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# Effects of harmful *Bangasternus planifrons* (Brulle, 1832) (Coleoptera: Curculionidae) control with different insecticides on yield and quality in safflower

*Bangasternus planifrons* (Brulle, 1832) (Coleoptera: Curculionidae)'un farklı insektisitler ile mücadelesinin aspirde verim ve kaliteye etkisi

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A B S T R A C T

The production of safflower (*Carthamus tinctorius* L.) (Asterales: Asteraceae), which is cultivated worldwide, is significantly affected by different abiotic and biotic factors such as insects. Different insecticides have been applied during safflower production to control pests. The application of insecticides can affect plants as well as pests. This study was carried out in Ankara and Eskisehir provinces in 2016 using four different insecticides against the *Bangasternus planifrons* (Brulle, 1882) (Coleoptera: Curculionidae) pest in Balcı safflower variety. The pest population was 73-91% effectively suppressed as of the 14th day after the application of insecticides, and the yield increased by 60.43-123.18% when compared to the control group. Deterioration of seed quality, loss of oil ratio, and loss of 1000 grain weight occurred as a result of damage occurred by pest feeding. Through control of pests and reduction of pest population, an increase in quality and productivity was achieved. Regression analysis made on the data obtained from the application areas determined that there were 83.73%, 75.83%, and 75.44% negative relationship between the number of adults of the pest and the yield, oil rate, and 1000-grain weight, respectively. In conclusion, *B. planifrons* is an important factor causing a loss in yield, oil rate, and loss of 1000-grain weight in safflower plant. The damage caused by the pest can be prevented by the application of a suitable insecticide.

## INTRODUCTION

Safflower (*Carthamus tinctorius* L.) (Asterales: Asteraceae) is an annual oil plant with a 30-50% oil content in its seeds. It is a broad-leaved and highly branched industrial plant grown especially for its seeds and petals that are used in the production of biodiesel or as pulp used to feed animals. Safflower leaves and oil are used in fabric dyes, food coloring and treatment of some diseases, human nutrition, and biodiesel production (Köse 2019a). Approximately 60% of consumed oil in Turkey is imported.

A result of limited production of existing oil crops and the gradual decrease in irrigable agricultural lands have increased the importance of the cultivation of droughtresistant plants such as safflower in recent years. Safflower cultivation area reached 43.107 ha, and the production amount reached 70.000 tons in 2015 with the support given to encourage agricultural production. However, safflower is affected by several harmful organisms that cause economic losses. Among these organisms, insects are the most important factors causing a decrease in production (Köse 2019b); for example, those in the *Bangasternus* genus cause significant economic damage.

Eight species in the genus *Bangasternus* are known to be in the Palearctic region (Hoffmann 1954), and three are in Turkey (Lodos et al. 1978, 2003). *Bangasternus* spp. (Coleoptera: Curculionidae) within the Asteraceae family, is especially specific to Centaurea species and is widely used in biological control studies of Centaurea spp. (Asterales: Asteraceae) conducted in the world. It has been determined that *Bangasternus orientalis* (Capiomont 1873) (Coleoptera: Curculionidae) feeds within the flower capsule of yellow pyrethrum [*Centaurea solstitialis* L. (Asterales: Asteraceae)] and causes damage to its seeds (Maddox et al. 1991). Sobhian et al. (1992a) stated that *B. orientalis* was fed in the laboratory and field trials were carried out for the control of the yellow pyrethrum. It was found that the white pyrethrum [Centaurea *diffusa* Lam. (Asterales: Asteraceae)] plant is infested with *Bangasternus fausti* (Reitter 1890) (Coleoptera: Curculionidae) at a rate of 72-100% (Sobhian et al. 1992b). Although it was stated that *B. planifrons* (Brulle) can be used as a biological control agent in studies carried out abroad, Damkacı (2013) first noted that it is a pest in safflower fields in Turkey. For instance, Yücel et al. (2019) stated that *B. planifrons* is an important pest in safflower areas, and it causes economic loss by feeding in the green parts and flower capsules of the safflower plant.

