Social and hygienic aspects of preserving the labor potential of the Russian Federation grain complex sustainable development

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Abstract. An analysis of the social and hygienic aspects of preserving labor potential as an important component of the sustainable development of the Russian grain complex was carried out. Based on social and hygienic studies, an assessment of the factors of maintaining labor potential during the operation of agricultural machinery is given. It has been established that technical and ergonomic imperfections, moral and physical aging of agricultural machinery create harmful working conditions, the chronic impact of which leads to the development of occupational diseases among agricultural machine operators (vibration disease, radiculopathy of the lumbosacral level, sensorineural hearing loss), as well as the development and severity of the course of general diseases (arterial hypertension, respiratory diseases). The interviewed machine operators (95%) associated the deterioration of their health with the negative impact of production factors ($r=0.9$, $p<0.005$) and social and living conditions that affect the prestige of agricultural work and the formation of personnel shortages. Technical re-equipment, development of rural infrastructure, ensuring safe working conditions, maintaining health, increasing the social well-being of workers are the main resources for the sustainable development of the agro-industrial complex of the Russian economy.

1 Introduction

Sustainable development of the Russian Federation, including the agricultural sector of the economy, is a necessary requirement of our time, which has become a global benchmark for the world economic system.

One of the important production areas of the Russian agro-industrial complex is grain production, on the innovative development of which the country's food security, economic stability and standard of living of the population largely depend.

An analysis of the material and technical base of grain complex organizations indicates the negative dynamics that developed in the 90s of the last century to the present, leading to

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an annual quantitative reduction in all types of tractors and agricultural machines, and the use of equipment with wear and tear of more than 10 years. The share of grain harvesters over 10 years old in 2021 amounted to 44%, tractors - 58%, and this equipment is predominantly of old models with an average service life of tractors of 19.95 years, grain harvesters of 15.67 years [1]. According to the farmers themselves, there is a lack of high-tech equipment, the design of which uses not only intelligent, automated and robotic systems, but also ergonomic solutions to ensure comfortable and safe working conditions [2].

When operating old-style agricultural machinery with expired service life, workers are exposed to the complex effects of harmful production factors that can be risk factors for the development and progression of occupational and work-related diseases [3, 4]. Modern trends in violations of the professional health of agricultural workers indicate that 56.3-70% of newly diagnosed cases of occupational diseases each year belong to tractor drivers in agricultural production (hereinafter referred to as agricultural machine operators) [5].

It is known that the health status of workers is the main qualitative indicator of labor potential, determining working capacity and labor productivity, on which the development of the national economy largely depends [6, 7]. The use of obsolete agricultural machinery with exceeded standard depreciation and operation periods leads not only to low labor productivity, but also to economic losses - failure to meet agricultural deadlines, losses of grain during harvesting, depletion and reduction of arable land, as well as loss of human resources [8]. Dissatisfaction with working conditions, along with low incomes, reduces the prestige of agricultural work, negatively affecting the motivation to return to the village for young specialists who received their education in the city. According to sociological studies, the share of young specialists who want to work in agriculture after graduating from higher and secondary educational institutions is 9.37% among men and 5.06% among women [9].

There are also a number of socio-economic reasons for the outflow of qualified personnel from villages. The main ones are unstable economic conditions, a low standard of living compared to the city, and an insufficiently developed social infrastructure. There is an “aging” and the formation of a shortage of labor resources with the necessary level of professional qualifications, which is one of the limiting factors for the sustainable development of agricultural production [10].

2 Materials and methods

The purpose of the study is to analyze social and hygienic aspects affecting the preservation of labor potential as an important component of the sustainable development of the grain complex.

An assessment was made of the ergonomic parameters of cabins and workstations and the hygienic factors of the working environment (working air pollution with chemicals and dust, noise, general and local vibration, microclimate parameters) and the labor process. Sociological research was conducted in a group of male agricultural machine operators numbering 267 people aged 21-65 years and with 10-35 years of experience in the profession using a distributed survey method. Statistical processing and analysis of data were carried out using Microsoft Excel and Statistica 10.0 application programs.

