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# The Evaluation Of Combining Ability Of Lines In Hybridization Of Pigs.

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**ABSTRACT**

The purpose of these studies was to evaluate the combining ability of agricultural animal lines using electronic templates and computer programs. The research study was carried out according to the results of a long-term breeding experiment conducted at pig breeding farms in the Krasnodar Territory and at the Artificial Insemination Center for Animals OAO Rostovplemoobedinenie, Aksai rayon, the Rostov region. In breeding farms, the selection work was aimed at genetic differentiation of existing lines according to the method of Maligonov-Libizov'sintraline selection. The main productivity indicators characterizing the reproductive, fattening and meat qualities have been studied. Algorithmization of Griffing's methods in modification by V.K. Savchenko presented in the form of electronic templatesenabled evaluating of the process of calculating the combining ability of animal lines. The results obtained allowed making a decision to implement the templates developed in the form of computer programs PRACS-I and PODBOR-1. The programs were tested at the Center for Artificial Insemination of Animals OAORostovplemoobedinenie, Aksai rayon under the supervision of the breeding department of the Ministry of Agriculture and Food of the Rostov region using electronic databases on breeding dairy stud bulls. The performed analysis of the combining ability of lines in animal husbandry made it possible to determine its size and identify patterns that are of practical importance. The total combining ability has been established to enhance due to an increase in degree of genotypic trait determination; the specific combining ability went down with an increase in the heritability estimate. Based on the research conducted, it was concluded that computer programs can automate the evaluation of the guaranteed heterosis effect according to the production traits, which made it possible to use them in the selection system of combining breed lines to increase the breeding value and breed new highly productive animal lines. The current situation with domestic animal husbandry in Russia and the state import substitution program necessitate creating a breeding base for selection of specialized lines and breeds in Russia. The implementation of this idea requires a complex set of measures and programs for the development of breeding centers, where it is necessary to implement testing of specialized lines for combining ability; only then, the heterosis effect during the animal hybridization can be guaranteed. Only the development of the entire system from breeding plants, breeders and breeding and genetic centers to commercial breeders will allow quick producing of high quality meat products.

**Keywords:** hybridization, general combining ability, specific combining ability, productivity indicators, reproductive, fattening and meat qualities, crossing variants, patterns, programs, lines, stud boars, stud bulls, milk production.

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## INTRODUCTION

At present, there is a need for a sharp qualitative increase in productivity that is capable of eliminating the disproportion between the requirements of the production technology and the selection and genetic potential of existing breeds, types and lines of animals. These issues can be solved using new techniques and methods for creating hybrid animals and breeding systems that allow obtaining qualitatively new animals that are capable of productivity on the verge of the physiological endpoint [9, 10, 13 and14].

## RATIONALE

In this regard, the problem of controlling the heterosis effect remains relevant. The theoretical basis for understanding this effect was substantiated more than 100 years ago by Professor A.A. Maligonov. He proved that the lines are not only highly productive, but also have stable heritability, i.e. are homozygous. Even then, the question was raised about taking into account the "combining ability" of lines when breeding animals [1 and 3]. For the first time in the world, Academician M.F. Ivanov created a clear vertical pyramid with a system of intraline selection and applied the hybridization method as a crossing of pig lines combined for the heterosis effect.

In 1965 the principles of linear breeding were applied in a long-term experiment on breeding of homozygous lines of large white breed pigs and their crossing in the system of commercial pig breeding in the North Caucasus [5 and 6]. The long-term breeding experiment (for 35 years) was aimed at increasing the level of line productivity and evaluating their combining ability. However, the Griffing's methods proposed in his works in the 1970s/80s were difficult to implement because of large volumes of mathematical calculations. The modern development of computing equipment, software and their accessibility made it possible to automate the process of evaluating the animal lines and their combining ability [2, 7, 8 and 9].

**Purpose and objectives of the research study**. The purpose of the research was to evaluate the combining ability of farm animals using electronic templates and computer programs, test the programs using specific examples of boar and stud bull lines and develop recommendations on the use of the lines in the hybridization system.