There has been no study, so far, on the biology and natural enemies of *B. planifrons*, the main pest of the safflower plant, both in Turkey and abroad. But since this pest has become an important limiting factor in safflower production, it must be controlled. There are a limited number of studies conducted in our country on this pest, and little is known of its natural enemies and their activities, so control is dependent on chemical means. Therefore, we investigated the effectiveness of different insecticides in order to prevent the economic loss caused by the pest. The effects of the capsule proboscis beetle, which causes a decrease in the seed quality and quantity of the safflower plant, on the yield and the effectiveness of the insecticides that can be used in the chemical control of the pest were determined. The studies were carried out in 2016 in two different experimental areas in Ankara and Eskisehir provinces where safflower is cultivated.

## MATERIALS AND METHODS

### *Plant materials and insecticides*

The experiments were conducted on the Balcı variety of safflower plants. Balcı safflower variety has a plant height of 55-70 cm, a yield of 120-240 kg/da in dry conditions, and 300-350 kg/da in watery conditions. Insecticides and active ingredients used in the study were; Insect.A (100 g/l Chlorantraniliprole + 50 g/l Lambda-cyhalothrin), Insect.B (5% Emamectin benzoate), Insect.C (227 g/l Chlorpyrifos-methyl) and Insect.D (141 g/l Thiamethoxam + 106 g/l Lambda-cyhalothrin).

### *Growing conditions and insecticide application*

Safflower seeds were sown in 45 cm row spacing with 45 kg/ha seed sowing norm in the field on March 2, 2016, in the Transitional Zone Agricultural Research Institute Directorate's trial field of Eskisehir Province Tepebasi district, (39°45''57'N, 30°24''5'E 868 m, 10 da) and in Gülhüyük neighborhood, Sereflikochisar district, Ankara Province on 3 March 2016. (39° 06'54 N 33° 34'39 E 970 m, 40 da). Eighty kg/ha of nitrogen (33 ammonium nitrate) and 60 kg/ha of phosphorus (diammonium phosphate) fertilizer were used in planting. Safflower in the experimental fields was grown under rain-fed conditions and weed control was done manually during the growth period. In order to determine the effects of insecticides against *B. planifrons*, the experiment was conducted against the overwintered adults of the pest on May 24, 2016. The doses of insecticides used in the experiment were determined based on the recommended doses in our country (Insect.A: 50 ml/da, Insect.B: 50 g/da, Insect.C: 200 ml/da, Insect.D: 30 ml/da). A knapsack sprayer was used in spraying. The insecticides doses were calibrated according to the 30 liters/da water norm, and the amount of effective substance per parcel and the water to be disposed of the norm were calculated and the application was made.

The applications were set randomized block design in four replications, together with the control plot (4 insecticides + 1 control; 5x4 = 20 plots) in a 100 $m^2$ plot (distance between each block is one meter). In counts, the average number of pests per plant was calculated by counting the adults of the pests on 25 plants randomly selected from each plot four times (pre-counting, third, $7^{th}$, and $14^{th}$ days). The efficiency of the insecticides was assessed based on 3 factors (insecticide*time*location) and factor levels were assessed according to the experimental design.

### *Measurement of growth and yield parameters*

Safflower plants were hand-harvested in duplicates from 1 $m^2$ area of each parcel on August 12, 2016. The harvested capsules were cleaned in the laboratory. For the productivity and parcel yields, 5 sets random of 100 seeds were weighed and the average was taken to determine the 1000 grain weights. To determine the oil content, 10 g of ground safflower seeds were weighed and placed in cones. The samples were extracted for 6 hours in the Soxhlet apparatus to which 90 ml of petroleum ether was added, allowing all of the oil to pass into the solvent. At the end of the extraction, petroleum ether was removed from the balloon in a vacuum evaporator under reflux, and the sample was kept in the oven at 103 + 2 °C until it reached constant weight to remove all solvent residue and moisture. The sample removed from the oven was kept in the desiccator until it reached room temperature, and the oil rate was determined by weighing (Andrich et al. 2001). These oil rates were multiplied by seed yields and oil yields were calculated.

