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New Methods and Products to Protect Agricultural Products from Birds: Aromatic Bird Repellents

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ABSTRACT

Isparta province is located in the Lakes Region and is placed on the migration routes of birds. Bird population in the region is richer in April-June. One of important problems of agriculture in Isparta vilayet is that birds damage agricultural products during harvest period of vegetables and fruits. Birds eat very little of agricultural products, mostly by pecking or leaving their droppings, causing the product to deteriorate and thus causing economic losses. They come to plants not only to eat agricultural products; also hunt invertebrates (flies, ants, bees, beetles) and eat larvae, caterpillars, fruit worms etc. These invertebrates also damage both the plants and their products. Both birds and these invertebrates become infected through wounds that occur when they eat the products, so even if the fruit is not completely eaten, it falls off before it is fully ripe and has no economic value. Carnivorous birds too damage to agricultural products. They come mostly in the early morning hours and to adult-sweet fruits. In sour cherry and cherry trees, comes to their fruits the most. It has been determined that magpies damage corn, crows damage walnuts, all bird species damage grapes, and sparrow group damages grains. They do not prefer medicated agricultural products. They do not come across contaminated environments. They generally do not like or are afraid of shiny objects, black and red colors, sudden and loud noises, and animals that hunt them such as hawks, eagles, and dogs. This situation should be taken into consideration in order to protect agricultural products from birds. The article focuses on two topics:

a) Repelling animals that will be prey for birds (flies, insects, ants, bees etc.) from the plants with scent of various aromatic plants and eliminating purpose of birds coming to plant,

b)The other is to protect areas where agricultural plants and products are located with aromatic plant scents and disturb or scare birds away from the plant/products…

In our experiments, essential oils or oily waters(hydrosols) of some aromatic plants were used plain or in mixtures as solid and liquid. 7 solid mixtures and 9 liquid solutions were prepared. The composition of these bird repellent mixtures were designed by us and for the first time. It was understood that lemon scent repelled ants, thyme, lavender, camphor and fennel repelled flies and insects from the environment; however, lavender and thyme (Labiatae) attracted bees. It was understood that birds did not like vinegar. It increased the effect of bird repellent; however, it attracted flies. It has been known for a long time that when coffee powder is burned, no animals come into the environment. The most successful results in keeping birds away from agricultural products were obtained from essential oils of

onion, garlic, fennel, dill, lavender and thyme. Although birds are disturbed by dog feces, since it is a means of spreading many diseases, its use as a bird repellent is not recommended. Naphthalene is also a carcinogenic chemical substance, so its use recommended, but it is an effective bird repellent. In our experiments, essential oils or oily waters of some aromatic plants were used plain or in mixtures. Sulfur compounds, vinegar, dog feces, diesel fuel, coffee odors disturb birds. If used after decaying and if more than one essential oil is used, bird repellent effectiveness increases. It has been observed that essential oils are 70-90% successful in protecting agricultural products at a distance of 2-4 m. It has been understood that bird repellents lose their effect after a short while, i.e. they need to be shaken. Bird repellent solutions designed for fruits and vegetables are not suitable for protecting grain. In agricultural production, in order to protect agricultural products that birds frequently visit, aromatic plants that birds do not like the smell of should be planted in sufficient quantities with main product and should not be harvested before the birds' damaging period has passed. To date, no study has been found that tries to protect agricultural products with essential oil plants. Use and effectiveness of scents may vary depending on species of birds. In our study; bird diversity that is, which bird species are disturbed by which scent to what extent, was not investigated. Similar studies should be conducted on animals that damage agricultural products such as squirrels, pigs, bears, badgers, foxes, turtles, hedgehogs, and grasshoppers. A way should be found to protect products without harming wild animals and nature. It is hoped that our study will make a significant contribution to agricultural production.

KEYWORDS: *Bird repellent, Bird damage, Agricultural Products, Fruit crops, Essential Oils, Nature Protection*

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INTRODUCTION

Türkiye is an agricultural country. Majority of Isparta residents live in rural areas and make a living from agriculture. It is located in the Lakes region, and this area is on the migration routes of birds. One of important problems of the country, especially in Isparta, is that during the harvest season for vegetables and fruits, wild animals such as pigs, badgers, foxes, squirrels, locusts and especially birds damage the products. For this reason, farmers wait for their fields during harvest season, scare animals away by making loud noises with rifles or gas cylinders, erect sculptures called 'Oyuk' in fields in form of humans; hang skulls of large animals and shiny objects on trees, and protect their products by creating mechanisms that scare animals by making various sounds and emitting light with reels that rotate with the effect of the wind or with radios.

Some farmers protect grapes from birds by covering them with perforated gauze. Some technological bird repellent devices prevent birds from entering area with the sonic and ultrasonic sounds they emit into the environment, odors and lights (Anonymous, 2024a, b).

