

ARAŞTIRMA MAKALESİ / RESEARCH ARTICLE

THE EFFECTS OF SUPPLEMENTAL FEEDING WITH SODIUM HUMATE ON THE PERFORMANCE OF HONEY BEE COLONIES (*Apis Mellifera* L.)

Bal Arısı Kolonilerinde (*Apis mellifera* L.) Sodyum Humat Katkılı Beslemenin Performans Üzerine Etkileri

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ABSTRACT

In plant and animal production, sodium or potassium compounds which are soluble forms of humic substances are used. Sodium humates are used because of the sodium content which is important for animals in animal production. This study was carried out to investigate the effects of sodium humate added to sugar syrup in the development of adult honey bees, brood production and honey yield. Experimental colonies were randomly selected, and 5 study groups were formed with 6 colonies in each group. In the study, 4 different doses of sodium humate (5 cc, 10 cc, 20 cc, 50 cc/L and control 0 cc/L) were added to 1 liter 1:1 ratio of sucrose syrup and given to the experimental colonies. The highest brood production was obtained at a dose of 10 cc. In addition to, high dose (50 cc) negatively affected brood production. The average honey yield for the 5 cc, 10 cc, 20 cc, 50 cc and control groups was determined as 19.15±1.48, 26.35±1,83, 22.50±1.86, 8.75±1.29 and, 18.50±1.57 kg/colony, respectively. The highest honey yield was obtained from the group of 10 cc. For this group, the honey yield was 29.79 % higher than the control group.

Keywords: Brood area, colony development, honey bee, honey yield, sodium humate

ÖZ

Bitkisel ve hayvansal üretimde, humik maddelerin çözünür formları olan sodyum veya potasyum bileşikleri kullanılır. Hayvansal üretimde hayvanlar için önemli olan sodyum içeriği nedeniyle sodyum humatlar kullanılmaktadır. Bu çalışma, şeker şurubuna eklenen sodyum humatın ergin bal arılarının gelişimi, kuluçka üretimi ve bal verimindeki etkilerini araştırmak amacıyla yapılmıştır. Deney kolonileri rastgele seçilmiş ve her grupta 6 tekerürlü koloni ile 5 çalışma grubu oluşturulmuştur. Çalışmada 1 litre 1:1 oranında sükröz şurubuna 4 farklı doz sodyum humat (5 cc, 10 cc, 20 cc, 50 cc/L ve kontrol 0 cc/L) ilave edilerek deney kolonilerine verilmiştir. En yüksek kuluçka üretimi 10 cc'lik dozda elde edilmiştir. Ayrıca yüksek doz (50 cc) kuluçka üretimini olumsuz etkilemiştir. Ortalama bal verimi 5 cc, 10 cc, 20 cc, 50 cc ve kontrol grupları için sırasıyla 19.15±1.48, 26.35±1,83, 22.50±1.86, 8.75±1.29 ve 18.50±1.57 kg / koloni olarak belirlendi. En yüksek bal verimi 10 cc grubundan elde edildi. Bu grup için bal verimi, kontrol grubuna göre %29.79 daha yüksekti.

Anahtar kelimeler: Bal Arısı, Bal Verimi, Kuluçka Alanı, Koloni Gelişimi, Sodyum Humat

GENİŞLETİLMİŞ ÖZET

Amaç: Bal arılarının temel gıda ürünleri nektar, polen ve baldır. Bitki kaynakları yeterli olduğunda arılar kendi ihtiyaçlarını karşılayabilir. Ancak arı kolonileri doğada yeterli nektar ve polen bulamadıklarında, bal akış dönemine kadar kolonilere ek yemleme yapılmalıdır. Arı kolonileri için ek yem genellikle polen, bal, soya unu, süt tozu, vitaminler ve mineral katkılı arı keki veya şeker şurubu ile yapılır. Beslenme bal arılarının (*Apis mellifera L.*) gelişiminde olduğu kadar bal veriminde de önemlidir. Bu sebepten dolayı beslenmenin etkinliğini artırmak amacıyla verim artırıcı yem katkı maddeleri kullanılmaya başlanmıştır. Ancak, arı beslenmesinde verimi artırıcı yem katkı maddeleri daha önce araştırılmamıştır. Humatlar birçok hayvanda verim artırıcı yem katkı maddesi olarak kullanılmıştır. Bu çalışmada, sodyum humat katkısının ergin arı gelişimi, kuluçka üretimi ve bal verimi üzerine etkileri araştırılmıştır.