*Data analysis*

The data of adult count obtained in the study were first converted to percentages, and then subjected to analysis of variance (ANOVA) after arc-sin transformation. Comparisons between percent mortality rate and corrected percent mortality effect rate (Henderson and Tilton 1955) means were made using Duncan Multiple Comparison Test. All statistical analyzes were done using SPSS 23.0 package program.

**RESULTS AND DISCUSSION**

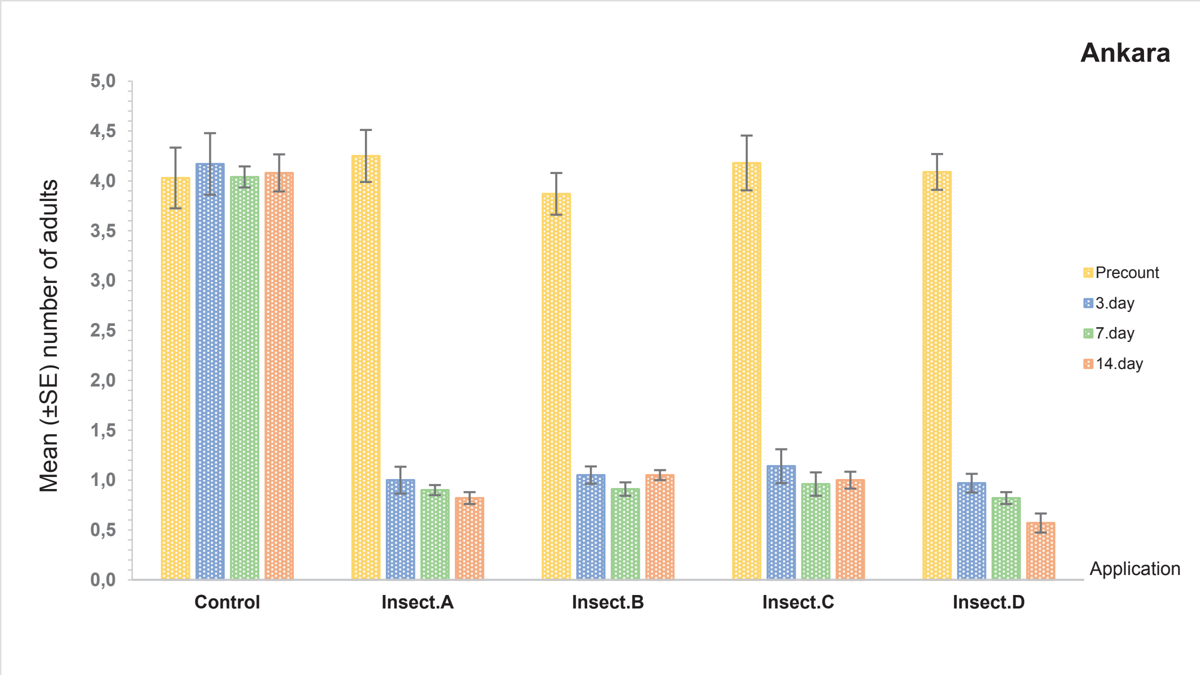
Experiments were conducted in Eskisehir province Tepebasi district and Ankara province Sereflikochisar district to prevent the damage given by *B. planifrons*, which causes a decrease in quality and quantity in the product, as a result of feeding on the safflower plant. The density of the individuals belonging to the post-wintering of the pest was suppressed in the early period and the damage to the product was reduced. The data showing the average of pest adults in the experiments are given in Figure 1.

As a result of the obtained data, there was no difference in the effectiveness of the insecticides used in the experiment according to the locations (insecticide*time*location interaction) where they were applied at different census times. ($F$=13.450; $P$=0.000; $df$=6). Similarly, it was observed that there was no difference between the effect values obtained as a result of the repeated adult census in Ankara and Eskisehir locations ($F$=4.226; $P$=0.062; $df$=1). No difference was found between the effect values (location*insecticide interaction) of the insecticides applied in the treatments ($F$=1.824; $P$=0.196; $df$=3). There is no difference between the effect values of the treatment locations and the repeated census dates (location*time interaction) ($F$=0.554; $P$=0.582; $df$=2).