Birds cause most damage to agricultural products. Unlike other birds, starlings move in large flocks and are omnivorous (both carnivorous and herbivorous). This both increases damage they cause and makes it difficult to combat them. Numerous studies have been conducted in the world about subject of

combating starlings. As these animals peck agricultural products, some diseases are also spread to poultry, domestic animals or humans. It has been estimated that 'Johne's disease' causes an economic loss of around 200-250 million dollars per year in USA. According to Pimentel et al. (2000), it was reported that damage caused by starlings in agricultural activities was $ 800 million per year in USA. It was stated that damage caused by birds alone to three large cattle feedlots in Kansas in 1999 was around $ 600,000 per year; and in 1968, cost of feed consumed by starlings during winter in large cattle feedlots in Colorado, i.e. feed loss, was $ 84 per 1,000 starlings. It should not be forgotten that the damages caused by diseases transmitted by starlings are much more important than feed losses (Boztepe et al., 2024; Şahin et al., 2019). Annually, birds cost farmers and growers hundreds of millions of dollars in revenue due to crop damage and loss. The extensive damage they cause leads to both direct and indirect losses (Anonymous, 2024a, b). It has been stated that the economic losses of some farmers in 5 states in USA due to birds have increased to very significant amounts (Anderson et al., 2013). Almost all of the studies conducted have been conducted on economic losses due to damage caused by birds to products (Elser et al., 2019). Therefore, protecting products from birds has emerged as an important problem (Eaton, 2010; Feare and Franssu,1992; Gorenzel and Salmon, 2008). Bird control tools can be categorized as auditory, visual, chemical, sound-emitting bird repellent equipment, habitat change and killing birds. Although it has been known for years that birds damage agricultural products, farmers and agricultural directorates have not found a solution to the issue. This study was conducted with the aim of protecting agricultural products without harming birds and nature.

It is known that animals are affected by smells and that they recognize their surroundings through smells. Birds also run away violently from places where they smell scent of animals that hunt them. One of these animals and the most important one is the hawk (Atmaca in Turkish). Then come the falcon and the eagle. Carnivorous mammals such as dogs and cats are also a nightmare for birds.

Therefore, this article focuses on two topics:
Repelling the animals that birds prey on (flies, insects, ants, etc.) from the plants with the scent of various aromatic plants and eliminating the purpose of birds coming to the plant,
The other is to protect the areas where agricultural products are located with aromatic plant scents and disturb or scare the birds away from the plant/products.
The experiments were small-scale and were carried out in Isparta in June-August 2023. It is expected that the findings and interpretations of our study will provide ideas and support to those engaged in agricultural production.

MATERIALS AND METHOD

Materials and their supply

The application area is a family's orchard in Isparta (Türkiye) (geographical location: 36 S 0282824, UTM 4189919, 1035 m). Trials have been conducted on sour cherry, apricot, peach, walnut, stuffed zucchini, and wheat fields in Gönen district. The experiments were carried out in June-August 2023 and the results were reported.
Some essential oils of plant origin were purchased from market in sufficient quantities: These oils are: Lavender/ *Lavandula angustifolia*, Mint/ *Mentha piperita*, Thyme/ *Origanum majorana,* Dill/ *Anethum graveolens,* Fennel/ *Foeniculum vulgare,* Camphor/ *Cinnamomum comphora;*
Oily aromatic waters (Hydrosols) of plant origin (produced separately from plants by us with the distillation system),
Grape vinegar (made from *Vitis vinifera* fruit) 30 lt (purchased from the market),
Onion (*Allium cepa*) and garlic (*Allium sativum*) purchased from the public market),
Naphthalene (open formula: $C_{10}H_8$, aromatic hydrocarbon); purchased from market,
Dog feces (obtained from the animal shelter of Isparta Municipality).

Figure 1: Some aromatic bird repellent solutions for protect agricultural products(A) and field observations.

Methods:
Bird repellent solutions were prepared with formulation specified below in the 'Ecological Products Laboratory' (SDU. Department of Biology) and applied to an orchard and a field. Bird repellent mixtures were hung on the trees, and mature fruits that had fallen at the base of the tree were collected using gloves, and bird repellent was placed nearby. After the solutions were placed near the product/tree, the situation was observed and recorded for weekly periods. Photographs were taken of the results that were deemed important.The results were recorded with writing and photographs. Bird repellents made of solid materials were placed in cloth bags; bird repellents consisting of liquid solutions carrying volatile oils were placed in glass bottles. The prepared mixture was placed equally in each bird repellent sample. It was hung in the area where birds were expected to come in the application area, such as the area where the fruit was abundant and mature. It was ensured that there was a distance of 3 trees without bird repellent samples between the trees taken into experiment. The fruits pecked by birds that fell to the ground were collected and placed near tree so that unpecked sides were visible. The process was carried out using gloves. Observations were made weekly. They were recorded with writing and photographs. The composition of the prepared bird repellent solutions/mixtures is explained below:

Solid bird repellents: Preparation and use
Onion (*Allium cepa*) + Garlic (*Allium sativum*) + Naphthalene($C_{10}H_8$):
7 kg of rotten and crushed kitchen onion, 1 kg of rotten and crushed garlic and 1900 g of crystal naphthalene (Acifinic in Turkish; open formula $C_{10}H_8$, an aromatic hydrocarbon) were used. It was shaken well, mixed; 3 bird repellents per tree, a total of 15 samples were hung on the branches of 5 cherry trees where the fruits were ripe (Table 1).

