

For roughly assessment and according to average condition of Bulgarian farms next recommendation can be used:

- a combine harvester with 5,4 m header, 1000 mm width of threshing cylinder, 165 kW engine power is suitable for 150 ha winter crops,
- a combine harvester with 6,6 m header, 1320 mm width of threshing cylinder, 220 kW engine power is suitable for 300 ha winter crops,
- a combine harvester with 7,5 m or wider header, 1580 mm width of threshing cylinder, more than 270 kW engine power is suitable for 550 – 600 ha winter crops.

Conclusion

The offered machinery for harvesting of rape seed and other grain crops can provide quality work. For yield collection within a specific appropriate period brand, model and modification and its number have to be chosen. We recommend such selection to be based besides on simple calculation, on answers to a sequence of questions too.

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