Yöntem: Araştırma, Mart-Haziran 2018 tarihleri arasında Artvin ili Ardanuç ilçesinde, Haziran-Eylül ayları arasında Ardahan Üniversitesi arıcılık ve araştırma merkezinde gerçekleştirildi. Denemede, eşit güçte arıların bulunduğu 10 çerçeveli standart Langstroth tipi kovanlar kullanılmıştır. Bu çalışma, 24 test ve 6 kontrol olarak rastgele seçilen 30 Kafkas bal arısı (*Apis mellifera caucasica*) kolonisinde gerçekleştirildi. Her grup 6 tekrardan (alt gruplar) oluşmuştur. Deneyde 1 litre 1: 1 sükröz şurubuna (1 birim şeker +1 birim su) 5 cc, 10 cc, 20 cc, 50 cc/L oranlarında 4 farklı doz sodyum humat katkılı gruplar ile kontrol (0 cc/L) grubu kullanılmıştır. Nisan'dan Ekim'e kadar olan dönemde arılar ile kaplı petek sayısı 21 günlük aralıklarla belirlendi. Elde edilen değerler yetişkin arı gelişiminin bir ölçüsü olarak kullanılmıştır. Kuluçka alanı Nisan'dan Ekim'e kadar 21 gün aralıklarla PUCHTA yöntemi ($S=3.14 \times A/2 \times a/2$) ile cm cinsinden ölçülmüştür. Alınan veriler, kuluçka alanının gelişiminin bir ölçüsü olarak kullanılmıştır. Bal verimi, kış ihtiyaçları için bal dışında kolonilerin bal haznelerinde depoladıkları bal miktarına göre belirlenir. Bu amaçla her koloninin bal odası numaralandırılmış ve toplu olarak hasat edilmiştir. Kolonilerin tam bal odası ağırlıkları belirlendi. Boş çerçeveler kendi bal haznelerine yerleştirildi ve boş çerçeve ağırlıkları bulundu. Ortalama bal verimi, iki tartım arasındaki farka göre belirlendi

Sonuç: Belirli dozlarda (5 cc, 10 cc ve 20 cc) sodyum humat, bal arılarında yetişkin arıların gelişimini, kuluçka üretimini ve toplam bal üretimini artırır. Ancak yüksek doz sodyum humat (50 cc) bal arılarının fizyolojik özellikleri üzerinde olumsuz bir etkiye neden olur. Arıcılar, ilkbaharın başlarında bal arısı kolonilerini güçlendirmek için şurup içinde ideal dozda (10 cc) humat kullanabilirler, bu da önemli bir maliyet artışı olmadan bal üretimini artırabilir (1 litre sodyum hümat yaklaşık 1 \$ 'dır).

INTRODUCTION

Nutrition is important in the development of honey bees (*Apis mellifera L.*) as well as in honey yields. The main food products of honey bees are nectar, pollen and honey (Silva et al. 2017). Bees can meet their own needs when plant resources are sufficient. However, when the bee colonies do not find enough nectar and pollen in nature, supplemental feeding should be done to the colonies until the honey flow period (Bonoan et al. 2018). Supplemental feed for bee colonies is usually made with pollen, honey, soy flour, milk powder, vitamins and mineral added bee cake or sugar syrup (Akyol et al. 2006; Genç and Dodoloğlu 2017). In one study (Kumova 2000), antibiotics were added to the cake or syrup used in the supplemental feeding of bee colonies because of their ability to kill pathogenic bacteria or to prevent their growth. As a result of the use of antibiotics as a feed additive, antibiotic residues have been found in animal products and some microorganisms have been found to be cross-resistant against antibiotics in humans (Moudgil et al. 2018). The use of antibiotics as feed additives in bees is prohibited in Europe due to their risks to human health (Higes et al. 2014; Suwannapong et al. 2018). For this reason, organic feed additives that have no negative effect on human and animal health have been used. One of these organic feed additives is humates, which are organic matter of high molecular weight; they are also hydrophilic, black or dark brown in color and originate from certain substances such as phenol, carbohydrate and amino acid, which are formed by the decomposition and decomposition of organic matter in the soil over time (Islam et al. 2005). It is reported that humates increase cell membrane permeability and increase the absorption of nutrients as a result of changes in the metabolism of some nutrients such as carbohydrates (De Melo et al. 2016). Soluble sodium humates are generally used in animal production since they increase the use of