Onion (*Allium cepa*) + Naphthalene ($C_{10}H_8$):
7 kg of kitchen onion was grated and divided into 14 bags of 500 g each and 100 g of naphthalene was added to each bag. After substances in bags were mixed well, they were placed in cloth bags and a total of 15 samples were hung on 5 cherry trees and 1 apricot tree, with 3 bird repellents per tree (Table 1).

Garlic (*Allium sativum*) + Naphthalene ($C_{10}H_8$):
1 kg of garlic was thoroughly crushed in a mortar and separated into 5 separate bags and 100 g naphthalene was added. It was mixed inside the bag. Then, it was placed in cloth bags and 3 trees were tested between them. A total of 9 samples were hung on 3 cherry trees, with 3 bird repellents for per tree (Table 1).

Onion(*Allium cepa*) + Garlic (*Allium sativum*) + Vinegar (*Vitis vinifera*) + Naphthalene ($C_{10}H_8$):
4 kg of rotten kitchen onion, 0.5 kg of garlic, 1 kg of grape vinegar and 1200 g of naphthalene. A

total of 5 samples were hung on 1 apricot tree (Table 1).

Onion (*Allium cepa*) + Naphthalene ($C_{10}H_8$):
4 kg of onion was grated and divided into 500 g packages and divided into 8 bags and 100 g of naphthalene was added to each bag. It was mixed in the bag and placed in the bags. 5 of the prepared bags were hung on 1 apricot tree and 3 of them were hung on 1 peach tree (Table 1).

Garlic (*Allium sativum*) + Naphthalene($C_{10}H_8$) **+ Grape vinegar:**
0.6 kg garlic was crushed in a mortar and divided into 2 bags of 300 g each. 100 g naphthalene and 300 cc grape (*Vitis vinifera*) vinegar were added to the bags. They were mixed in the bags and the bags were hung on an apricot tree (Table 1).

Dog Feces + Vinegar:
5 kg of dry solid dog feces and 5 kg of grape (*Vitis vinifera*) vinegar were used. It was prepared in bags using 1 kg of feces and vinegar each. The 5 bags prepared were placed with the mouths open at the bottom/near/on 5 stuffed zucchini plants (*Cucurbita pepo*) (Table 1).

2.2.2. Liquid bird repellents: Preparation and use:
A total of 300 cc Fennel (*Foeniculum vulgare*) oil, 300 cc Mint (*Mentha piperita*) oil, 300 cc Camphor (*Cinnamomum comphora*) oil, 300 cc Garlic (*Allium sativum*) oil and 300 cc Lavender oil were found. 1700 cc Dill (*Anethum graveolens*) oily water and Thyme (*Origanum majorana*) water, 5100 cc Lavender (*Lavandula angustifolia*) oily water and 200 g Naphthalene amount to be mixed with the oils (Table 2, Fig. 1).

Essential oil mixtures used in the experiment:
Fennel-Dill 1:
20 cc Fennel (*Foeniculum vulgare*) essential oil + 180 cc Dill (*Anethum graveolens*) oily water 5 Can Plum/ *Prunus domestica* trees were hung in 3 bottles each. The total number of prepared bottles is 15 (Table 2),

Fennel Dill 2:
40 cc Fennel (*Foeniculum vulgare*) essential oil + 160 cc Dill (*Anethum graveolens*) juice 5 Can Plum/ *Prunus domestica* trees were hung in 3 bottles each. The total number of bottles prepared is 15 (Table 2),

Mint-Lavender 1:
5 bottles of the solution consisting of 40 cc Mint (*Mentha piperita*) essential oil + 180 cc Lavender (*Lavandula angustifolia*) oily water were placed in the crop/Wheat/*Triticum vulgare* field at harvest time (Table 2),

Mint-Lavender 2:
5 bottles of the solution consisting of 20 cc Mint (*Mentha piperita*) essential oil + 180 cc Lavender (*Lavandula angustifolia*) oily water were placed in the crop/Wheat/*Triticum vulgare* field at harvest time) (Table 2),

Camphor-Thyme 1:
5 bottles of the solution consisting of 20 cc Camphor (*Cinnamomum comphora)* oil + 180 cc Thyme water were placed in the crop/Wheat/*Triticum vulgare* field at harvest time (Table 2),

Camphor-Thyme 2:
5 bottles of the solution consisting of 40 cc Camphor oil + 160 cc Thyme water were placed in the crop/ Wheat/ *Triticum vulgare* field at harvest time (Table 2),

Lavender 1:
5 bottles of the solution consisting of 20 cc Lavender (*Lavandula stoechas*) oil + 180 cc Lavender oil water were hung on the Peach/ *Prunus persica* tree (Table 2),

Lavender 2:
5 bottles of the solution consisting of 40 cc Lavender (*Lavandula angustifolia*) essential oil + 160 cc Lavender oil water were hung on the Peach/*Prunus persica* tree (Table 2),

Garlic-Lavender-Naphthalene($C_{10}H_8$):
Apricots that fell on the ground were collected and placed at base of the tree. After making sure that the birds came and ate the apricot fruits

here, 5 bottles of bird repellent solution consisting of 50 cc Garlic oil + 180 cc Lavender (*Lavandula angustifolia*) oil water + 20 g

Naphthalene solution were placed near the apricots collected at the base of the tree (Table 2).