3 Results and discussion

The results of ergonomic studies have made it possible to establish that the overall dimensions of the cabins of most tractors and agricultural machines of old brands currently used in agriculture do not fully comply with the ergonomic and sanitary and hygienic requirements for this equipment. Typical design flaws were as follows:
- insufficient overall dimensions of cabins and workplaces;
- imperfect work chairs, the profiling and dimensions of elements (cushions, backrests, armrests) of which do not correspond to the body size of workers and ergonomic requirements;
- the location of a number of controls outside the reach of the hands and feet of workers in a comfortable working position;
- forces on controls exceeding permissible values;
- insufficient visibility from the workplace in a comfortable working position.

Ergonomic shortcomings of cabins lead to irrational spatial layout characteristics of workplaces, contributing to the formation of an uncomfortable physiologically irrational working posture, increasing static and dynamic loads on the musculoskeletal system [11].

The location of the controls outside the optimal motor zone and the excessive length of the lever stroke (up to 880 mm) force machine operators to work while sitting without support on the back of the seat with the body and head tilted forward, making deep (up to 45°) bends (up to 300 times per shift). Taken together, uncomfortable working posture and physical activity create harmful working conditions (classes 3.2-3.3).

Lack of back support contributes to static tension in a large number of core and leg muscles. In this case, the natural curvature of the spinal column in the lumbar region is disrupted, the load on the intervertebral discs increases, which leads to their premature degradation and pathological conditions of the lumbar-sacral spine and ligamentous apparatus [12].

Long-term maintenance of a working posture with the body and head tilted forward also leads to overload of the upper spine, contributing to the formation of compensatory scoliosis, both in the cervical and thoracic regions. The volume of the chest cavity decreases, its excursion becomes more difficult, internal organs, larynx, and neck vessels are compressed, respiratory and digestive functions deteriorate, which leads to the development of diseases of the cardiovascular system, digestive organs, and metabolism [13].

The wear and tear and structural imperfections of old equipment create a serious problem in ensuring the safety of agricultural machine operators. According to official statistics, among them the majority of victims of industrial accidents are noted, with tractor drivers suffering more often (almost 24% of the total number of deaths of agricultural workers annually). Among the main causes of injuries, low operational reliability of equipment ranks first [14]. Insufficient qualifications of personnel are also indicated as causes of industrial injuries [15].

Domestic and imported equipment of modern models are equipped with a comfortable ergonomic workplace with a sprung seat, a steering column adjustable in height and angle, the location of controls within the optimal reach of the operator’s arms and legs, good visibility from the workplace due to wide glazing, which ensures work in comfortable working position [16]. However, it should be noted that being in an uncomfortable static working position while sitting persists and reaches 50% or more of the shift time, forming difficult working conditions of the 1st degree (class 3.1).

The results of sanitary and hygienic studies made it possible to establish that the design deficiencies of the cabins of older models (lack and/or ineffective means of normalizing the air environment, insufficient noise, vibration and heat insulation, low shock-absorbing properties of the cabins) are the reason for the formation of a working environment harmful to the health of machine operators.

The most unfavorable working conditions (class 3.4), capable of causing severe forms of occupational diseases (with loss of general ability to work), are formed due to the heating microclimate, dustiness of the air in the working area and vibroacoustic load.

Due to the installation of old models of ineffective ventilation systems on equipment, the microclimate parameters in the cabins are closely dependent on meteorological conditions.
The average weighted air temperature in the warm period of the year can reach 38-44°C, surface temperature – 45°C and more, THC index values – 38.1±1.78 ºС, indicating extreme conditions leading to overheating and accumulation of heat in the body at levels exceeding permissible values (classes 3.2-3.4). Long-term exposure to a heating microclimate leads to strain in the activity of the main functional systems of the human body, primarily the circulatory system, with the subsequent development of arterial hypertension, myocardiopathy, and neurocirculatory dystonia of the hypertensive type [17].

