Innovative Techniques in the Mechanization of Beekeeping

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Abstract. The innovative development of the agro-industrial complex determines the need for mechanization of all sectors, including beekeeping, through the creation and implementation of technologically interconnected machines and beekeeping equipment. Together, they must ensure the crowding out of manual labor at all stages of production and processing of bee products, create comfortable working conditions, and relieve beekeepers of manual loading of beehives during the nomadic period. Ultimately, the stress load on the bees will decrease and honey collection will increase. The aim of the research was to study the level of mechanization in Russian beekeeping and develop proposals for the technological transformation of the industry. In the course of the research, a scientific substantiation of the principles of industrial beekeeping was formulated, based on the use of the most rational methods of beekeeping. Due to the mechanization of labor-intensive processes (selection and distribution of honeycombs, pumping and processing honey, the use of mobile honey-pollinating complexes), it is possible to simplify the maintenance of bees and achieve high labor productivity.

1. Introduction

In recent years, the role of bees as the main pollinator of entomophilous crops has increased significantly [19]. This requires the apiary to move to flowering honey plants almost every 2-3 weeks, and creates additional technological and domestic difficulties. Moreover, it was found that for effective pollination, it is necessary that the bees visit each flower several times [3;13]. For example, it takes 6-8 visits for sunflower, and 15-20 for cucumbers. Depending on this and the number of flowers per unit area, the required number of bees can be determined (table 1).

Table 1. The number of bee families for pollination of 1 ha of entomophilous crops.

| Crops        | The number of bee families for 1 ha |
|--------------|------------------------------------|
| Gourds       | 0,3-0,5                            |
| Outdoors cucumber | 0,5                              |
| Sunflower    | 0,5-1                              |
| Buckwheat    | 2                                  |
| Coriander    | 2,5-3                              |
Apple, pear, plum, raspberry, gooseberry  
Cherry  
Sainfoin  
Currant  
Red clover  
Cotton  
Lucerne  

The number of bee colonies necessary for pollination of entomophilous crops and honey collection should be increased if the crops are removed from apiaries at a distance of more than 500 m [4]

2. Relevance and significance of the problem
In the Southern Federal District, with unique climatic conditions, bees participate in pollination of crops from May to August-October. It is in this region that a large number of entomophilous crops are cultivated. Under the main honey-bearing crop - sunflower - 1618.6 thousand ha are occupied in the region, that is almost 23% of the Russian lands (Table 2)[12]. In addition, in this zone more than 27% of the area is under fruit plantings, which are also in need of pollination, [5]. Most of the gardens are in the Krasnodar Region (35.0 thousand ha) and the Rostov Region (17.4 thousand ha). At the same time, planting of gardens is constantly growing under the import substitution program due to the high suitability of the climate and land for garden plantings.

**Table 2.** Sowing area of sunflower, thousand ha.

| Region                              | 2010  | 2019  | increase, % |
|-------------------------------------|-------|-------|-------------|
| Russian Federation                  | 7 158.52 | 8 583.62 | 20           |
| Central Federal District            | 1 322.38 | 1 434.37 | 8            |
| Northwest Federal District          | -     | -     | -            |
| Southern Federal District           | 2 423.15 | 1 977.70 | 18           |
| North Caucasian Federal District    | 317.71 | 365.55 | 15           |
| Volga Federal District              | 2 485.74 | 3 923.55 | 58           |
| Ural Federal District               | 24.94 | 114.37 | 359          |
| Siberian Federal District           | 584.53 | 767.60 | 31           |
| Far-Eastern Federal District        | 0.07  | 0.48  | 586          |
Considering the fact that in the zone of intensive agrocenosis, to which the South of Russia belongs, crops requiring pollination occupy large areas, a large number of insects is required. At the same time, in modern conditions, bees became the main organized pollinators because wild pollinators were almost completely destroyed due to the widespread use of chemical plant protection product [5; 7;20].

3. Problem statement
The aim of the research was to study the level of mechanization in Russian beekeeping and develop proposals for the technological transformation of the industry.

For this research, the universal dialectical-materialistic method of cognition was used. When studying the topic, methods of comparative analysis, comparison, methods of induction and deduction were applied.