FINDINGS AND DISCUSSION

Isparta is located in the Lakes Region of Türkiye. The region is on the migration routes of birds. Thus, one of the important problems of agriculture in Isparta is damage birds cause to vegetables and fruits during harvest period. Birds eat very little of the agricultural products, but they cause spoilage of the product, spread of diseases and economic losses by pecking or leaving their droppings. They come to plants not only to eat vegetables/fruits; they also hunt flies, ants, insects and larvae, caterpillars, fruit worms etc. and eat various parts of the plants. Birds do not like or are afraid of shiny objects, black and red colors. The article focuses on two topics:

The scent of various aromatic plants is used to repel animals that would be prey for birds (flies, insects, ants, bees, etc.) from the plants and eliminate purpose of birds coming to the plants. The other is to protect areas with agricultural products with aromatic plant scents and disturb or scare the birds away from the plant/products. After one of our cherry trials was cancelled, bird repellent materials were hung on nearby cherry trees and observations were made.

In sour cherry and cherry trees, the Jay (Alakarga in Turkish) visits the most. Crows visit walnut trees, Magpies visit corn trees, and Sparrows visit grain fields more. It has been understood that the smell of lemon keeps ants away, and Thyme, Lavender, Camphor and Fennel keep flies and insects away. It has been known for a long time that when coffee powder is burned, no animals come to the environment. In our experiments, essential oils or oily waters of aromatic plants were used plain or in mixtures. Sulfur compounds, vinegar, dog feces, fuel oil and coffee smells disturb birds. If products such as onion and garlic are used after they have rotted, this odor effect increases even more. If more than one essential oil is used, its effectiveness increases. It has been observed that essential oils are successful in protecting agricultural products at a distance of 2-4 m, by 70-90%. It has been observed that bird repellents lose their effects after a short while and there is phasing in the solution. It has been understood that they need to be shaken to prevent this. Therefore, observations should be made in a short time and the solutions should be shaken in meantime. If bird repellents are hung on a tree in a windy area, their effect will be less. Their effect will also decrease in hot weather. Crow group birds can get used to bad smells over time. The type of product, air movements, and genera, species and number of birds are important factors in product protection. Studies, findings and comments are presented in Table 2, Fig. 2.

Figure 2a: Using bird repellent solutions prepared for apricot trees protection, and damaggd fruits by birds

Figure 2b: Using bird repellent solutions prepared for peach trees protection, and damaggd fruits by birds

Figure 2c: Using bird repellent solutions prepared for plum and walnut trees protection, and damaggd fruits by birds

Figure 2d: Birds eat every mature zucchini(*Cucurbita pepo*) in the field. After bird repellents were placed near of the stuffed zucchinis that were well pecked and had just started to reach the adult stage, they did not eat the zucchinis.

Figure 2e: An unsuccessful and dangerous model: It is not understood how many birds come to the grain fields and how much damage they cause. It may be fire from glass bottles

Field observations:

1. Fruits, vegetables or grains (wheat, barley, corn) are eaten by birds when ripe. Corn is produced in large quantities in the fields around Lake Burdur. Since there are many farms in the same area, Lake Burdur is an indispensable area especially for water birds. It has been understood that a grape variety called 'Burdur Dimriti' is produced in the same area and the farmer suffers a lot from birds.

2. In the vicinity of Burdur Lake, Çünür neighborhood, Bozanönü, Kayı, Deregümü, Gelincik, Yakaören villages (Central district), Atabey plain, Keçiborlu district, there is a large amount of vegetable Bostan/Hıyar/Salatalık (*Cucumis sativus* etc.) production. It has been understood that farmers here also suffer from birds.

3. Birds come to apricots, cherries, sour cherries, black squash, stuffed squash, grapes, walnuts, sunflowers,
melons, watermelons, corn, wheat, etc. and eat these products. They do not prefer medicated agricultural products. They do not come across contaminated environments. Birds eat a lot of cherries when they are fleshy, juicy and mature. They do not prefer them after they have dried or rotted. This experiment was wrong in terms of time. Similarly, they love apricots, plums, peaches, grapes, but they do not eat them when they are not ripe because they taste sour. Birds do not come to those that taste sour such as blackberries, raspberries, apples, rosehips, lemons, oranges. That is why vinegar bothers birds.

4. Birds damage the products more in the early hours of the morning (between 5:oo-9:oo), move away from the area as the temperature increases and are afraid of the noise; they escape from the environment. Alakarga mostly haunt the products. All crows come to walnuts, and Magpies come to corn. Small birds such as sparrows and starlings come to grain fields a lot.