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animal feed and stabilize intestinal flora. Humic acids have anti-bacterial properties (Tunç and Yörük 2017) as well as anti-inflammatory ones (Van Rensburg 2015). In a study conducted in chickens, humic acid has a positive effect on the immune system (Sanmiguel and Rondón 2016). Due to these characteristics, humates have been used as a feed additive for many livestock. However, no feed additives have been studied that are an important source for bees and are necessary for crop production. In this study, the effects of the sodium humate additive on the adult bee development, the brood production, and the honey yield were investigated.

MATERIALS and METHODS

Creation of experiment groups

The research was carried out between March and June 2018 in the Ardanuç district of Artvin province and between June and September at the beekeeping and research center in Ardahan University, Turkey. In the study, 10-frame standard Langstroth type hives with the presence of bees of equal strength were used. Experimental colonies were formed with sister bees who were reared from the same breeder colony in 2017. This study was conducted on 30 Caucasian honey bee (*Apis mellifera caucasia*) colonies, which were randomly selected as 24 tests and 6 controls. Each group consisted of 6 replicates (subgroups). The experiment started on 15 March 2018 and ended on 6 October 2018. At the beginning of the experiment (15 March) the colonies were equalized in terms of food stock, the number of comb with bees and the brood areas.

Feeding program

In the experiment, 4 different doses of sodium humate (5 cc, 10 cc, 20 cc, 50 cc/L and control 0 cc/L) were added to 1 litre 1:1 sucrose syrup (1 unit sugar +1 unit water). The spring feeding program was applied to colonies during 6 weeks (between 21 March and 4 May). In addition, periodic maintenance and control of all colonies were conducted during the research. The sodium humate preparation used in the study was taken from Humat Chemistry Pharmaceutical Industry Trade Limited Company Limited Company. The specification of the preparation is given in the table below;

Table 1. Specification of sodium humate

Tablo 1. Sodyum humatın spesifikasyonu

Sodium humate	12%
Organic C	8.5%
pH	11–12
Density	1.12 kg/L
The size of the colloid particles	<100 µm
Color	Dark brown -black
Product type	Sodium suspension
Energy	195 kcal/100 g
Protein	2,6 g/100 g
Fat	none
Carbohydrate	46,1 mg/kg
Ferrous (Fe)	6776 mg/kg
Zinc (Zn)	40,2 mg/kg
Magnesium (Mg)	2017 mg/kg
Selenium (Se)	18587 µg /kg
Molybdenum (Mo)	2300 µg /kg

Taking data from experimental colonies

During the period from April to October, the number of combs covered with bees was determined at 21-day intervals. The obtained values were used as a measure of adult bee development (Akyol et al., 2014). The brood area was measured by PUCHTA method ($S = 3.14 \times A / 2 \times a / 2$) in cm at 21 days intervals from April to October (Yücel & Kösoğlu, 2011; Akyol et al., 2014; Cengiz & Erdoğan, 2017). The obtained values were used as a measurement of the development of the brood area. Approximately 15-16 kg of honey is left to each colony for winter needs. Honey yield is determined by the amount of honey that colonies store in their honey chamber, except the honey for their winter needs. For this purpose, the honey chamber of each colony was numbered and mass harvested. The full honey chamber weights of the colonies were determined. Empty frames were placed in their own honey chamber and empty framed weights were found. Average honey yields were determined by the difference between the two weighings (Akyol et al. 2014; Cengiz and Dülger 2018).