4. Theoretical part
In order to conduct pollination in a quality manner, it is very important that by the beginning of flowering of honey plants the apiaries should be in close proximity to the flowering honey plant. This can be realized due to the frequent movement of the apiary to the honey plants [2] by using mobile honey-pollinating complexes. Despite the fact that nomadic beekeeping has long been known, in modern Russia the possibilities of nomadic beekeeping are not used enough. Its wide distribution is constrained by the lack of commercially available honey-pollinating complexes [9;10].

Meanwhile, in the conditions of intensive farming, prompt delivery of bee colonies is required in a short time. In this case, it is important that the bees were brought precisely to the beginning of flowering, when there is intensive nectar production. In addition, mobile complexes also allow beekeepers to quickly transport bees in the case of planned chemical treatments of crops and plantings. All this requires new approaches to the organization of labor in beekeeping with a high degree of consistency between the agronomic service and beekeepers [18]. Beekeepers should know not only the location of melliferous lands, but also the timing of processing fields with herbicides and other pesticides to quickly dislodge (relocate) to a place safe for insects. It should be noted that the distance for insects from the place of field cultivation is, as a rule, 6-10 km. It is important that the bees are delivered at the beginning of flowering. Therefore, it is necessary within a few hours to load the hives into vehicles and set off.

Of course, pollination activity brings income to farmers and beekeepers many times higher than the profit from the sale of beekeeping products [15]. This is confirmed by numerous data from foreign and Russian beekeepers. The efficiency of bee pollination is related to the mass of the honey bee, its high tendency and intensity to collect and accumulate nectar, as well as the ability to live in controlled conditions created by humans. It should be noted that in the last six years it has become apparent to farmers that pollination of sunflower and orchards increases productivity by 15-25%. Therefore, beekeepers are paid 800-1000 rubles for staging bees for pollination for 15-20 days of work with the strength of families of 9-12 frames Such conditions interested beekeepers and provided grounds for preventing a decrease in the number of bees in the southern region[18].

As a result of pollination by bees, the yield of entomophilous crops increases from 15 to 40%, and it is impossible to replace cross-pollination of plants with any other agrotechnological technique. The areas in need of crops pollination in areas of intensive agriculture amount to more than 9 million hectares, while the cost of the additional crop obtained through bee pollination is estimated at 10-12 billion rubles. According to the researchers, at present time about 1 hectare of entomophilous crops accounts for only about 0.26 bee families, which is 3-4 times less than required. Meanwhile, the number of bees in the Southern Federal District in recent years has decreased by 2.5-3.5 times compared to the beginning of the 90s, but even then they were half as much. Currently, about 2.3 million bee families are lacking for full-fledged pollination of crops in Russia. The calculations of a number of agricultural technologists show that in Russia it is necessary to have 57 million bee colonies.

5. Research results and discussion
For the successful implementation of the pollination function of bees, a technological transformation of nomadic beekeeping is required [23]. If in earlier times hives were loaded onto carts and delivered
by animal drawn to the fields, then automobile trailers began to be used on which 14-36 hives could be loaded. Beekeepers try to lengthen car or tractor trailers and place 50-60 bee families on them. Moreover, in some cases, forklifts are used for loading (if the hives are installed on pallets), which greatly facilitate the work of beekeepers and increase labor productivity [12]. It should be specially noted that in the system of providing beekeepers with equipment for transporting beehives there are no optimal technical solutions. Each beekeeper, at his discretion, arranges transport, acquires and modernizes cars, which often leads to contradictions with the traffic police. RD-APK 1.10.08.01-10 “Methodological recommendations for the technological design of beekeeping facilities” also does not say anything about mobile bee complexes.

Meanwhile, all the documents on improving the agro-industrial complex in the last 10-15 years indicate the need to reduce labor costs per unit of output. This also applies to beekeeping. Observations of work in this industry in the USA, Canada, and China indicate that the average load per beekeeper is more than 1.5 thousand bee colonies and higher. In our country, there are 85-100 bee families per beekeeper. Therefore, the creation of mobile cluster-type bee complexes became quite logical. We at the Kuban State Agrarian University have developed such a pavilion that has been successfully tested in the apiary of the small innovative enterprise ZHIVPROM [11]. A patent of the Russian Federation for invention No. 2 284 103 was obtained for the construction of the pavilion, and the prototype was awarded the silver medal of the LEPIN competition (Paris, France). The design provides sections for the installation of hives along the side walls, each of which is divided into hive cells with 24 Dadan frames. Retractable cartridges in the form of horizontal frames for honeycombs are placed in the cells. The pavilion can be equipped with solar panels and electrical wiring.