2. According to our observations; birds do not prefer to eat sour fruits. For example, sour cherries are not normally eaten, but when they ripen, they are eaten a lot by birds. In other words, products are consumed when the sugar content increases. If they are hungry, they consume sour fruits and even non-fruit parts such as pumpkin leaves. When birds start to visit sour fruits, it should be understood that the fruit is ripe, needs to be harvested, and the sugar content in the product has increased.

5. We also witnessed the wrong practices of farmers. Like pouring raw manure on the field and orchard. The purpose of collecting this manure and bringing it to the field is to clean the barn as soon as possible. Many birds come to the place where the manure is poured. In other words, fresh barn manure does not drive the birds away, but rather attracts the birds to the area. Cattle breeding and dairy farming are carried out at the Farmer Education Center of ISUBU Faculty of Agriculture. In addition, there are many experimental animals, cattle, in this

center for feeding purposes. We conducted 3 pilot applications at the bottom of a barn to understand this. Project advisor Prof. Dr. Tahsin Karadoğan observed this trial. According to the advisor; there was no decrease in the birds coming to the manure. We interpreted this event as follows. Manure is a sought-after environment for birds and since the smell of manure overpowered the smell of onion and garlic, the birds were not bothered by the smell of garlic. Or they did not want to leave the area because they found it to be a strong nutrient… In that case, raw barn manure should not be poured near the products damaged by birds.

6. The wild boar is also an animal that causes great damage to crops. It is a farmer's nightmare. It is an animal that is very picky about smell and is a protected animal(meaning it is forbidden to hunt). Villagers pour sulfur on the boar's passageways, and since this animal comes by sniffing environment, it does not enter places where there is a sulfur smell. Sulfur solutions are important bird repellents. Ants, bees, flies, etc. are also greatly harmed by sulfur. If there is no prey, the reason for the hunting bird to come is also eliminated.

7. According to the information received from the Provincial Directorate of Agriculture; Europe has resorted to preventing birds from landing in such operations, for example by placing barbed wires on the places where the vehicles will be placed to protect them.

8. The smell that bothers birds the most is the smell of hawks, eagles, falcons, cats, dogs, weasels, etc. that hunt them. They perceive the environment as dangerous from these smells. In addition, not every animal likes its own feces. Bird manure can also be an important bird repellent. We dissolved dry dog feces with vinegar and obtained a very bad smell. Although dog feces is dry, it occurs a very bad smell when mixed with vinegar. This smell disturbs a lot of birds. Dog feces does not lose its effect for a long time and carries the parasites of many infectious diseases. However, it is not possible to use raw/fresh dog feces. In practice; we did not find dog feces suitable for repelling birds because it attracts flies and birds hunt flies. In other words, vinegar is a smell that birds do not like because it gives a bad and sour smell. However, flies, bees, butterflies are very attracted to sour foods such as vinegar. Therefore, the expected results were not obtained from our vinegar experiments.

9. No animal likes the smell of petroleum products, especially diesel. Ants are bothered by the smell of lemon, and all living things (flies, insects, bees, etc.) are bothered by the smell of burnt coffee. Ants run away from the smell of lemon.

10. Birds do not come to products in places where onions and garlic are planted. In other words, birds do not like plants that contain sulfur compounds. The smell of rotten onions is especially effective in repelling birds.

11. There is a high level of ammonia smell in the pond under Gelincik village (Isparta, center). Although it is a wetland, birds do not visit it much. To prove this idea, we made observations in the dam pond under Gelincik village. Since the main rock around this pond is sulfurous, it was determined that birds did not visit it much despite being a wetland and being very close to Lake Burdur. Because when the water in the relevant area decreases and turns into mud, it emits a very bad smell like ammonia to the environment and is unwanted by living beings. This situation disturbs the passengers passing by the highway. Another observation is a swamp called 'Red Water/Kırmızı Su' in Keçiborlu, Isparta. The town is a sulfur bed, it is not very important for birds. pH of Kırmızı Su is 2.5 and it is strongly acidic. It is red because it is rich in iron and sulfur. This area emits a very bad smell: It is almost like the smell of rotten eggs. This area is located in the area where the old sulfur factory is located and where it receives materials for processing. It emits a very strong ammonia smell (like the smell of sewage) to its surroundings. It was also seen that the bird populations were very weak here.

12. Birds do not like the smell of basil (*Ocimum basilicum*), mint (*Mentha* spp.), lavender (*Lavandula* spp.) (Labiatae), camphor (*Cinnamomum camphora*) (Lauraceae), fennel (*Foeniculum vulgare*), garlic (*Allium sativum*), onion (*Allium cepa*) and vinegar. It has been observed that birds do not visit the trial plots where medicinal aromatic plants are produced within the ISUBU(in Isparta) Faculty of Agriculture, they pass by edges and do not harm these plants. Since the smells of the aromatic plants mentioned repel ants, insects, flies etc., these animals will also be prevented from

damaging the product. Vinegar especially attracts flies. However, it has a function of dissolving solids and increasing the odor. Birds are afraid of cats and dogs; hawks and eagles. They also do not like or are afraid of black and red colors, shiny and moving objects and noise. It is not possible to use fresh dog feces. The dried form must be prepared in the field in a short time and placed in the environment. Vinegar has an important function as a solvent. However, its negative feature is that it attracts flies.