Statistical analysis

SPSS 17.0 package program was used in the statistical calculations. The data about the development of adult bee and brood production were analyzed by univariate analysis of variance and one-way ANOVA was used for analyzing the honey yield. Duncan multiple comparison test was performed for the features with a significant effect (Ergün and Aktaş 2009; Mendeş and Akkartal 2010).

RESULT

Development of Adult Bee

According to the amount of sodium humate applied to colonies; the average number of combs covered with bees for 5cc, 10 cc, 20 cc, 50 and control groups was determined as 11.71±0.75, 13.74±0.88, 12.61±0.82, 9.34±0.43 and 10.95±0.66 number/colony, respectively. The difference between groups was statistically significant ($F_{4, 265} = 119.67$; $p < 0.01$), according to applied sodium humate amount. Among the groups, the best result was observed in colonies fed with 10 cc of sodium humate (Fig 1).

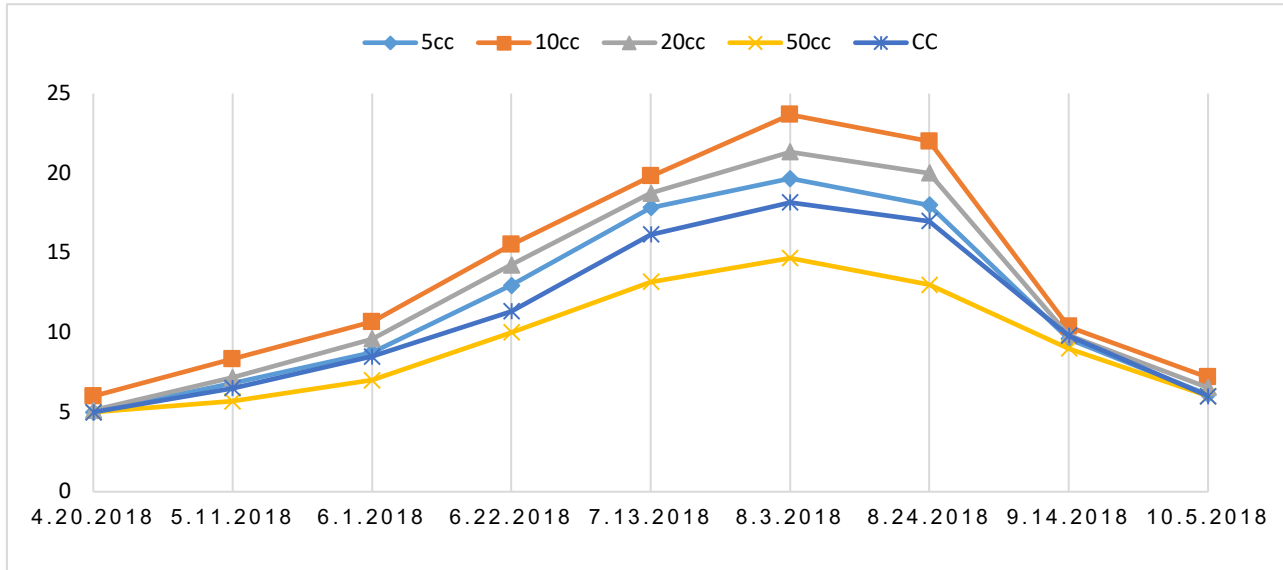


Figure 1. The average number of combs covered with bees of the groups

Figür 1. Grupların ortalama arı ile kaplı çerçeve sayısı

Development of Brood Area

The average brood areas for 5 cc, 10 cc, 20 cc, 50 cc and the control group was determined as 2009.5±189.7, 2417.4±240.3, 2207.3±222.3, 1604.14±147.1 and, 1806.56±164.1cm²/colony, respectively. The differences in the brood production

between the groups according to the applied sodium humate doses were also statistically significant ($F_{4, 265} = 34.58$; $P < 0.01$). The highest brood production was obtained at a dose of 10 cc, followed by 20 cc and 5 cc doses (Fig. 2). High dose (50 cc) negatively affected brood production.

