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Determination of the Machine and Tractor Fleet Optimal Composition for a Model Cotton-Textile Cluster

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Abstract. The authors showed that the cotton-textile cluster efficiency (the capacity of the machine-tractor fleet, cotton yield, the production profitability) largely depended on the use of the optimal number of tractors and agricultural machines. The existing methods (theoretical, graphic, economic and mathematical) were difficult for practical use and did not take into account the specifics of mechanized cotton growing processes. Therefore, it was important to develop a simple normative method for determining the optimal composition of the machine and tractor fleet for clusters, corresponding to the technological map for the production of raw cotton. (*Research purpose*) To calculate the required amount of agricultural machinery based on the established standards. (*Materials and methods*) The authors developed an algorithm for determining the standard coefficients of the equipment necessity per 1000 hectares of arable land. These coefficients for each type of equipment were established in the context of technological operations of growing cotton: plowing, soil preparing for sowing, sowing seeds, cultivating the soil between cotton rows, mechanized removal of growth points of the main stems and side branches of plants, defoliation with chemicals, machine harvesting and transportation of harvested cotton – raw. (*Results and discussion*) The authors proposed the term "model cotton-textile cluster". They calculated the required amount of equipment for such a cluster with an area of 13,732 hectares. They determined the percentage of the machine and tractor fleet: the share of tractors – 28 percent, cultivators – 22, trailers – 19.8, cotton pickers – 13.8, the rest – 16.4 percent. They emphasized that the machines fleet could expand with the arrival of new modern machines produced by machine-building plants of the republic and imported from foreign countries. (*Conclusions*) The authors accepted the machine and tractor fleet of the cotton-textile cluster with the number of equipment 1660 units as rational. They proved that it ensured the implementation of all technological operations within agrotechnical terms.
Keywords: model cotton-textile cluster, cotton growing, optimal machine and tractor fleet composition, technological operations, standard coefficients.

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Определение оптимального состава машинно-тракторного парка для модельного хлопково-текстильного кластера

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Реферат. Показали, что эффективность хлопково-текстильного кластера (мощность машинно-тракторного парка, урожайность хлопчатника, рентабельность производства) во многом зависит от применения оптимального количества тракторов и сельхозмашин. Существующие методики (теоретические, графические, экономико-математические) сложны для практического использования и не учитывают специфику механизированных процессов хлопководства. Поэтому важно разработать простой нормативный метод определения оптимального для кластеров состава машинно-тракторного парка, соответствующего технологической карте по производству хлопка-сырца. (*Цель исследования*) Рассчитать требуемое количество сельхозтехники на основе установленных нормативов. (*Материалы и методы*) Разработали алгоритм определения нормативных коэффициентов потребности в технике на 1000 гектаров пашни. Эти коэффициенты для каждого типа техники установили в разрезе технологических операций выращивания хлопчатника: пахота, подготовка почвы к посеву, посев семян, культивация почвы в междурядьях хлопчатника, механизированное удаление точек роста главных стеблей и боковых ветвей растений, дефолиация химикатами, машинная уборка и транспортировка убранного хлопка-сырца.

(*Результаты и обсуждение*) Предложили термин «модельный хлопково-текстильный кластер». Вычислили требуемое количество техники для такого кластера с площадью 13732 гектара. Определили процентный состав машинно-тракторного парка: доля тракторов – 28 процентов, культиваторов – 22, прицепов – 19,8, хлопкоуборочных машин 13,8, остальных – 16,4 процента. Подчеркнули, что шлейф машин может расширяться при поступлении новых современных машин, выпускаемых машиностроительными заводами республики и импортируемых из зарубежных государств. (*Выводы*) Признали рациональным машинно-тракторный парк хлопково-текстильного кластера с количеством техники 1660 единиц. Доказали, что он обеспечивает выполнение всех технологических операций в агротехнические сроки.
Ключевые слова: модельный хлопково-текстильный кластер, хлопководство, оптимальный состав машинно-тракторного парка, технологические операции, нормативные коэффициенты.

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In Uzbekistan, there is a rapid increase in the number of cotton-textile clusters intended for growing cotton, processing raw cotton and producing finished products [1]. Each cluster is expected to have a fleet of agricultural machines that ensure the implementation of such agrotechnical operations as ploughing, soil preparing for sowing, seed sowing, intertillaging, mechanized removal of plant growing points, defoliation of fields, machine harvesting and transportation of raw cotton at minimal operating costs [2-7]. Provided the cluster is insufficiently equipped with regulated technological maps for growing cotton, necessary types and models of tractors and other agricultural vehicles, it results in the undermined timing and quality of technological operations, and decreased mechanization level and production efficiency of the entire industry.

There is vast literature on the issues of substantiating the rational composition of agricultural producers' (farmers, agricultural firms, agricultural holdings') fleet [8-12].

It is noted that it is important to meet the following requirements: an appropriate fleet of vehicles must contribute to high yields; each type of machine must fulfil the corresponding technological operation in full scale within the set agrotechnical terms; product production must be carried out at minimal costs; the expansion of the fleet with new models should not reduce the use of existing equipment and require additional resources; the selection of new machines should take into account the machine operators' qualifications; it is necessary to prevent purchasing different models of the same machine type.

