DOI: https://doi.org/10.24297/jaa.v14i.9509

THE EFFECT OF BORON AND IAA APPLIED TO SUNFLOWER GROWED AS A SECOND PRODUCT ON SEED SETTING

Samet Gölkaya[1] Ahmet Tamkoç[2]

sametgolkaya@gmail.com [1] tamkoca@gmail.com[2]

Astract

This research was carried out on the second crop oil sunflower, which was planted directly on the stubble in the Central Anatolia region. Increasing doses of boron (4.2 gr, 8.5 gr, and 16.8 gr) and increasing doses of IAA (12 ppm, 16 ppm, and 20 ppm) were applied to leaves of sunflower at R2 and R3 development stages of sunflower in order to increase the number of full seeds (Pieces/Capitulum) of the second crop oil sunflower. The data obtained from the experiment with 4 replications were evaluated statistically, and the difference between them was significant at the $p<0.05$ probability level. However, the difference between the potential seed number (Pieces/Capitulum) was insignificant. While 4.2 gr and 8.5 gr boron doses from the boron doses applied plots and 20 ppm IAA dose from the IAA applied plots had the highest grain yields, the lowest seed setting was observed in the 16.8 gr boron applied plots and the 12 ppm and 16 ppm IAA applied plots. It has been concluded that the IAA used in the research has both positive and negative effects on productivity against stress conditions created by environmental factors.

Keywords: Boron, IAA, Second Product, *Helianthus annuus* L., Seed Setting, Environmental Impact

Introduction

Sunflower is the most important plant in vegetable oil production in our country. In addition to the oil sunflower production, which is produced especially in the Marmara, Central Anatolian region, and coastal areas of Turkey, seed sunflower production is also carried out. Despite the suitability of ecological conditions, in addition to the rotation applied in the existing arable agricultural lands, oil sunflower production, which is not very attractive compared to other field crops, is not sufficient.

Since the vegetable oil consumed in our country cannot be met by production, crude sunflower oil is imported to our country in order to meet the vegetable oil deficit (Gül et al., 2016).

While sunflower for oil is grown as the main product in the Central Anatolia region, growers in the regions with irrigation facilities are grown as a second product after barley, wheat, and forage crops produced for grass. A similar alternation is applied in the second crop sunflower in Europe. However, since the yield of oil sunflower grown as a secondary product is lower than the product grown as the main product, growers do not prefer it much (Lamichhane et al., 2022).

Çil et al. (2016), in their research in Çukurova region, the most suitable planting time for oil sunflowers to be grown under second crop conditions was determined as 12 June. However, they stated that due to the delay in planting time, it caused a decrease in yield and oil rate.

This study, it was aimed to increase seed set and yield by applying increasing doses of boron and IAA (Indole-3-acetic acid) in order to eliminate the effect of environmental conditions such as day length, weather conditions, and light intensity as the flowering period of the second crop oil sunflower grown in the Central Anatolia region coincides with the beginning of early autumn.

Materials and Methods

This study was carried out on a field cultivated in irrigated conditions and oil sunflower (P63MM54) planted by the grower in the second crop production season of 2022 in Konya (Atlanti Mahallesi). The experiment was set in a randomized block design with 4 replications in the grower's field (September 1, 2022). The plots are 70 cm (centimeter) between rows, 16 cm on rows, 192 cm in length, and consist of 3 rows. Randomly distributed 1 block, 3 increasing doses of boron, and 3 increasing doses of IAA were applied in the plots.

Liquid fertilizer containing 11% water-soluble boron (boron ethanol amine) content is weighed with a tared plastic on a precision scale, 38.22 gr (gram), 76.82 gr and 152.92 gr are weighed respectively and then mixed with water. As pure substance, B1: 4.2 gr, B2: 8.5 gr and B3: 16.8 gr were applied to the sunflower leaf areas of the parcels with a hand sprayer separately for each applied parcel.

IAA (Indole-3-acetic acid) was weighed on a precision scale with a tared plastic cup, and 0.06 gr, 0.08 gr and 0.1 gr were weighed, respectively. Weighed IAA were mixed with 150 ml (milliliter) of pure ethyl alcohol, labeled as O1, O2 and O3, respectively. The solutions were mixed sequentially by adding water to the labeled 5-liter jars. The solutions were applied to the sunflower leaf areas with a hand sprayer in the evening cool, with O1: 12 ppm (units per million), O2: 16 ppm and O3: 20 ppm, respectively. No technic was made to the witness parcel, which has 1 in each block. Witness plots were placed randomly within the blocks.

Application Schneiter and Miller (1981), R2 (The distance between the immature bud and the leaf closest to the bud on the sunflower stem is between 0.5 cm and 2 cm. The leaf in the bud is not taken into account.), R3 (The immature bud is 2 cm from the nearest leaf.) extends over it.) was done in growth stages.

In addition to irrigation and fertilization in the sunflower field, an intermediate anchor was made once, and a sprinkler irrigation system was used for the water need of the sunflower field. It was observed that the second crop sunflower field was not uniform, and the sunflowers were in different growth stages.

Schneiter and Miller (1981), defined by R9 (Bract leaves are yellow and brown. This stage is considered physiological maturity.) was counted. The average of filled seeds was recorded as the number of filled seeds per capitulum (Pieces/Capitulum). The sum of full and empty seeds was recorded as potential yield per capitulum (Pieces/Capitulum). Analysis of variance and LSD (Least Significant Difference) test of data on the number of filled seeds per capitulum and seed potential per capitulum was performed.