Differences were determined in the effectiveness of insecticides according to the census times ($F$=23.268; $P$=0.000; $df$=2). The difference between the census dates is expected due to the action mechanisms and duration of action of insecticides. In the study, it was determined that the effect values of insecticides were different according to the census dates. As a result, there was a difference in yield, 1000-grain weight, and oil rate obtained from different insecticide-treated plots.

In both studies, a high effect was observed in decreasing the number of adults, and the average number of adults was observed to one or less. Among the insecticides used, Insect.A and Insect.D showed an effective rate of over 80% as of the 14th day. Insect.D, in particular, had the highest impact in the field of the Institute and reached an impact rate of 91.02% (Table 1).

Due to the lack of studies on safflower in Turkey and worldwide, the effects of insecticides were discussed with studies on other oilseed plants and their effects on the product. It was determined that, the damage is given by *Uroleucon compositae* (Theobald). (Hemiptera: Aphididae) causes loss in yield in safflower and that among the five different insecticides applied for control, thiamethoxam active exhibited the highest effect as 0.83 aphids per 5 cm plot, while an average of 66.13 aphids per 5 cm plot was found in the control plots (Gore et al. 2010). In the study conducted by Gvozdenac et al. (2019) to control wireworm in sunflower [*Helianthus annuus* L. (Asterales: Asteraceae)], 15.8% damaged plants were found in control and 1.86% in thiamethoxam application. Showler and Robinson (2005) stated that the application of insecticides in cotton [*Gossypium* spp. (Malvales: Malvaceae)] against *Anthonomus grandis grandis* (Boheman) (Coleoptera: Curculionidae) with different methods resulted in a 46-56% increase in yield. When different insecticides from neonicotinoid, organophosphate/carbamate, pyrethroid groups were applied against *Thrips tabaci* (Lindeman, 1889) (Thysanoptera: Thripidae) and *Lygus lineolaris* (Palisot de Beauvois 1818) (Hemiptera: Miridae) pests in cotton, both pests were controlled to decrease the economic damage threshold in all periods of the cotton and an average yield increase of 8.51% was achieved in the product (North et al. 2019). Similarly, the lint yield was increased by 8% (111 kg/ha) as a result of applying thiamethoxam to cotton seeds to prevent damage given by thrips (Lahiri et al. 2018). Prathibha et al. (2017) stated that the activities of different insecticides have been tested to control *Leucophalis burmeister* Brenkske (Coleoptera: Scarabaeidae), which causes yield loss in Areca palm, and as a result, bifenthrin insecticide at a dose of 2 kg/ha can be used in the management of this pest due to its mechanism of action and a long stay in the soil.