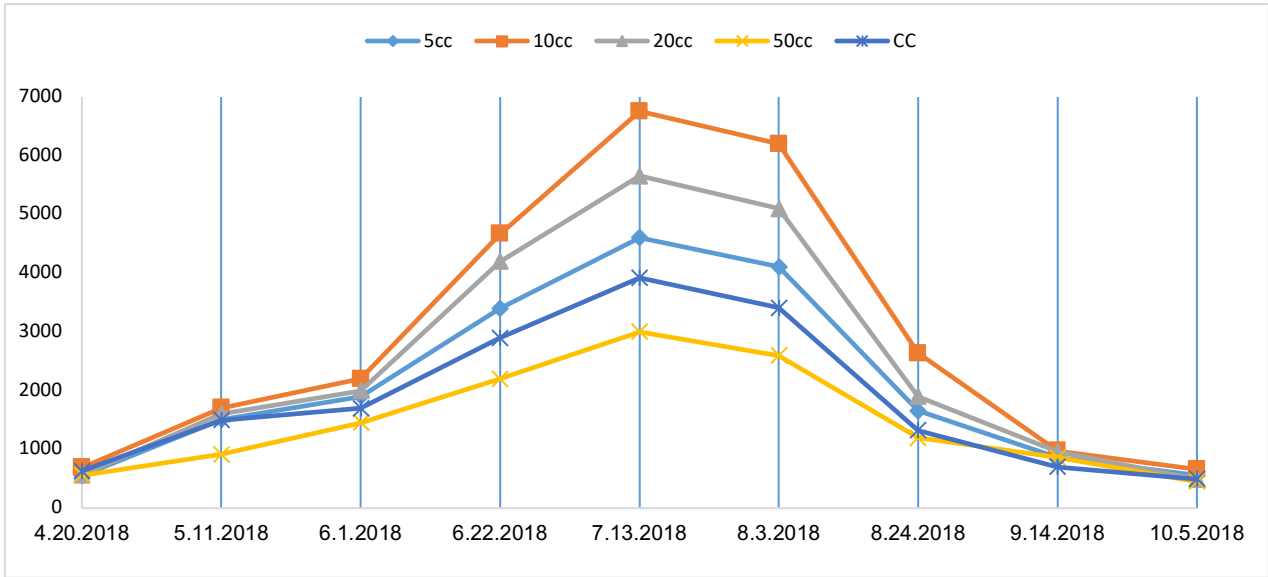


Figure 2. The average brood areas (cm²/colony) of the groups

Figür 2. Grupların ortalama kuluçka alanları (cm²/koloni)

Honey Yield

Figure 3 shows the average honey yields of the groups. The average honey yields for 5 cc, 10 cc, 20 cc, 50 cc, and the control group were determined as 19.15±1.48, 26.35±1.83, 22.50±1.86, 8.75±1.29 and, 18.50±1.57 kg/colony, respectively. The effect

of applied sodium humate on honey yield was statistically significant ($F_{4,25} = 16.24$; $P < 0.01$). The optimum dose for honey production was determined as 10 cc, and the 5 cc and 20 cc groups also increased honey production compared to the control group (Fig.3).