## MATERIAL AND METHODS

The experimental work was carried out taking into account the results of the long breeding experiment (for 35 years) at breeding farms in the Krasnodar Territory for breeding large white pigs "Gulkevichski," "Venzy-Zarya" and "Caucasus."The stock breeding was aimed at the genetic differentiation of the lines existing. To automate the calculation of the effects of general and specific combining ability, the staff of the laboratory of the theoretical foundations of farm animal selection at DonState Agrarian University developed spreadsheets in M. Excel. The templates were compiled using the Griffing'smethods in the modification by V. Savchenko [3 and 5]. The evaluation of results was carried out according to the databases of breeding plants, evaluating the combining ability of the pig lines of Svat, Sekret, Smaragd, Vents and Leopard.

Further, the templates were implemented in the PRACS-I and PODBOR-1 computer application programs. The programs were tested at the Center for Artificial Insemination of Animals at OAORostovple moobedinenie, Aksai rayon under the supervision of the breeding department of the Ministry of Agriculture and Food in the Rostov region using electronic databases on breeding dairy stud bulls.

**The scientific novelty** of the research lies in the fact that the Griffing's methods for the first time were automated in electronic templates and computer programs PRACS-I and PODBOR-1; the programs were tested on experimental material obtained from breeding plants. The results of the evaluation of the combining ability of farm animal lines have been obtained. The theoretical background of the relationship between heritability and manifestation of the heterosis effect has been confirmed.

**Practical significance** of the research lies in the fact that there are domestic software products that allow evaluating lines on homozygosity and predicting the heterosis effect according to their productivity. Evaluation of the combining ability of the lines allows using the results in the system of pair selection or breeding schemes to increase their breeding value and breed new highly productive lines. The results of the

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general and specific combining ability made it possible to correct existing crossing patterns (hybridization) and develop new ones.

## RESULTS

The electronic templates and programs developed are universal for all types of farm animals and poultry and allow quantifying the assessment of the lines' combining ability in hybridization or crossing systems [11 and 12].

The work of electronic templates was checked on the stud boar lines at the breeding factories in the Krasnodar Territory, using the data base of the ACC software system. Figure 1 shows an example of estimating the A, B, C, D and E lines in the direct and reciprocal variants of the hybridization of pigs.

| Линия P2 | Gi(P2) | | Линия P′ | Gj(P1) |
|---|---|---|---|---|
| A | 0,278 | | a | 0,268 |
| B | 0,238 | | b | 0,148 |
| C | 0,068 | | c | 0,178 |
| D | -0,312 | | d | -0,372 |
| E | -0,272 | | e | -0,222 |

**Figure 1: Evaluation of cross variants for pig lines,**

*where A is the Svat line, B is the Secret line, C is the Smaragd line, D is the Vents line and E is the Leopard line*

The A♂line(Svat) when crossed with the B♀(Secret) and♀C (Smaragd)lines had aprolificacy excess in the direct crosses variant by +0.28, +0.24 and +0.07 and in the reverse crosses variant of the lines ♀A (Svat), B (Secret) and ♂C (Smaragd) by +0.27, +0.15 and +018 piglets, respectively. The research results showed that the Swat line was the most consolidated with respect to all traits under study compared to other lines [5 and 6].

The high variability of reproductive fitness indices for the cross lines (♀Secret x ♂Svat) and (♀Secret x ♂Smaragd), and of fattening and meat qualities for the cross line (♀Venets x ♂Leopard)was noted. An increase in the phenotypic diversity of breeding traits was observed in the reverse mating variants, so the variability of reproductive fitness varied in terms of the crosses ♀Svat x Smaragd from 10.1 to 26.0%; ♀Smaragd x ♂Secret from 9.92 to 21.7%; and ♀Secret x ♂Svat from 10.85 to 13.54%.

When crossing the A line (Svat) with the D (Venets) and E (Leopard) lines, negative values of -0.31 were obtained with respect to the prolificacy of -0,31 and -0.27 piglets in the direct variant and -0.37 and -0,22 piglets in the reverse one, respectively. The data showed that the evaluation allowed selecting of the most effective combination variants for the lines and developing a reasonable hybridization program [5, 7 and 8].