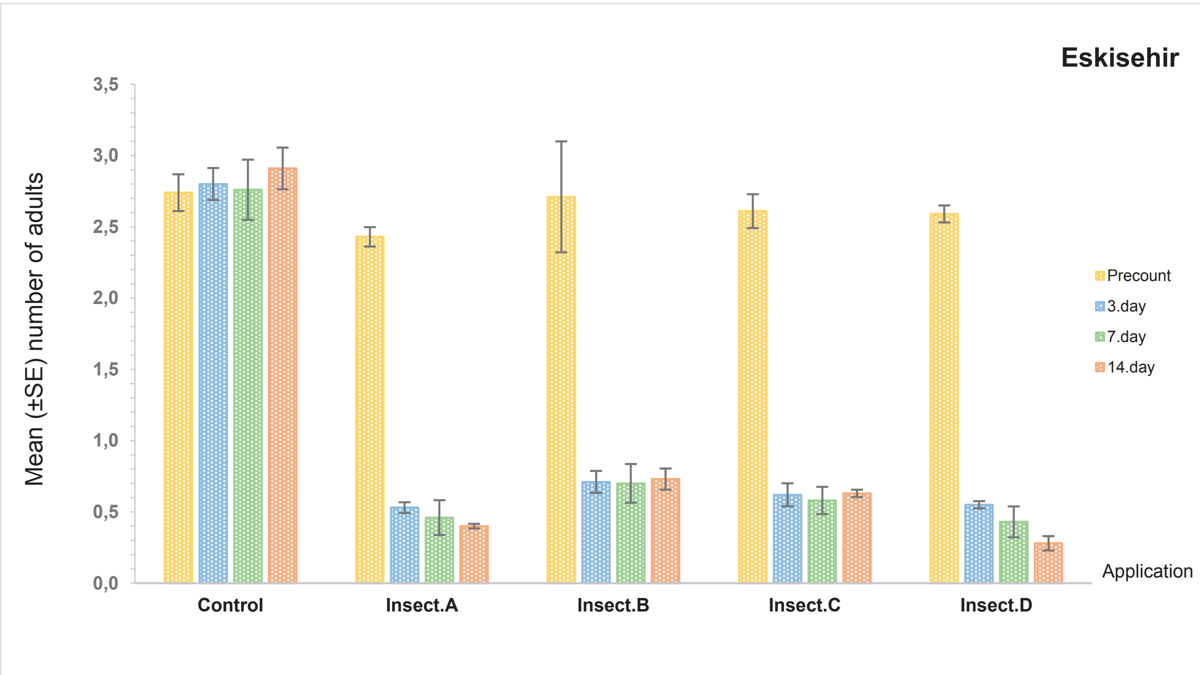




**Figure 1.** Mean (±SE) number of adults of different insecticides applied against *Bangasternus planifrons* (Brulle) (Coleoptera: Curculionidae) in Ankara and Eskisehir provinces of safflower fields

In other studies, carried out in the world, it is seen that treatments against pests prevented product loss. The differences in the effects of the insecticides applied may be caused by differences in the action mechanisms of insecticides and their molecular structures. The metabolic activities and morphological structure of targeted insects are among the important factors affecting the rate of action of insecticides. In our study, as of the 3rd day, Insect.A (Chlorantraniliprole + Lambda-cyhalothrin) and Insect.D (Thiamethoxam + Lambda-cyhalothrin) showed similar rates of the effect of 77.85% and 78.37%, respectively, while the effect of Insect.D continued in the following period and reached an average impact rate of 88.74%.

The effects on safflower grains were determined by sampling from the application areas during the harvest period. An increase of 60.43-123.18% was achieved in safflower yield

**Table 1.** Mean (±SE) efficacy of different insecticides applied against *Bangasternus planifrons* (Brulle) (Coleoptera: Curculionidae) in safflower fields

| Fields | Days | Insect.A±SE | | | Insect.B±SE | | | Insect.C±SE | | | Insect.D±SE | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Eskisehir | 3 | 78.54±1.97 | B* | a** | 73.97±1.23 | A | a | 76.95±2.12 | A | a | 79.20±0.97 | C | a | $F$=2.039; $P$=0,162; df=3 |
| | 7 | 81.10±1.79 | AB | ab | 75.87±2.73 | A | bc | 77.75±1.68 | A | c | 83.61±2.68 | B | a | $F$=4.913; $P$=0,019; df=3 |
| | 14 | 84.44±0.93 | A | b | 73.03±1.75 | A | c | 74.68±1.77 | A | c | 91.02±1.64 | A | a | $F$=38.823; $P$=0,00; df=3 |
| | | $F$=34.982; $P$=0,081; $df$=2 | | | $F$=0.969; $P$=0,416; $df$=2 | | | $F$=0.940; $P$=0,426; $df$=2 | | | $F$=19.792; $P$=0,001; $df$=2 | | | |
| Ankara | 3 | 77.16±1.52 | A | a | 73.74±1.93 | A | a | 74.22±1.26 | A | a | 77.54±0.90 | B | a | $F$=1.175; $P$=0,360; df=3 |
| | 7 | 79.39±1.34 | A | a | 77.24±1.46 | A | a | 78.04±1.27 | A | a | 80.68±0.72 | B | a | $F$=1.519; $P$=0,260; df=3 |
| | 14 | 80.59±2.19 | A | b | 73.10±1.20 | A | c | 76.42±0.96 | A | bc | 86.46±1.73 | A | a | $F$=13.119; $P$=0,00; df=3 |
| | | $F$=1.025; $P$=0,397; $df$=2 | | | $F$=2.040; $P$=0,186; $df$=2 | | | $F$=1.656; $P$=0,244; $df$=2 | | | $F$=12.844; $P$=0,002; $df$=2 | | | |

