The Efficiency of the Use of Glauconitic Sandstone as an Adsorbent in Beekeeping

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Abstract*: In the process of studying the efficiency of the use of glauconitic sandstone as a mineral beehive lining contributing to the normalization of the moisture regime, the authors noted its positive effect on the honey production. Bee colonies, in which glauconite lining was used, produced about 3 kg of honey more than those of the control group. The application of the developed method allows enhancing bee colonies' life quality and increasing gross and marketable honey production with minimal expenses, which is important during the adverse period of the year. Glauconite use allowed decreasing the moisture level from 100% to the normal rate, reducing colonies' weakening during the spring season by 17% and increasing queen bees' egg production in the experimental group by 343 eggs, as compared to the control group. The authors believe that the mineral is promising in terms of optimization of bee nest microclimate. Having a tetrahedral frame with cavities, glauconite can be used as an adsorbent for the condensate.

Index Terms*: egg production, glauconitic sandstone, honey production, moisture regime, wax production, varroatosis.

I. INTRODUCTION

Bee colonies' over-wintering remains one of the most important problems in beekeeping. Change of the external temperature has a significant influence on the internal microclimate of the nest during the winter period, causing the moisture level in the beehive to increase, which is negative for bees' safety, their spring and summer development, flight and pollination activity, as well as productivity [1-7].

Glauconitic sandstone from the Abadzekhsk deposit is a potassium-bearing aqueous aluminosilicate compound, a mineral of the hydromica group of the layered silicate subclass. The mineral is actively used in the agricultural sector as a fertilizer and a feed additive for farm animals [8, 9].

Acceptability assessment criteria for any substance are based not only on its useful properties but it's the harmlessness for bees as well [10, 11]. Therefore, the purpose of the experiment was to determine glauconite doses, which are harmless for bees and can be used for bee colonies feeding. During the experiment, we were guided by the methods of performance of scientific and research work in beekeeping.

For this purpose, the following tasks were solved:

determination of the influence of glauconite' s adsorption properties on bee' safety;

determination of the bee colony's development rate when using glauconite;

determination of bee colonies' productivity;

determination of the economic efficiency of natural mineral substance use.

II. METHODOLOGY

The experiment was carried out on bee colonies of the Carpathians breed of the Maykop ecotype in the apiary No. 25 of the FSBSI BBF "Maykopskoe". The test groups were formed by the analogous pairs method: a control group and experimental group, five bee colonies in each group. The queen bees' origin and age were considered, as well as the bee colonies' weight, presence of a brood, the amount of carbohydrate and protein feed, as well as hive construction. The control group included colonies No. 35, 56, 58, 63 and 64. The experimental group included colonies No. 61, 73, 77, 82 and 102. Queen bees of all colonies were granddaughters of the 2nd year of a record holder of 33 lines.

10-frame hives with 44 mm walls were used for the experiment. It was planned, that bee colony would overwinter in the wild. For the experimental group's colonies, an organic substance – glauconite – was used at a dose of 150 g. Glauconite was placed in the hives near the outer walls in the form of powder in a cloth bag.

Bee colonies' winter hardiness was estimated based on the following indicators:

the decrease in the bee colony's weight during over-wintering – based on the difference between the bee colony's weight in fall and in spring after the first cleansing flight;

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feed consumption per one bee colony and one seam of bees between two combs during over-wintering – based on the difference between the amounts of honey produced by a colony in fall and in spring;

presence of diarrhea traces and wetness in bees' hives – on a scale from one to five;

honey production at the end of the main honey harvest – on weighing of honey received for sale with the use of electronic platform scales VTM-100 and of feed honey, which was weighted and remained in the hives for the winter period.

III. RESULTS

Meteorological conditions of the experimental season in comparison with long-term average indicators are shown in Table 1 (based on the information provided by the Maykop Experimental Station of the All-Russian Research Institute of Plant Industry).

Table 1. Meteorological conditions.