Unfortunately, at the present stage of development of Russian animal husbandry, this approach is not applied, which is due to the lack of relevant genetic material, as well as qualified analysis of the assessment of the genetic parameters of real populations in the conditions of industrial commercial production.

After testing the work of the templates, the PRACS-I and PODBOR-1 computer application programs were developed [4 and11].

The PRACS-I program was written in the Delphi programming language; it calculated the general and specific combining ability of lines and reciprocal effects using four Griffing's methods, depending on the available information on the productivity of animal lines in direct and reverse cross variants. There were at least 3 lines tested, at most 10. The program interface was clear; the dialog boxes appeared on the monitor screen and enabled the key board input of initial information in Russian or English. Figure 2 shows the program window.

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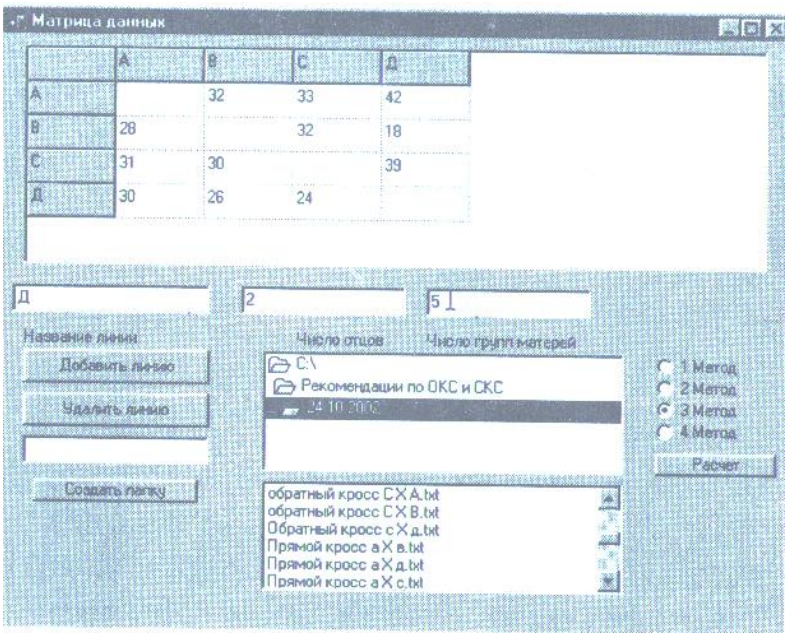


**Figure 2: The PRACS-I program window**

In the row “Number of fathers” and “Number of mothers groups,” the number of stud animals and groups of mothers for each combination were entered. This information was necessary for the analysis of diversity due to the hereditary characteristics of animals of various combinations. The “Calculate” command provided the calculations. The program provided the ability to create a new folder and a name assigned to the automatically created file, where the results obtained would be typed in. Viewing calculation files and their printing was carried out of the program using standard operating Windows procedures [11 and12].

The “PODBOR-1”computer program was intended for assigning stud bulls. The program was developed on the NET platform that represents a new technology for creating Microsoft applications, the C # programming language, Access was used as a database. This database was much simpler than its analogs with respect to the installation-setup-maintenance and therefore did not require an administrator to operate; the PC user level was sufficient to use it.

The program provided for solving the following tasks: drawing up an application for the number of semen doses in accordance with the population of mating animals, evaluating the combining ability of the stud bulls lines, assigning the stud bulls to the herd of dairy cows, summarizing tables, printing them, adding and correcting the program data bases, stud bulls sperm database seeding and making a list of farms. The program consists of two autonomous units, i.e. templates of an electronic application and the program itself (Figure 3).


**Figure 3: The application form window in “Podbor-1” program**

The algorithm of the program provided for editing the previously saved files. Their reloading into the program was performed using standard operating procedure after clicking the “Download” button.

The program began with the “Settings” tab in the “Work directory” row (Figure 4).