* Different capital letters in a column were significantly different (P<0.05)
** Different small letters in a line were significantly different (P<0.05)

compared to the control. Similar increases were found in the 1000 grain weight and oil ratio. There was an increase of 6.28-15.82% in the safflower 1000 grain weight compared to the control. It was determined that there was an increase of 6.33-11.92% in the oil rate compared to the control. While the highest increase was in Insect.D application, a higher increase was detected in Insect.A application compared to other Insect.B and Insect.C applications. Data on yield, oil rate, and 1000 grain weight obtained from the experiments are given in Figure 2.

Linear regression analysis was applied to the data to determine the correlation between the increase in yield, 1000 grain, and oil rate with many adult insects. As a result of the regression analysis, a negative correlation of 83.73% was determined between the number of adults and the increase in yield, while a negative relationship of 75.44% and 75.83% was determined in 1000 grain weights and oil rates, respectively (Figure 3).

Brown et al. (1999) used different insecticides to control pests in canola [*Brassica napus* L. (Brassicales: Brassicaceae)] in their study and stated that while the yield increased by 10-46% compared to the control due to the damage caused by insects. The oil rate increased by 5.4-6.9% and that the oil quality was not affected by insect damage. Gvozdenac et al. (2019) stated that the damage of wireworms in sunflower was reduced with thiamethoxam application when compared to the control and that the applications did not differ from the control in the oil rate