Figure 3: A field was observed to understand the damage birds cause to agricultural products. Cross farm manure brought birds to the field/gardens. It is a wrong application. Birds love plum fruit, but they do not eat it when it is unripe because it is sour.

Table 1: Bird repellent mixtures prepared from solid scented material and observation results

Code and Name of bird repellent mixture	**Plant/Product** **Total bird repellents number in using**	**1. Observation and its history**	**2.Observation and its history**	**3.Observation and its history**	**Conclusion and Opinion**
2.2.1.1: Onion + Garlic + Naphthalene	5 Cherry trees (Kiraz)	**27.06.2023**	**29.06.2023**	**01.07.2023**	The smell continued to spread for 7-10 days. It was effective at a distance of 2-4 m. The effect of the bird repellent is more or less 80%.
	15 bird repellents	The smell continues to spread. The cherries that fell to the ground but were pecked, but the ones on the tree were not pecked.	No pecking was observed in cherries, pecking was present in those that fell to the ground	No new pecking has been observed. There is pecking on the ones that have fallen to the ground	
	5 Cherry trees (Kuş kirazı)	**20.06.2023**	-	-	The early riped cherry trial was

	15 bird repellents	This cherry is a variety of wild cherry, it is early riped. Since the fruit is harvested and dried at once, sufficient observations could not be made.			unsuccessful. The timing was not suitable. This type of cherry has a high sugar content and ripens when feed is scarce. For this reason, birds prefer this type of cherry.
	1 Apricot tree (Kayısı)	**27.06.2023**	**29.06.2023**	**01.07.2023**	The scent continues to spread for 7-10 days and is effective at a distance of 2-4 m. Its protective effect on apricots is approximately 70-80%.
	3 bird repellents	The smell continues to spread. The apricots that fell to the ground were pecked, but the apricots on the tree were not pecked.	No pecking was observed in apricot fruits. Pecking was present in apricots that fell to the ground.	There was no pecking observed in the apricots (fruit) on the tree. There was pecking in the apricots that fell to the ground.	
	5 Sour cherry trees (Vişne)	**20.06.2023**	**27.06.2023**	**02.07.2023**	The most common pests that come to sour cherry and cherry trees are the Jays. The smell lasts for 7-10 days and is effective at a distance of 2-4 m. Its protective effect is more or less 70%.
	15 bird repellents	The smell continues to spread. The cherries that fell to the ground were pecked, but the ones on the tree were not pecked.	The smell continues to spread. There has been no new pecking. It has been observed that birds are no longer landing on the tree.	The smell continues to spread. The birds do not visit the trees.	
2.2.1.3: Garlic + Naphthalene	3 Cherry trees	**20.06.2023**	**27.06.2023**	**02.07.2023**	The protection effect is around 70-80%.
	9 bird repellents	The smell continues to spread. The cherry fruits that fell to the ground were pecked but those on the tree were not pecked.	There was no pecking. It was observed that birds did not land on the tree.	The smell continues to spread. Birds are visiting the trees with bird repellents hanging from them.	

2.2.1.4: Onion + Garlic + Naphthalene + Vinegar	1 Apricot tree (Kayısı)	**20.06.2023**	**27.06.2023**	**02.07.2023**	The scent lasts for 7-10 days and is effective at a distance of 2-4 m. The product protection effect is 80-90%.
	5 bird repellents	The smell continues. The cherry fruits that fell to the ground were pecked, but those on the tree were not pecked.	There is no pecking on the fruits. Birds are not perched on the tree.	No pecking was observed in the neighboring trees with or without bird repellent.	
2.2.1.5: Onion + Naphthalene	1 Apricot tree (Kayısı)	**27.06.2023**	**29.06.2023**	**02.07.2023**	The smell lasts for 5-7 days and spreads at a distance of 2-4 m. The product protection effect is 70-80%.
	5 bird repellents	The smell continues to spread, no pecking has been observed on the tree where the mixture is hung and on its fruit.	No pecking was observed in the neighboring trees where the mixture was hung or not.	No pecking was observed in the neighboring trees with or without bird repellent.	
	1 Peach tree (Şeftali)	**27.06.2023**	**29.06.2023**	**02.07.2023**	The scent continues to spread for 7-10 days and is effective at a distance of 2-4 m. The effect of the mixture on peaches is 90%.
	3 bird repellents	The smell continues to spread, no pecking has been observed on the tree where the mixture is hung and on its fruit.	No pecking was observed on the neighboring tree with or without bird repellent. The onion juice flowing onto the fruit damaged the fruit.	No pecking was observed in the neighboring trees with or without bird repellent.	
2.2.1.6: Garlic + Naphthalene + Vinegar	1 Apricot tree	**27.06.2023**	**29.06.2023**	**02.07.2023**	The scent lasts for 7-10 days; it is effective at a distance of 2-4 m. The effect of the mixture on apricots is 80%.
	2 bird repellents	The smell continues to spread, there is no pecking on the tree and fruit where the bird repellent is hung.	No pecking was observed in the fruits of neighboring trees with or without bird repellent. The onion juice flowing onto the fruit damaged the fruit.	No pecking was observed in the fruits of neighboring trees with or without bird repellent. The onion juice flowing onto the fruit damaged the fruit.	
	1 Apricot tree	**27.06.2023:**	**29.06.2023:**	**02.07.2023**	