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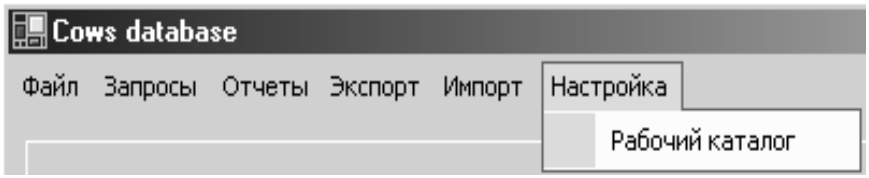


**Figure 4: The "PODBOR-1" program window**

To assign bulls to farms in rayons, it was necessary to follow the route "Requests" → "Sampling" → "Search for a bull" (Figure 5).

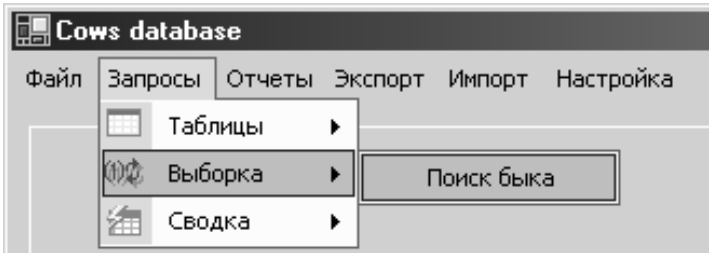


**Figure 5: Selecting a bull in the "PODBOR-1" program**

To evaluate lines and herds in terms of the combining ability, it was necessary to fill out a form. Figure 6 shows the window, where there is a system of filters that allow setting restrictions on selecting a bull for a dairy herd.