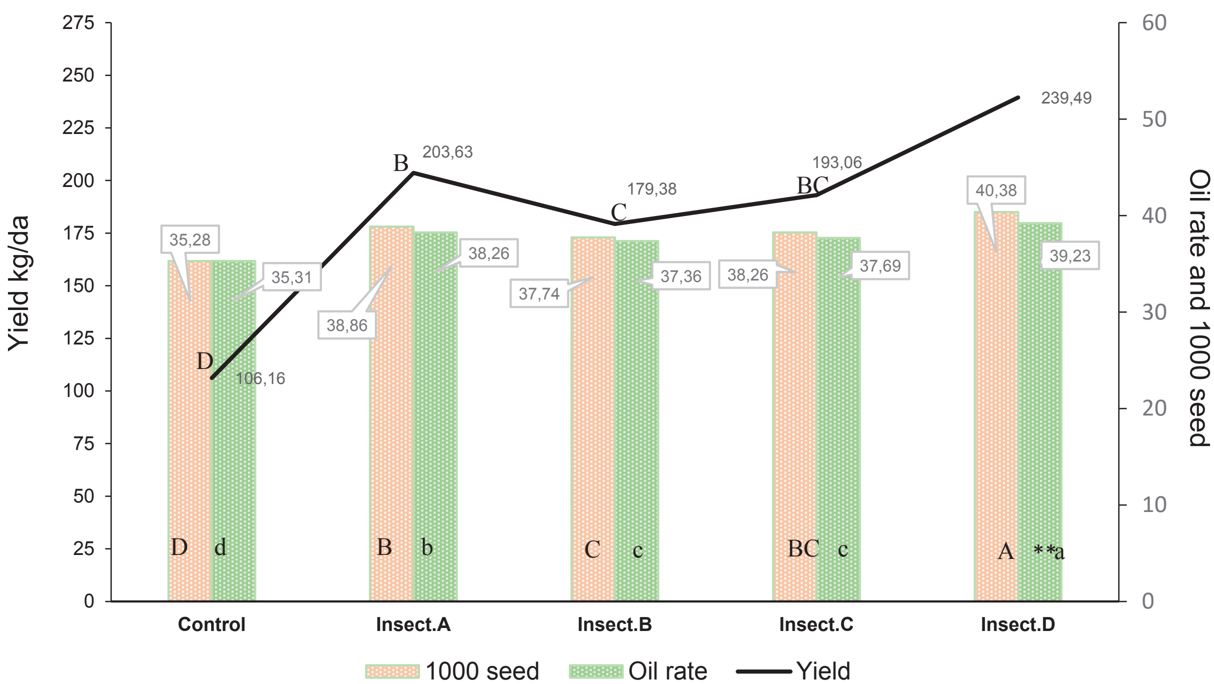



**Figure 2.** Mean (±SE) yield, oil rate, and 1000 seed weight results obtained from different insecticides applied against *Bangasternus planifrons* (Brulle) (Coleoptera: Curculionidae) in safflower fields. Note 1: *Different capital letters in a column were significantly different, (yield: $F$=86.074, $P$=0.00, $df$=4; 1000 seed: $F$=61.574, $P$=0.00, $df$=4) Note 2: **Different small letters in a line were significantly different, (oil rate: $F$=66.416, $P$=0.000, $df$=4)