2.2.2. Garlic + Vinegar + Naphthalene	3 bird repellents	The vinegar part has decreased due to evaporation but smell continues. No pecking was observed in the product (fruit).	The vinegar continues to evaporate and decreases, but the smell continues. No pecking (eating) of apricot fruits has been observed.	The vinegar continued to evaporate and decreased, but its smell continued. No pecking (eating) of the apricot fruits was observed.	The smell lasts for 7-10 days. It is effective at a distance of 2-4 m. The product protection effect is 100%. However, vinegar attracts flies. Vinegar increases the effectiveness of the smell.
2.2.3: Dog poop + Vinegar	5 Stuffed Zucchinis (Dolma Kabak)	**27.06.2023**	**29.06.2023:**	**02.07.2023**	The smell lasts for about 1 month.The effect of scaring away birds is 100%. However, this bird repellent attracts flies. The smell is effective at a distance of 4-5 m.
	5 pieces of bird repellents.	The vinegar has evaporated, stool has dried; odor has diminished. There is pecking (eatenness) in some pumpkins.	No pecking was observed in the pumpkins.	No pecking was observed in the pumpkins.	

Table 2: Bird repellent mixtures prepared with essential oils and application results

Code and Name of Bird Repellent Solution	**Plant/Product Amount of total bird repellents**	**1. Observation (20.07.2023)**	**2. Observation (25.07.2023)**	**3. Observation (31.07.2023)**	**Conclusion and Opinions**
2.2.2.1: Fennel-Dill-1	1 Plum tree (Erik) 3 bird repellent	The smell continues to spread. Some fruits have been pecked.	The smell continues to spread. No pecking was observed on branches where the mixture was hung. However, pecking was observed on fruits on branches where the	The scent emission is reduced. There are some pecked fruits on branches far from scent bottle.	Since the mixture is separated into oil and water, the odor spreading area is not much. The solution is effective, but a mixing mechanism is required for odor spreading. The effect time of the solution is about 1 week and the spreading area is 1 m away. The approximate effect is 50%.

			mixture was not hung.		
2.2.2.2: Fennel-Dill-2	5 Plum trees 15 pieces of bird repellent	The smell is spreading. Pecking is less.	There is no new pecking.	There is no new pecking.	Birds love plum fruit. Even though they are uncomfortable, they do not give up on this environment. The success rate is approximately 65%.
2.2.2.3: Mint-Lavander-1	Field of grain 5 bird repellents were placed in clusters at 5 m intervals.	It is difficult to detect. The modeling was done incorrectly.	-	-	A few of the ears were examined, eaten not grain was seen. However, the fact that no eaten grain was seen in many ears does not mean that the birds did not come to the area. Maybe they ate from another ear, or maybe they did not want to eat the ears of grain when there were fruits around.
2.2.2.4: Mint			-	-	
2.2.2.5: Camphor + Thyme -1			-	-	-
2.2.2.6: Camphor + Thyme -2			-	-	-
2.2.2.7: Lavander-1	1 peach tree 3 pieces of bird repellent	The smell continues to spread. A few fruits have been pecked.	The smell continues to spread. Pecking has been observed in some fruits far from the mixture.	The smell continues to spread. Pecking has been observed in some fruits far from the mixture..	Lavender oil and oily water mix well. Therefore, there is no problem in spreading the scent. The scent spreads to a distance of 2 m and the effect period depends on the homogeneity of the mixture and is approximately 1 week. Its effect on peach protection is 50%.

2.2.2.8: Lavander-2	1 Walnut tree 3 pieces of bird repellent	No pecking was observed.	No pecking was observed in the walnuts.	No pecking was observed in the walnuts.	There are wooden structures at the base of this tree for sitting. Sometimes food etc. is eaten here. According to our observation from a distance, birds visit the bench, walk on the ground but do not land on the tree. Since the walnut tree itself is also fragrant, the hanging bird repellent partially reduces the effect of smell. Therefore, an 80% effect was observed and when compared to other walnut trees, it was determined that birds did not land on the walnut tree where bird repellent was hung, but only walked on the ground. The effect period of the mixture is 1 week and its spread is 2 m
2.2.2.9: Garlic + Lavender + Naphthalene	5 Apricot trees 15 pieces of bird repellent	The smell continues to spread. The fruits have dried out in the heat, but there are no signs of birds pecking on them.	The smell continues to spread. The fruits have dried and no pecking has been seen, the experiment is over.	-	Since oil and water do not mix, the effect of the smell decreases. Accordingly, the spreading area of smell also decreases. In order for smell to be more effective, mixture must be constantly stirred. The spreading area is approximately 2 m and the effect time is 1 week. It is a 100% effective solution. It needs to be developed and disseminated.