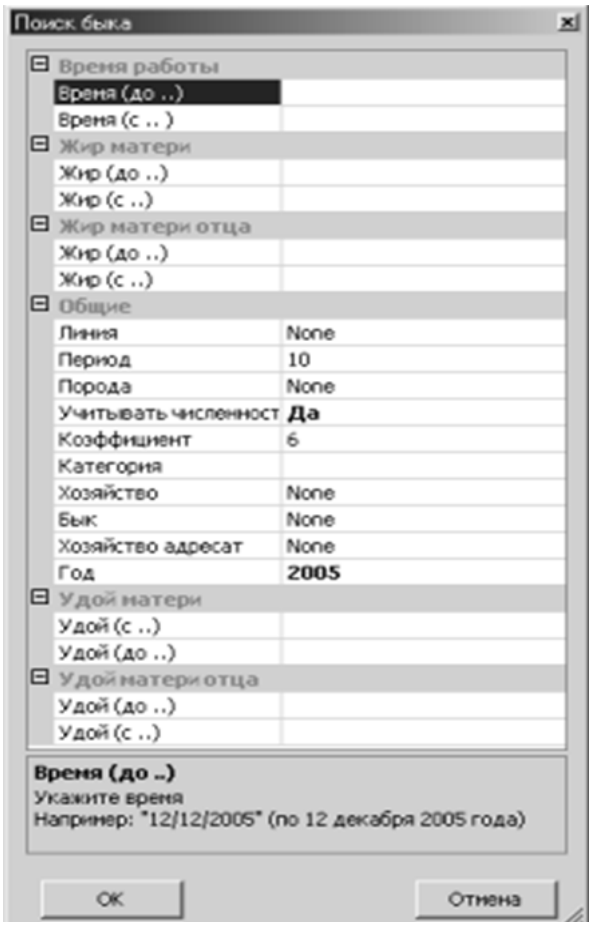


**Figure 6: The "Search for a bull" window**

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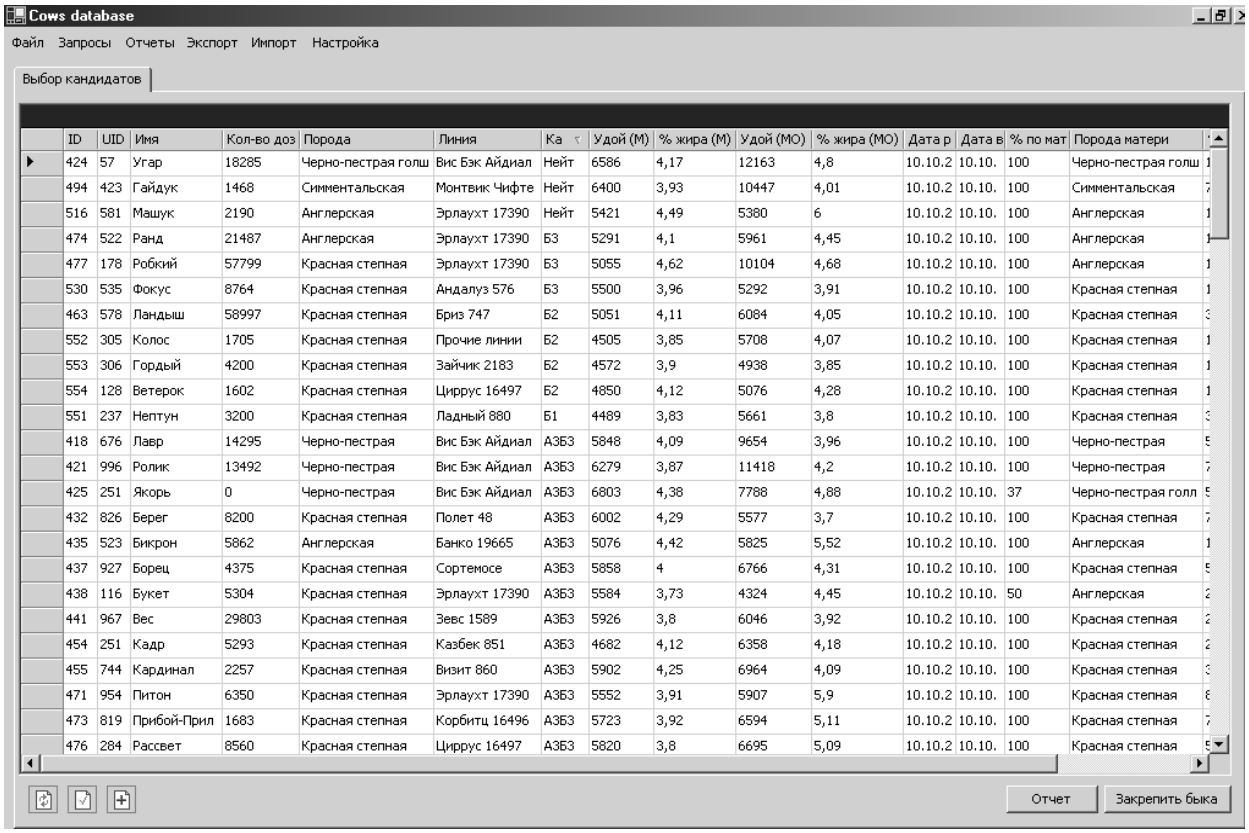
When selecting a row at the bottom of the window, prompts were automatically displayed for the user to simplify the work with the program. In the “Line” and “Breed” rows, the line and breed of bulls were selected to choose the sperm from the sperm data bank. In the “Period” row, a limit was set on the reuse of the sperm from related bulls on the farm. By default, this period was 10 years. The user can change it at his discretion. The row “Consider the number” allowed selecting only the bulls, whose dose of sperm was enough for insemination of the entire mating cows of the farm for two years.

The program automatically checked the combining ability of lines in the database. According to the query results, the program generated a table of candidate bulls for assigning to the household marked by the user (Figure 7).