Month	Long-term average indicators		Conditions during the 2018 season	
	Atmospheric temperature	Total precipitation	Atmospheric temperature	Total precipitation
	degrees	mm	degrees	mm
March	8.3	51.0	4.8	68.3
April	12.7	64.0	9.1	92.5
May	15.8	84.0	18.7	174.6
June	19.3	105.0	22.3	88.2
July	21.6	81.0	24.5	50.1
August	21.0	69.0	24.9	69.9
September	19.7	83.0	21.8	89.8
October	16.7	67.0	11.1	81.5
November	10.7	59.0	9.9	90.5

Overall, the beekeeping production season was extremely unfavorable.

According to the Maykop meteorological station, monthly average temperatures in December, January and February were 4-8°C higher than long-term average indicators, which caused bud swelling in winter in separate regions and even blooming of early spring honey plants. Bees were active during the whole winter period: queen bees did not stop ovipositioning, bees flew out to gather nectar, pollen and water for brood growing. This contributed to their tiredness, decreasing their life cycle.

In the Republic of Adygeya, the change of overwintered bees by young ones begins in March and stops at the end of April. The average monthly temperature in March and April was 3.5-3.6°C lower than long-term average indicators while the total snow, wet snow and rain precipitation was 1.3-1.5 higher. The high death and feed consumption rates were noted in the colonies. After overwintering, bees were weakened, the period of their change was unharmonious and very long.

Starting from the third decade of May, air temperature jumped by 2.9°C against long-term average indicators. There was 2.1 times more precipitation, which is favorable for honey plants and allows increasing the bee colony's weight, involving bees in honey production, forming nucleus parks and selling packets.

However, as from the end of June, the drought period began and lasted during July and August. The temperature in June was 3.0°C higher, in July – 2.9°C higher and in August – 3.9°C higher than long-term average indicators. The precipitation total was 1.2-1.7 lower than long-term average indicators.

Due to the blooming caused by the winter warming, during the natural spring period, honey plants bloomed inharmoniously or did not bloom at all (hawthorn, maples, dogwood, honey locust, etc.). Due to the hot weather and drought, the blooming period of summer honey plants was short, and their nectar production was much lower than the usual.

A great drop in temperature in October and November should be noted as a negative factor of fall 2018, which significantly reduced the bee colonies' adaptation period. At the same time, the fall moisture regime in terms of precipitation amount was significantly higher than the average statistical indicators of the same period for the last five years. Under such weather conditions, the issue of hive microclimate balancing in terms of moisture content becomes even more relevant.

Water balance in a hive is crucial for bees' life in winter. Water imbalance causes the appearance of excessive moisture in the hive. Despite the extremely negative impact on bees' overwintering, the moisture in hives can be observed quite often. The increased level of moisture in the hive causes significant harm to bees in winter, as honey sours and bees, eating it, get sick, which often results in the death of the whole colony. Furthermore, due to the dampness, honeycombs get moldy, insulation becomes worse and hives putrefy. An observation over the experimental colonies showed that the bees were peaceful and continued working calmly on combs taken out for examination.

A queen bee, laying eggs on the comb taken out for examination, was often observed. In good weather, bees allowed us working without a face veil and bee smoker.

Colonies' comb capping type was mixed, in a honey chamber and right after capping, it was mostly white, "dry". It should be noted, that in the case of long-term comb keeping, wax caps sag and contact honey surface of the cell, due to which the comb capping eventually becomes mixed and then "wet".

Bees have great wax building abilities; they connect hive frames from above with solid cross wax bulkheads. In case of delay in a hive expansion, they build their own combs, "tongues" and bulkheads in any available free space in the hive – between honeycomb frames, under the feeder, behind the diaphragm, etc. They moderately seal beehives with propolis.

Honey is collected mainly in the honey chamber and, to a lesser degree, in the brood part, which under the conditions of weak yield of feed honey, typical for the place of the apiary location, allows for a fast increase in the bees' weight in big colonies, which, in turn, enables the provision of formation of bee packets for sale and the nucleus park at queen-breeding apiaries in the first half of May and then the efficient use of the main honey yield from sunflowers in the steppe areas of the Krasnodar region.