The most successful results in the work were obtained from essential oils of onion, garlic, fennel, lavender and thyme. Although birds are disturbed by dog feces, it is not recommended because dog feces is a means of spreading many diseases. Naphthalene is also a carcinogenic substance, so its use is not recommended, but it is an important bird repellent.

Birds come to plants not only to eat vegetables/fruits but also to hunt flies, ants, insects and their larvae, caterpillars, fruit worms etc. and to eat various parts of plants. Therefore, in order to prevent damage from omnivorous birds, insects, flies, ants, bees, etc. should be removed from the environment. All bird species

do not like or are afraid of shiny objects, black and red colors.

CONCLUSION AND SUGGESTIONS

In this study; technical solutions were sought from essential oils and natural scents to the problem of birds damaging agricultural products. The farmers interviewed were very interested in our topic, wanted to learn the results and shared their own practices with us. The widespread impact of our study is high.
It is clear that we are in favor of continuing study of the subject. It is thought that we have made a small contribution to Türkiye and organic agriculture. Birds, flies, insects, bees, ants and caterpillars do not like the volatile oils of plants belonging to the Labiatae and Apiaceae families and avoid relevant area. Whether or not they are harmful to plant or plant product, removing such invertebrates from the environment reduces damage birds cause to the products.
Birds damage to agricultural products in 2 ways.
a) One is those that come to eat the fruit or vegetable.
b) The other is that they come to hunt ants, termites, caterpillars, flies, etc. that are hosts on the vegetable/fruit plant and damage agricultural products in different ways such as pecking, eating, pooping on them, and hollowing them out.

Below we discuss our findings and make recommendations to manufacturers:
Heteroculture should be widespread instead of monoculture. For example, after the fruit trees, a row of Fennel or Lavender should be planted.

Considering all the findings, it is understood that the most effective bird repellent is a mixture of solid dog feces, lavender oil water, and rotten crushed onions. Studies should be carried out on the proportions of these materials and the establishment of a shaking mechanism to continuously emit the scent.

'The view that birds are not sensitive to odors despite their ability to smell' is erroneous. This result is an important finding. Essential oils and aromatic oily plant waters or the plants themselves (onion, garlic, fennel, dill, lavender, basil, marigold, etc.) repel ants, flies, insects, etc. However, they are not as effective as garlic-onion and dog feces in repelling agricultural products from birds.

Cereal fields are far from being a good model. Detailed models should be developed to understand the effect of odor. The study should be comprehensive. For example, it should be applied to a crop field of at least 1 decare. No clear results could be obtained from the solutions applied to the grain fields. It seems impossible to determine whether a grain from a large number of ears is edible or not. This method is not well designed.

It was difficult to determine the success of some solutions hung on fruit trees. Therefore, the method was changed. It is difficult to determine how much fruit was harvested from each tree and how much of the fruit was bitten by birds. Therefore, it was possible to determine the plants that birds frequently visited and whose fruits were eaten. The most reliable method for the experiment is to prepare the solutions without human intervention and to collect the fruits that the birds eat a lot and place them next to each other.

Many birds come to apricots. They have caused excessive damage to the fruits (Anderson et al., 2013; Elser et al., 2019; Eaton, 2010; Şahin et al., 2019). These fruits were collected and placed in a place close to the tree with the uneaten parts facing up. … solutions were placed next to it. Photographed and monitored. The formula used for apricots is an effective bird repellent.The odor of scented plants such as walnuts reduces the odor of bird repellent solutions. For this reason, scented/aromatic trees/herbaceous crop plants should not be preferred in repelling birds with scent. Birds do not eat smelly and sour products.

It was observed that many birds came to stuffed zucchini plants and damaged the product. Onion + vinegar solutions were placed at the bottom of these products. They were observed. Their photographs were taken(Fig. 2). The newly formed zucchinis were not harmed, and the injured zucchinis that they had eaten in the past were no longer harmed. The products closed the wound. It is an effective solution. Because birds

do not like sulfur solutions and their smells. They also do not like products that give a sour taste.

Raw manure should not be poured next to products that need to be protected[8]. Raw manure attracts birds and suppresses the bird repellent smell. Birds prefer juicy and fleshy fruits more than grains. Although many flies came to the place where vinegar + dog feces were hung, no birds came. Since birds hunt flies, it is recommended to hang such solutions on high branches.Some of the bottles used in the experiments were made of glass. Using glass bottles can be dangerous, especially in crop fields. The focus of the light and the abundance of flammable material can cause fire. Therefore, the use of glass is not recommended.

Although it is known that birds damage agricultural products in our study, how much damage they cause, which bird species and how many of them cause this damage, has not been investigated. From now on, studies should be conducted on which plant odor will be effective for which bird species and at what distance and for what time. In addition, the agricultural products pecked by birds should be evaluated economically and the infectious diseases that may occur in those who eat these products should be emphasized. No method study has been conducted before us to prevent the damage caused by birds, and publications have been made in Europe and the USA based on information received from farmers on the amount of damage caused by birds. It is hoped that our study will contribute to the relevant sector. Efforts should be made to commercialize and publish the products. All these studies must be carried out with a multidisciplinary approach (Gorenzel and Salmon, 2008).

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