| ID | UID | Имя | Кол-во доз | Порода | Линия | Ка | Удой (М) | % жира (М) | Удой (МО) | % жира (МО) | Дата р | Дата в | % по мат | Порода матери |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 424 | 57 | Угар | 18285 | Черно-пестрая голш | Вис Бэк Айдиал | Нейт | 6586 | 4,17 | 12163 | 4,8 | 10.10.2 | 10.10. | 100 | Черно-пестрая голш |
| 494 | 423 | Гайдук | 1468 | Симментальская | Монтвик Чифте | Нейт | 6400 | 3,93 | 10447 | 4,01 | 10.10.2 | 10.10. | 100 | Симментальская |
| 516 | 581 | Машук | 2190 | Англерская | Эрлаухт 17390 | Нейт | 5421 | 4,49 | 5380 | 6 | 10.10.2 | 10.10. | 100 | Англерская |
| 474 | 522 | Ранд | 21487 | Англерская | Эрлаухт 17390 | Б3 | 5291 | 4,1 | 5961 | 4,45 | 10.10.2 | 10.10. | 100 | Англерская |
| 477 | 178 | Робкий | 57799 | Красная степная | Эрлаухт 17390 | Б3 | 5055 | 4,62 | 10104 | 4,68 | 10.10.2 | 10.10. | 100 | Англерская |
| 530 | 535 | Фокус | 8764 | Красная степная | Андалуз 576 | Б3 | 5500 | 3,96 | 5292 | 3,91 | 10.10.2 | 10.10. | 100 | Красная степная |
| 463 | 578 | Ландыш | 58997 | Красная степная | Бриз 747 | Б2 | 5051 | 4,11 | 6084 | 4,05 | 10.10.2 | 10.10. | 100 | Красная степная |
| 552 | 305 | Колос | 1705 | Красная степная | Прочие линии | Б2 | 4505 | 3,85 | 5708 | 4,07 | 10.10.2 | 10.10. | 100 | Красная степная |
| 553 | 306 | Гордый | 4200 | Красная степная | Зайчик 2183 | Б2 | 4572 | 3,9 | 4938 | 3,85 | 10.10.2 | 10.10. | 100 | Красная степная |
| 554 | 128 | Ветерок | 1602 | Красная степная | Циррус 16497 | Б2 | 4850 | 4,12 | 5076 | 4,28 | 10.10.2 | 10.10. | 100 | Красная степная |
| 551 | 237 | Нептун | 3200 | Красная степная | Ладный 880 | Б1 | 4489 | 3,83 | 5661 | 3,8 | 10.10.2 | 10.10. | 100 | Красная степная |
| 418 | 676 | Лавр | 14295 | Черно-пестрая | Вис Бэк Айдиал | АЗБ3 | 5848 | 4,09 | 9654 | 3,96 | 10.10.2 | 10.10. | 100 | Черно-пестрая |
| 421 | 996 | Ролик | 13492 | Черно-пестрая | Вис Бэк Айдиал | АЗБ3 | 6279 | 3,87 | 11418 | 4,2 | 10.10.2 | 10.10. | 100 | Черно-пестрая |
| 425 | 251 | Якорь | 0 | Черно-пестрая | Вис Бэк Айдиал | АЗБ3 | 6803 | 4,38 | 7788 | 4,88 | 10.10.2 | 10.10. | 37 | Черно-пестрая голл |
| 432 | 826 | Берег | 8200 | Красная степная | Полет 48 | АЗБ3 | 6002 | 4,29 | 5577 | 3,7 | 10.10.2 | 10.10. | 100 | Красная степная |
| 435 | 523 | Бикрон | 5862 | Англерская | Банко 19665 | АЗБ3 | 5076 | 4,42 | 5825 | 5,52 | 10.10.2 | 10.10. | 100 | Англерская |
| 437 | 927 | Борец | 4375 | Красная степная | Сортемосе | АЗБ3 | 5858 | 4 | 6766 | 4,31 | 10.10.2 | 10.10. | 100 | Красная степная |
| 438 | 116 | Букет | 5304 | Красная степная | Эрлаухт 17390 | АЗБ3 | 5584 | 3,73 | 4324 | 4,45 | 10.10.2 | 10.10. | 50 | Англерская |
| 441 | 967 | Вес | 29803 | Красная степная | Зевс 1589 | АЗБ3 | 5926 | 3,8 | 6046 | 3,92 | 10.10.2 | 10.10. | 100 | Красная степная |
| 454 | 251 | Кадр | 5293 | Красная степная | Казбек 851 | АЗБ3 | 4682 | 4,12 | 6358 | 4,18 | 10.10.2 | 10.10. | 100 | Красная степная |
| 455 | 744 | Кардинал | 2257 | Красная степная | Визит 860 | АЗБ3 | 5902 | 4,25 | 6964 | 4,09 | 10.10.2 | 10.10. | 100 | Красная степная |
| 471 | 954 | Питон | 6350 | Красная степная | Эрлаухт 17390 | АЗБ3 | 5552 | 3,91 | 5907 | 5,9 | 10.10.2 | 10.10. | 100 | Красная степная |
| 473 | 819 | Прибой-Прил | 1683 | Красная степная | Корбитц 16496 | АЗБ3 | 5723 | 3,92 | 6594 | 5,11 | 10.10.2 | 10.10. | 100 | Красная степная |
| 476 | 284 | Рассвет | 8560 | Красная степная | Циррус 16497 | АЗБ3 | 5820 | 3,8 | 6695 | 5,09 | 10.10.2 | 10.10. | 100 | Красная степная |