Due to the high humidity during fall months, starting from September we began to put glauconite in beehives. The bees' weight in all colonies of the control and experimental groups with queen bees was significantly increased in comparison with average indicators at the apiary. Thus, the selection differential in the control group amounted to about 1.5 kg of bees with a variation range from 0.5 to 2.4 kg (Table 2).

Table 2. Bee breeding in the experimental group colonies during the spring and summer periods (by the sum of three accounts).

Colony No.	Control group			Colony No.	Experimental group		
	Bees' weight	Selection differential			Bees' weight	Selection differential	
	kg	kg	%		kg	kg	%
35	4.6	2.4	209.1	61	4.8	2.8	168.3
56	3.4	1.2	154.6	73	4.1	1.0	124.4
58	4.1	1.9	186.4	77	4.4	2.3	156.1
63	3.7	0.5	122.7	82	4.7	0.6	114.6
64	3.8	1.6	172.7	102	4.9	1.9	146.3
group average	3.9±0.2	1.5±0.3	168.2±14.6	group average	4.6±0.1*	1.7±0.4	141.5±9.9

The most intensive development was observed in the colonies No. 35 and 58, the bees' weight in which amounted to 4.6 and 4.1 kg, which is 109.1% more than the initial population average.

It should be noted, that as at the end of the fall period, during the fall inspection, indicators of all bees of the experimental group were higher than those of the control group. In the experimental group colonies, the highest results were noted in the colonies No. 61 and 102. On average, the advantage of bees of the experimental group, as compared to the control, amounted to 0.7 g or 17.9% ($P \leq 0.05$).

It should be noted, that the selection differential in the control group was of a wider range.

Based on the analysis of data on daily average egg laying by queen bees of the control group colonies, we can state that considering adverse weather conditions the egg-laying indicators were quite high – 1,617 eggs. Nevertheless, the egg-laying indicators of queen bees of the colonies No. 35 and 58 reached 1,917 and 1,779 eggs per day, which is 68.2 and 56.1% more than the apiary average. The selection differential of these colonies was more than 1.6-1.4 times higher than the group average and amounted to 777 and 639 eggs. It should be noted, that the queen bee of the colony No. 56 had the lowest egg laying indicators in the experimental group. Moreover, the indicators were 8.71% lower than the daily average level (1,774.4). Such a tendency was also detected in the colony No. 63, but its retardation was of 2.1%. The maximum egg laying indicators were detected in the colony No. 73: they exceeded the daily average egg-laying indicators by 429.6, which is 24.21%. The group average indicators were also significantly exceeded by 105 (4.99%). The experimental group colony average indicator was 2,099.2, which exceeded that of the control by 382.8 eggs (Table 3).

The high rate of egg laying by queen bees allows for a more intensive increase in the bee colonies' weight.

Table 3. Queen bee's daily average egg production.

Colony No.	Control group			Colony No.	Experimental group		
	Number of eggs	Selection differential			Number of eggs	Selection differential	
	pcs	pcs	%		pcs	pcs	%
35	1,917	777	168.2	61	2,058	542	126.9

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56	1,620	280	124.6	73	2,204	188	109.3
58	1,779	639	156.1	77	2,005	509	125.2
63	1,696	166	114.6	82	2,037	157	107.8
64	1,770	530	146.5	102	2,192	376	118.7
group average	1,756.4 ±49.4	478.4 ±112.8	142.0 ±9.9	group average	2,099.2 ±41.3**	354.4 ±79.4	117.6 ±3.9

It is important to consider the perimetral location of beehives of the above-stated control group colonies within the apiary, due to which they were less protected from adverse weather conditions.

According to the research carried out earlier by A.V. Borodacheva, the hive microclimate has a significant influence on queen bees' productivity. Thus, in the case of high humidity and the presence of condensate, the egg-laying indicators decrease by 5-15% on average, depending on the breed and hive type [1].

The honey and wax production by the colonies of the groups, participating in the experiment, is shown in absolute terms and in terms of 1 kg of bees. The data are given in Tables 4 and 5.

Table 4. The honey production of bee colonies of the control group.