Dust entering the breathing zone of combine operators, being a weakly fibrogenic aerosol of mixed origin, can cause the development of bronchial asthma and obstructive pulmonary disease. The composition of soil dust present in the breathing zone of tractor drivers contains from 2.7 to 9.5% of free silicon dioxide. When inhaled, insoluble particles of silicon dioxide remain for a long time in the deep parts of the respiratory system, affecting the bronchial tract, contributing to the development of pneumoconiosis, chronic dust non-obstructive bronchitis [18].

In the air environment of agricultural machinery cabins, exhaust components of internal combustion engines containing hydrocarbons, nitrogen oxides, and mineral oil vapors are constantly present (in acceptable concentrations). Particularly harmful is air pollution with carbon monoxide, which has a highly targeted and dangerous effect on human reproductive health, and nitrogen oxide, a substance with a highly targeted and irritating effect [19].

When working on all types of agricultural machinery, agricultural operators are exposed to noise, general and local vibration. It was established that the maximum permissible noise levels (MALs) in the cabins of obsolete equipment were exceeded from 5 to 18 dBA, and in the cabins of new equipment - up to 5 dBA. The leading negative impact of industrial noise on the human body is occupational hearing damage. In addition to the specific effects, noise has a pronounced biological effect on many organs and systems, significantly inhibiting the adaptive capabilities of the body [20]. Under its influence, dysfunctions of the central nervous and cardiovascular systems and biochemical blood parameters occur: carbohydrate, protein, lipid, vitamin, water-salt metabolism [21].

Chronic exposure to general vibration, especially the resonant (close to the natural frequencies of vibration of the human body and internal organs) range, characteristic of agricultural machinery, leads to the development of vibration disease, manifested in damage to peripheral vessels, the nervous system, pain and numbness of the upper extremities in combination with bone-muscular dystrophic changes [22]. Damage to the central nervous system is manifested by autonomic-vascular and sensory disorders. Trauma to intervertebral discs and bone tissue leads to the development and progression of degenerative changes in the spine [23]. The effect of vibration and noise on the body is aggravated by high muscle loads, uncomfortable working posture, unfavorable microclimatic conditions, as well as psycho-emotional stress.

The neuro-emotional stress on machine operators when operating agricultural machinery is caused by the high quantity and density of incoming and evaluated information, the need to take quick response actions, and high responsibility for traffic safety and material assets. Continuous monitoring of the technological process and the operation of equipment requires high concentration, distribution and switching, and attention. Emotional stress can also be caused by disturbances in the organization of work, often caused by physical wear and tear of equipment, and weather conditions [24].

The negative impact of harmful production factors leads to disruption of the health of machine operators, a decrease in the reliability of performing work functions, and labor productivity. The results of the survey made it possible to establish that 94.8% of the surveyed machine operators subjectively assessed working conditions on agricultural machinery as “harmful” to their health, noting a combination of production factors.
A significant portion of the interviewed (52.4%) machine operators pointed to the unsatisfactory organization of workplaces. The largest number of negative ratings were given by workers with a body length below average, for whom these discrepancies were most pronounced. A direct correlation (r = 0.8) was revealed between the perception of the organization of workplaces as “inconvenient” and the degree of correspondence of the parameters to the anthropometric data of the respondents. At the same time, there was a clearly visible relationship between the degree of discrepancy between the placement of controls and ergonomic requirements and the perception of irrational workplace layout as an unfavorable production factor (r = 0.65). More than 30% of respondents associated an uncomfortable working posture with the occurrence of temporary and/or permanent pain in the back and lumbar region. The share of respondents who considered the remoteness of controls to be the reason for an uncomfortable working posture reached 54.6%, and poor visibility - 80.4%.