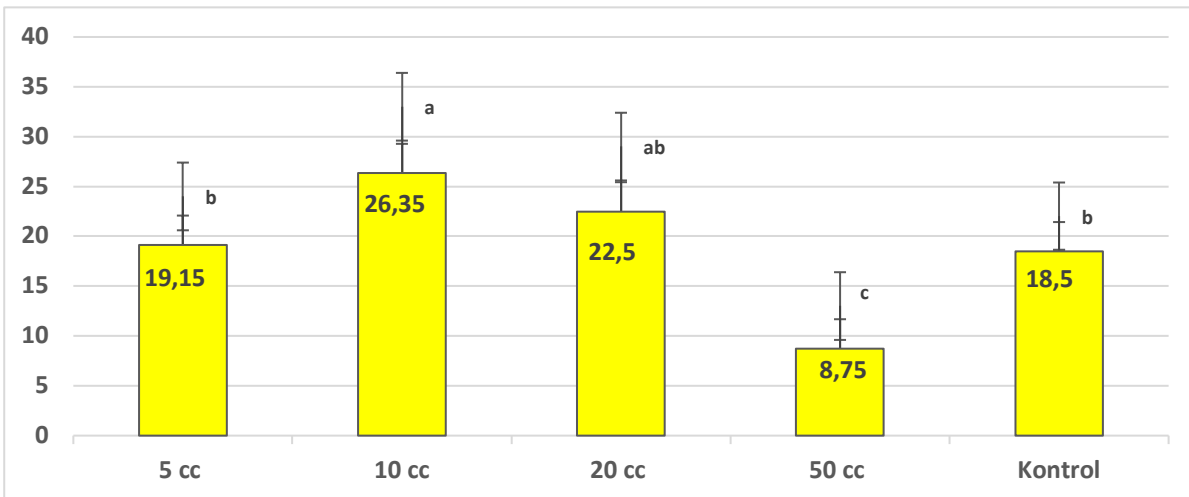


Figure 3. Average honey yield (kg/colony) of the groups

Figür 3. Grupların ortalama bal verimi (kg/koloni)

DISCUSSION

In this study, the average number of combs covered with bees for the control group was found to be 10.95 ± 0.66 number/colony. However, this finding was found to be lower than the one reported by Genç et al. (1999) for Caucasian honey bees (15.62 number/colony). The average number of combs of Caucasian honey bees in our research was consistent with the previous studies reported by Arslan (2003) and Yeninar et al. (2009) (informed as 10.40 and, 11.06 number/colony). In addition, in previous studies, sugar syrup and feed additives were reported to increase the development of adult bees (Güler 2000; Şahinler and Kaya 2001). These findings were consistent with our study. The results show that the optimal dose of sodium humate for honey bees is 10 cc. On the other hand, a high dose of sodium humate (50 cc) has a negative effect on the development of adult bees. According to these results, the addition of 10 cc humate to the sugar syrup will increase the development of adult bee in the spring feeding.

In the study, the average brood area for the control group was determined as 1806.56 ± 164.1 cm²/colony. This finding was found to be higher than the average value (1184.8 cm²/colony) reported for Caucasian honey bees by Güler and Kaftanoğlu (1999). The average brood area of Caucasian honey bees in our research was consistent with the previous results reported by Akyol et al. (2014) (informed as 1701.9 cm²/colony). In this study, the highest brood area was obtained in the 10 cc sodium humate group. In this case, it can be said that adding 10 cc of humate to sugar syrup increases the brood production activity in colonies in the spring feeding. The results obtained in this study are parallel with the findings of previous studies: supplementary feeding increased brood production in honey bees (Kumova 2000; Karacaoğlu et al. 2003; Mortensen et al. 2018).

The average honey yield in the control group was 18.50 ± 1.57 kg/colony. The honey production of Caucasian honey bees was found to be lower than the findings by Genç et al. (1999), and Yeninar et al. (2009) (reported as 30.6 and 36.3 kg/colony, respectively), but they were consistent with the previous results reported by Kutluca (2003), Cengiz and Erdoğan (2017) (informed as 18.13 and 19.28 kg/colony, respectively). In addition, it has been reported that supplementary feeding increased the total honey yield in previous studies (Karacaoğlu et al. 2003; Dodoloğlu et al. 2004). The average honey

yield in the dose of 10 cc of the sodium humate was 29.79% higher compared to the control group. According to these results, it can be said that certain doses of sodium humate (5 cc, 10 cc and 20 cc) increase the total honey yield but high dose (50 cc) has the opposite effect.

CONCLUSIONS

As a result, certain doses (5 cc, 10 cc and 20 cc) of sodium humate increase the development of adult bees, the brood production and total honey production in honey bees. However, a high dose of sodium humate (50 cc) causes a negative effect on the physiological properties of honey bees. Beekeepers can use the ideal dose (10 cc) of humate in syrup to strengthen their honey bee colonies in the early spring, which could increase honey production without a significant cost increase (1 liter of sodium humate is approximately \$ 0.97).

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