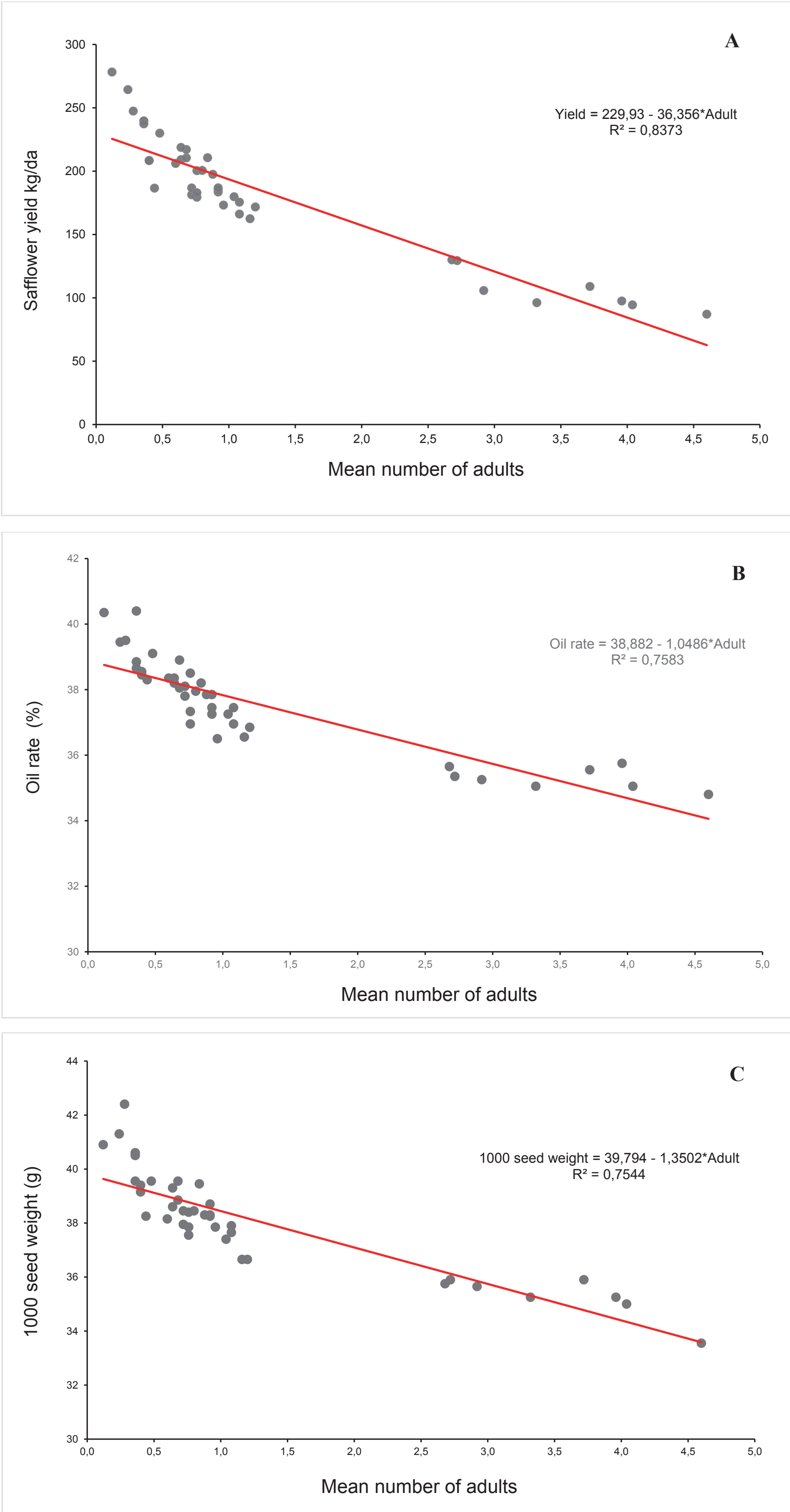



**Figure 3.** The correlation relationship graphs between *Bangasternus planifrons* (Brulle) (Coleoptera: Curculionidae) adults and seed yield (a), oil rate (b), and 1000 grain weight (c) in safflower fields

and 1000-grain weight. In a study conducted on winter canola, they found that insecticide application increased the yield, but there was no change in 1000 grain weight (Leach et al. 1994). The pest did not only cause yield loss, but it also negatively affected the product quality. It is thought that the decrease in the seed quality of the product, especially the development of safflower seeds in a closed capsule, was a result of the insect's feeding and the enzymes it secretes which prevents the formation of healthy seeds by the destruction of the seed and seed receptacle.

Many factors that cause losses in the products obtained during agricultural activities. One of the most important abiotic and biotic factors is insects. In safflower production, characteristics such as yield, oil ratio, and oil yield are highly affected by insect damage. Application of insecticides has often become inevitable in protecting crops. In this study, the effectiveness of some insecticides in the control of *Bangasternus planifrons*, which causes yield loss as a result of feeding on safflower plant, and the effect of Balcı variety on yield components were investigated. Application of insecticides suppressed the insect pest thereby reducing the damage in the products. Changes in the quality of the product were also determined while assessing the damage found between the areas where the control was made and the areas where no control was done. It was determined that the pest in question causes loss of yield and reduces the amount of oil rate and 1000 grain weight of the product. Among the four insecticides applied, thiamethoxam + lambda-cyhalothrin application provided the highest seed yield, 1000 grain weight, and an increase in oil rate. Current research shows that insecticides applied in safflower against *B. planifrons* can reduce pest damage.

**ÖZET**

Dünya çapında yetiştiriciliği yapılan aspir (*Carthamus tinctorius* L.) (Asterales: Asteraceae) üretimi böcekler gibi farklı abiyotik ve biyotik faktörlerden önemli ölçüde etkilenmektedir. Aspir üretimi sırasında zararlıları kontrol altına almak için farklı insektisitler uygulanmaktadır. İnsektisitlerin uygulanması, zararlılarla birlikte bitkileri de etkileyebilir. Bu çalışma *Bangasternus planifrons* (Brulle, 1882) (Coleoptera: Curculionidae) zararlısına karşı Balcı aspir çeşidinde dört farklı insektisit kullanılarak Ankara ve Eskişehir illerinde 2016 yılında yapılmıştır. Çalışma sonucunda zararlı popülasyonu insektisit uygulamasının 14. günü itibariyle %73-91 etki oranında azalmış ve verimde kontrol grubuna göre %60.43-123.18 artış sağlanmıştır. Zararlının beslenmesi sonucunda tohum kalitesinde bozulma, yağ oranı kaybı ve 1000 tane ağırlığı kaybı meydana gelmiştir. Zararlıların kontrolü ve zararlı popülasyonunun azaltılması yoluyla kalite ve verimde artış sağlanmıştır. Uygulama yapılan alanlardan elde edilen verilere yapılan regresyon analizi sonucunda zararlının ergin sayısı ile verim, yağ oranı ve 1000 tane ağırlığında da sırasıyla %83.73, %75.83 ve %75.44 oranında negatif ilişki belirlenmiştir. Sonuç olarak *B. planifrons*'un aspir bitkisinde zararı ile verimde, yağ oranında ve 1000 tane ağırlığında kayba neden olan önemli bir etken olduğu, zararlıya karşı yapılacak uygun bir insektisit uygulaması ile oluşan zararın önlenebileceği sonucuna varılmıştır.

Anahtar kelimeler: *Bangasternus*, insektisit, yağ oranı, aspir, verim, Eskişehir

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