An unfavorable microclimate was indicated by 55.8% of respondents, with 41.8% complaining of increased temperature, 14.2% of high humidity, and 35.6% of unsatisfactory air movement speed. High noise levels were indicated by 43% of respondents, general and local vibration by 52.8%, and air pollution by dust and chemicals by 89.7%.

More than half (58%) of respondents rated their work as “hard.” Among the unfavorable factors of the labor process, physical overload was indicated in 53.6% of cases and neuro-emotional overstrain in 20.2% of cases. At the same time, 86.8% of the respondents noted the presence of chronic diseases of the musculoskeletal system (66.3%), respiratory organs (35.2%), digestive organs (23.2%), circulatory system (23.2%).

The majority (64.8%) of respondents associated the deterioration of their health with harmful working conditions. In their opinion, difficult working conditions have a greater impact on the development of diseases of the musculoskeletal system (66.29%), respiratory organs (35.21%), and cardiovascular system (23.22%). A statistically significant correlation was established (r = 0.9, p <0.005) between the assessment of health as “poor” and the respondents’ opinion that it has worsened due to work in the profession.

The etiopathogenetic role of harmful factors in working conditions in affecting the health of agricultural machine operators is confirmed by the results of a study of occupational morbidity. In the nosological structure of occupational diseases registered among agricultural machine operators in Russia in the period from 2011 to 2017, the first ranking places were occupied by vibration disease (36.7%), radiculopathy of the lumbosacral level (28.5%), sensorineural hearing loss (24.6%) [5].

Among non-occupational chronic non-infectious diseases associated with exposure to harmful production factors, the most frequently diagnosed were arterial hypertension, reflex syndromes of the cervical and lumbosacral levels, chronic dust non-obstructive bronchitis, and bronchial asthma [25].

It was found that most of the respondents (76.03%) lived in their own houses or in separate apartments, had garden plots and livestock. 85.39% of respondents after a working day were busy with household chores for 3-5 hours, exposed to health risk factors inherent in their professional activities (dust of mineral, plant and/or animal origin, noise, physical stress).

Despite complaints about deteriorating health, 68.6% of respondents sought primary health care and specialized medical care only when necessary, 6% did not seek it at all, pointing to the territorial remoteness of medical organizations and the high cost of reimbursable medical services. 12% of respondents indicated stress associated with an unstable or unsatisfactory family budget and fear of losing their job.

Scientific literature sources contain numerous data that dissatisfaction with unfavorable conditions and low wages are one of the main reasons for changing professions, which increases the risks of forming the necessary competent personnel potential in the industry.
The increased turnover of machine operator personnel may also be due to other reasons, among which the most frequently cited are insufficiently developed social infrastructure (territorial distance from qualified medical care) and poor living conditions (lack of hot water supply and sewerage, power outages) [26].

Thus, the results of the research indicate that an important role in preserving the labor resources of the Russian grain complex is played by technical re-equipment, renewal of the agricultural machinery fleet, development of rural infrastructure, ensuring safe working conditions, maintaining health, and increasing the social well-being of workers.

4 Conclusion

The current state of the agricultural machinery fleet is characterized by underequipping, technical and technological aging and physical wear and tear, leading to the formation of hazardous working conditions, characterized by ergonomically imperfect spatial layout parameters of workplaces, increased levels of noise and vibration, air pollution of the working area with harmful chemicals and dust, microclimatic discomfort, heaviness and tension of the labor process.

Harmful working conditions act as triggers for the development and progression of occupational and chronic general somatic diseases among agricultural machine operators and cause a decrease in the prestige of professional activity in the agricultural industry.

The main resource stimulating the sustainable development of agricultural production is technical and technological re-equipment, promoting the development of production, safe work and the preservation of the health of workers, which is a qualitative indicator of the labor potential of the industry.

Improving socio-economic conditions, raising living standards, supporting young professionals, and developing the social infrastructure of rural settlements are the conditions for the formation of personnel potential with the necessary professional competencies and numbers, as one of the basic factors for the sustainable development of the agro-industrial complex.

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