Colony No.	Gross honey productivity			Honey received for sale per 1 kg of bees		
	Honey Amount	Selection differential		Honey Amount	Selection differential	
	kg	kg	%	kg	kg	%
35	81	43	213.2	10.3	4.0	163.5
56	58	20	152.6	9.4	3.1	149.2
58	73	35	192.1	10.2	3.9	161.9
63	54	16	142.1	8.8	2.5	139.7
64	69	31	181.6	10.0	3.7	158.7
Group average	67±4.9	29±4.9	176.3±13.0	9.7±0.3	3.4±0.3	154.6±4.5
Apiary average	38	-	100.0	6.3	-	100.0

As shown in Table 4, all colonies of the experimental group had very high gross honey productivity, amounting to 67 kg on average, which is 76.3% higher, than the apiary average. The colonies No. 35 and 58 reached record values of the indicator: their honey flow values were 81 and 73 kg respectively, which is 43 and 35 kg or 113.2 and 92.1% more than in the initial population. Values of the colony No. 64 should be also noted: its selection differential was a little below the leader's one, but 81.6% higher, than the apiary average.

The more objective estimated indicator of honey production and bees' work intensity during the honey yield is the amount of honey gathered with respect to the weight of bees, participating in gathering. By the given indicator, the leaders were the colonies No. 36, 58 and 64. During the main honey flow, they gathered 10.3, 10.2 and 10.0 kg of honey from sunflowers respectively, which is almost 1.6-1.8 times more, then the initial population average. The colonies No. 56 and 63 worked with less intensity and efficiency, their selection differential was only 3.1 and 2.5 kg.

The colonies No. 73 and 102 had the highest honey production indicators among the colonies of the experimental group. During the season of 2018, bees of the colony No. 73 gathered 79 kg of honey, which, in terms of 1 kg of bees, amounted to 10.1 kg and exceeded the average indicator of the control group by 400 g and the apiary average indicator by 3.8 kg. Bees of the colony No. 102 exceeded the control and apiary average values by 700 g and 4.1 kg respectively.

Table 5. The honey production of bee colonies of the experimental group.

Colony No.	Gross honey productivity			Honey received for sale per 1 kg of bees		
	Honey amount	Selection differential		Honey amount	Selection differential	
	kg	kg	%	kg	kg	%
61	59	53	212.3	8.7	4.2	163.5
73	79	20	152.6	10.1	3.3	149.2
77	67	33	191.1	9.9	3.9	161.9
82	62	17	142.1	9.6	2.6	139.7
102	83	33	183.6	10.4	3.7	158.7
Group average	70±4.7	31.2±6.4	176.34±12.8	9.7±0.3	3.5±0.3	154.6±4.5
Apiary average	38	-	100.0	6.3	-	100.0

Based on the analysis of the average values in the experimental group, we noted their exceedance by 3 kg in terms of gross productivity and by 40 g in terms of honey received for sale per 1 kg of bees, as compared to the control group. Comparing the received data with the average apiary indicators, we observe the superiority of both the control and experimental groups.

The fact of the selection differential superiority in the colonies of the experimental group, as compared to the control group, is of particular notice. It testifies to the higher level of implementation of the genetic productivity potential (Figures 1 and 2), which is crucial for the assessment of the economic feasibility of glauconite use as a natural lining in beehives.

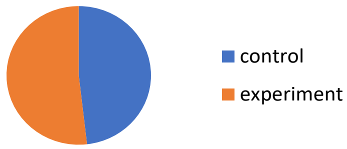

Figure 1. Honey production selection differential in absolute terms.

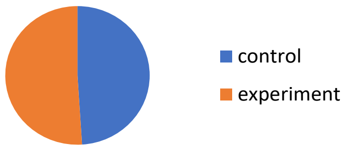

Figure 2. Honey production selection differential in terms of 1 kg of bees.

IV. CONCLUSION

Thus, the use of glauconite as the beehive bottom lining for the purposes of water condensate elimination during the increased humidity period and vapor release during the dry period demonstrates the high potential of this natural mineral in beekeeping. The tested technology allows creating fully optimal microclimate conditions and implementing queen bees' genetic potential.

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