Keeping bees in mobile pavilions not only ensures quick delivery to the field, but also reduces energy and material costs. It is estimated that the arrangement of the pavilion per 100 families requires 2-2.5 times less timber and transport for transportation than when kept in individual hives. Operational movement can significantly increase the period of honey collection, which increases the productivity and profitability of beekeeping [21]. Mobile pavilions have a high capacity of bee colonies in a small area and can be aggregated with vehicles. When wandering, a pavilion with bees is placed in close proximity to agricultural honey plants, most often near shelter belts.

The use of mobile pavilions and platforms in addition to apiary mobility eliminates the time-consuming work of loading and unloading hives. As a rule, bees are kept in the pavilions year-round, while there is no need to build winter houses [9]. The compact arrangement of bee colonies allows you to save heat in winter, which contributes to the early work of the uterus on egg laying and better development of families, the possible implementation of bee packages. The tests carried out on cassette-type pavilions confirm the possibility of their use for bees of different breeds. Mobile apiaries can increase labor productivity several times, thereby improving the social status of this profession and increasing its attractiveness. With the rational management of nomadic beekeeping for a season from one family you can get up to 120 kg of honey. Pavilion beekeeping allows you to perform all production functions: honey-commodity, pollinating and breeding, thereby ensuring the competitiveness of this industry. The advantages of this direction in beekeeping include increasing honey collection by 18-25% compared to single hives, increasing the yield of pollinated crops by 20-30%, compact placement of bee colonies with the possibility of mobile movement around the area for pollination of agricultural crops and honey collection, improving conditions wintering, improving the safety of bees, increasing labor productivity due to improved ergonomics, reducing labor intensity by eliminating loading and unloading.

Plant growers in their experience have felt the effectiveness of bee pollination. Today, many farms invite beekeepers to pollinate entomophilous crops, including orchards, crops of sunflower, alfalfa, etc. It should be noted that, at least in the Kuban, field owners already pay for pollination of orchards (up to 20 kg of apples per family of bees), sunflower (900-1000 rubles for a family of bees from 8-9 lanes) [8].

Our studies indicate that in mobile complexes, honey productivity, due to a more efficient use of the honey conveyor, increases by 20-25%.

The “bottleneck” in Russian beekeeping is the pumping and processing honey. It should be noted that the reason for this is almost complete absence of honey pumping complexes, where almost 50% of labor cost consumed. A big scale of honey production requires high-performance devices for printing honeycombs, as well as multi-frame electric semi-automatic honey extractors that can pump
out up to 350-450 or more frames per hour. Therefore, it is necessary to create a stationary point for pumping out honey, where honey frames from several apiaries would be delivered. Naturally, the creation of such points will require the adoption of sanitary and veterinary measures. In addition to the honey separator, reception tanks, devices for pumping honey from the honey separators to the honey settlers, as well as devices for packing honey should be provided. In some cases, it is necessary to provide a heat chamber for dissolving the crystallized honey and its underworking [2;6;14].

An energy-saving plant for convective drying has been developed to extract high-value bee bread from honeycomb honeycombs [21].

Innovative transformations are carried out in the technology of keeping bees. Light, durable and waterproof polyurethane foam hives are gaining ground, they reduce abnormal temperature differences and have a beneficial effect on the physiological state of bees. Maintaining optimal microclimate parameters inside the hive has a positive effect on the egg production of the uterus and the development of brood. This contributes to accelerated spring growth and earlier renewal of families. The advantages of such hives can also be attributed to their strength and resistance to the effects of rodents and corrosion.

A large number of technical proposals are aimed at maintaining the microclimate in the hives and their disinfection using ozone. The use of electric heating and electrozoning increases the intensity of the spring development of bees by 40%, it positively affects the honey productivity. One of the aspects of the technological revolution in beekeeping is the development of a “smart hive” based on the use of digital technologies. While this is being tested, there is every reason to believe that digitalization will allow the beekeeper to remotely monitor the state of the bee family[16].

The modern technical means include non-frame honey production, plastic wax and plastic collapsible frames, and much more.

6. Conclusion
In the course of the research, a scientific substantiation of the principles of industrial beekeeping was formulated, based on the use of the most rational methods of beekeeping. Due to the mechanization of labor-intensive processes (selection and distribution of honeycombs, pumping and processing honey, the use of mobile honey-pollinating complexes), it is possible to simplify the maintenance of bees and achieve high labor productivity.

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