The existing methods are difficult for practical use and do not take into account the specifics of mechanized cotton-growing processes [13-20]. Therefore, the substantiation of the rational composition of the machine and tractor fleet for the cotton and textile cluster has become an important scientific and methodological task.

The research purpose is to determine the standards for the cotton-textile cluster needs for technology and to calculate the optimal composition of their machine and tractor fleet.

Materials and methods. The following algorithm was used to determine the standard coefficients of the need for equipment per 1000 hectares of arable land:

1) the state tests protocols of the Center for Certification and Testing of Agricultural Machinery and Technologies were used to choose a changeable capacity value of a specific machine model (machine-tractor unit) – w_c;

2) based on the operational data of the regional departments of agriculture, sets of one shift duration values (T_c) were obtained for a vehicle or machine-tractor unit performing the corresponding technological operation and considering the number of shifts per day (n_c). By the summarizing and statistical processing of the numerical data, their arithmetic mean values for the Republic of Uzbekistan were determined;

3) the machine productivity per day was calculated by the formula:

$$w_1 = w_c\, T_c\, n_c,$$

where w_1 is the machine productivity per day, hectares;

w_c – machine productivity per shift, hectares;

T_c – one shift duration, h;

n_c – a number of shifts per day.

4) as the agrotechnical season duration ($T_м$), the peak of the given season was taken not the calendar period from its beginning to the end. At this time, as a rule, all the necessary machines are involved in the work, sudden failures are reduced and sustainable machinery operation is ensured. Test engineers clock the w_c, T_c and n_c parameters to calculate the machine's performance in one day;

5) the seasonal machine output ($w_м$, ha) is determined by the formula:

$$w_м = w_1\, T_м;$$

6) the standardised coefficient or the required number of specific type machines per 1000 hectares of the cotton field was set as follows:

$$M_T = 1000/w_м.$$

The calculated values (M_T) were summarized for the tractor and machine types and models (*table*).

Results and discussion. Let us introduce the term «a model cotton-textile cluster» which means a cluster of account in which the soil, climatic, production and other features of the cluster group are relatively fully reflected.

Let us calculate the required amount of equipment of each type for a model cotton-textile cluster with the square

Table

Machine and tractor fleet composition per 13,732 hectares of arable land in the cotton and textile cluster

Name, type and model of equipment	Standard coefficient, MT	Required amount of equipment, NT, units
Wheeled and tracked arable tractors such as Belarus 1221.2, MX-140, AXOS 340C, VT-100	8.572	118
Rowing tractors such as MTZ-80X, TTZ-811 for row spacing 90 cm	13.300	183
Universal row-crop tractors such as MTZ-82, TTZ-812	12.000	165
Planners with laser devices	1.388	19
Subsoilers such as GR-270, GRP-3/5	0.952	13
Spreaders of mineral fertilizers such as GS2-600, RMU-0.75	3.846	53
Tractor trailers such as 2PTS-4-793A (for one universal row-crop tractor)	2 ед.	330
Plows such as PYa-3-35, PLN-4-35	8.572	118
Disc harrows such as KD-3000, TDB-3/5	4.651	64
Pneumatic seeders such as Case IH 1200	2.857	39
Cotton cultivators such as KHU-4	13.300	183
Device for removing plant growth points, such as PChM-4B	13.300	183
Chemical sprayers VP-1, OVKh-600, OSHU-50	4.000	55
Cotton pickers: horizontal spindle vertical spindle	 10.000 16.666	 137 229

of $E_м$ = 13732 hectares of cotton using the following formula:

$N_T = E_м M_T/1000$, units (*table*).

For example, the demand for wheeled and tracked arable tractors equals to N_T =13.732 · 8.572 = 118 units; for row-crop tractors for the intertillaging of 90 cm – N_T=13.732 · 13.3 = 183 units etc.

The *table* shows that for the complete mechanization of technological operations on 13,732 hectares of arable land for the model cluster, 1,660 agricultural machinery units will be required. The share of tractors is 28%; trailers – 19.8%; cotton cultivators equipped with a device for removing cotton stalks growing points – 22%; horizontal-spindle cotton pickers – 8.25%, vertical-spindle cotton pickers – 13.8%.

All new and more efficient tractor and agricultural machine models, both manufactured by the machine-building plants of the Republic of Uzbekistan and imported, must pass state tests.

The test reports help to determine the values of w_c, T_c, n_c, w_1, $T_м$ и $w_м$. Thus, the number of machines for 1000 hectares of arable land can be obtained by the equation: $M_T = 1000 / w_м$.

Conclusions. The term "a model cotton-textile cluster" was introduced and defined. A normative method was developed to determine the number of tractors and agricultural machines per 1000 hectares of cotton arable land. Based on this method, the required number of vehicles in the fleet was calculated for a model cotton-textile cluster with a cotton area of 13,732 hectares. This vehicle fleet containing 1660 units ensures the implementation of all technological operations within the set agrotechnical terms.

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