**Figure 7: Selection of candidate bulls for assignment to a farm**

A bull according to the user-defined search criteria was selected from the database. It contained information about the stud bulls, i.e., herd number, nickname, number of sperm doses, breed and line, category (improver, etc.) and mother and father’s productivities of milk yield, fat content of milk and breed.

The databank of OAO “Rostovplobodinenie” contained information about 140 bulls of 13 breeds, i.e.,Black-and-White Holland, Black-and-White, Black-and-White Holstein, Red-and-White, Angler, Red-Steppe, Hereford, Red-and-White Holstein, Simmental, Ayrshire, Danish Red, Kalmyk and Brown Swiss. There were 35 lines in the structure of the breeds, i.e.,VisBackIdeal, CeilingTryjuneRocket, Reflection Sovering ,AnnasAdema, Hojager, Korbitc, Polet 48, Frem 17291, Chernomor, Banko 19665, Erlauht, Sortemose, Zeus 1589, Breeze 747, Andaluz 576, Minomet562, Vizit 860, Kazbek 851, Ladny 880, MontwickChieftein, RomanAndale, Hannulan Yayuskyari, KingErant, YutteroRomeo, HiltesAdema, Cirrus 16497, Zaichik 2183, Riihiviidan, Python 919, Erdol 17011, Master 106902, Meridian 90827 and Locke 22761. The Vis BackIdial, Erlaucht and Reflection Sovering lines are most widely represented. The bulls’ population of these lines was17, 9.3 and 7.2% of the total population in the database.

The final stage was to select a desired bull and confirm the “Assign the bull” row. After that, a specified number of doses were automatically excluded from the sperm bank. The program algorithm

provided for the possibility of putting information about the newly received sperm into the database (if purchased), as well as rejecting of the doses consumed; selection and assignment of some stud bulls to a farm.

A summary table of the results of the bulls' assignment to dairy herds in farms of the region was created in the "Reports" tab.

## CONCLUSIONS

The line breeding, when it is necessary to ensure the manifestation of a number of properties and qualities that make it possible to increase the strength of the constitution, the animals' adaptation to modern technologies providing high quality products for a short period of time, is of great importance for intensive industrial animal husbandry. Only line breeding easier ensures greater specialization, retaining however sufficient variability of productivity indices.

The obtained results of the combining ability evaluation of the lines showed that the heterosis effect manifested in crosses in traits with low heritability; in terms of traits of high heritability, hybrid combinations get high rates due to their high hereditary determination. It should be noted that the livestock import to the households of the Russian Federation should be based on the guaranteed heterosis effect, that is, the acquired livestock should be checked with respect to the combining ability and used in the hybridization system only after identifying positive variants.

The current situation with Russian animal husbandry and the state program of import substitution necessitate creating of a breeding base with the specialized lines and breeds being selected in Russia. The implementation of this idea will require a complex set of measures and programs for the development of breeding centers where it is necessary to implement testing of specialized lines for combining ability; only this can guarantee the heterosis effect in the hybridization of animals.

Unfortunately, computer programs that allow for the combining ability evaluation and enable automation of evaluation remain unclaimed in the circumstances of domestic livestock production. Only the development of the entire system from breeding plants, breeders, breeding and genetic centers to commercial breeders will allow quick producing of high quality meat products.

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