Results and Discussion

After the application, phenotypic differences between plots were observed in general. Curvatures were observed on the stems of sunflowers near the capitulum in the O3-treated plots (Fig. 1.) In the same way, there were curvatures on the stems close to the capitulum partially in the plots where B3 was applied. While there was burning and shrinkage in the leaves as a result of the toxicity caused by the boron applied at high doses in the B3 applied plots, (Fig. 2.), B2 plots had a partial toxic effect. Chen et al. (2014), boron toxicity affects photosynthesis proteins in the cell, such as boron deficiency.

Figure 1. Curved stems in plot O3.

Figure 2. B3 Toxic effect.

Upright and inverted sunflowers were observed in O1 and O2 applied plots (Fig. 3., 4.) Bernardo and Atamian (2019), observed in their research that sunflowers exhibit a movement out of normal heliotropic activity due to IAA applied to different parts of the sunflower and stated that the sunflower, on the contrary, turns to the west at sunrise. They stated that the heliotropic movement of the sunflower may be caused by hormonal signals, and there may be a connection between the table temperature and the sunflower's response to light (Vandenbrink et al., 2014).

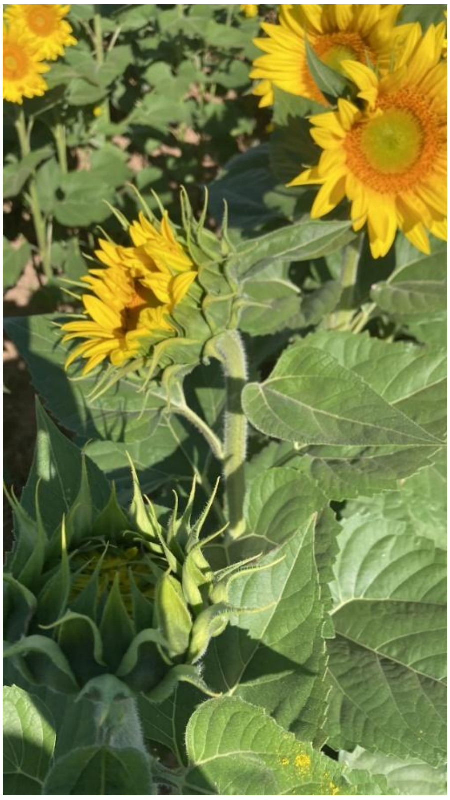

Figure 3. O2 applied plot.

Figure 4. O1 Applied plot.

The general view is when the flowering begins Schneiter and Miller (1981), from the development stages of the sunflower he describes, R4 (Flowers begin to open. When viewed directly from above, immature sterile flowers can be seen.), R5 (At this stage, it is the beginning of flowering and with lower percentages (R5.1, R5.2, R5.3 etc.) are defined.

It was observed that there was no uniform flowering in the field that was in the flowering period 15 days after the application, and the honeybee was working in the sunflower capitulum. The general appearance, Schneiter and Miller (1981) was observed to be in the R5.1, R5.3 (Flowering 30%), and R5.8 (Flowering 80%) stages of the flower stages they described. While it was observed that the pollen status was good and the pollen was spilled on the sunflower leaves in the parcels where IAA and boron application were applied, it was observed that the sunflowers in the B3 parcel were weak.

The general appearance, which started to dry out sterile flowers 22 days after the application, was observed in the R5.3, R5.8, and R6 (Flowering complete and sterile flowers starting to dry.) stages, which are defined by Schneiter and Miller (1981) It was observed that the first flowering started in the field 6 days after the application and continued until the end of 27 days after the application. While the average flowering took 6 to 8 days for a single capitulum, the average field took 21 days to bloom. Sunflower sizes varied between 80 cm and 138 cm even in the same plot, while the diameter of the capitulum varied between 12 cm and 21 cm.

According to the results of the analysis of variance of the data obtained in this study, boron and IAA applications were significant at the $p<0.05$ probability level in terms of the number of filled seeds. On the other hand, it was insignificant in terms of seed potential per capitulum.

LSD test was performed for the difference between the application doses as a result of the analysis of variance, (Table 1.) While there was no statistically significant difference between the B1, B2 parcels with boron application and the O3 parcel with IAA application and the witness parcels, the grain yields were low in the B3, O1 and O2 applied parcels.

Original Sequence				Ranked Rank						
O1	1	428.5	BCD	B1	4	687.7	A			
O2	2	388.8	CD	B2	5	639.7	A	B		
O3	3	579.7	ABC	O3	3	579.7	A	B	C	
B1	4	687.7	A	Ş	7	543.8	A	B	C	D
B2	5	639.7	AB	O1	1	428.5		B	C	D
B3	6	340.0	D	O2	2	388.8			C	D
Ş	7	543.8	ABCD	B3	6	340.0				D

Tablo 1.LSD test results of full seed count..

Kurşun et al. (2016), in their research in the Thrace region, stated that there were statistically significant increases in boron content of both soil and leaves as a result of soil and leaf boron applications in field trials established in 2013 and 2014. Yield results from 16 of the 18 field trials established in 2013 and 2014, and according to the results of the variance analysis performed, the results of 9 trials were found to be $p<0.01$, the results of 4 trials were significant at the $p<0.05$ significance level, and they concluded that 3 trials were statistically insignificant.

Boron is a micro element that is required by plants in trace amounts and its deficiency and toxicity limits are close to each other. The fact that the boron application has an important role in pollen tube growth and pollen germination (Barut et al., 2018), Bozca Donbaloğlu (2020) the increase in boron application at low temperatures encourages plant growth in her the research. The appearance of B3 toxicity supports statistical parameters.

The fact that there is no statistical difference between parcel O3 and parcels B1 and B2, Öktüren and Sönmez (2005) indicates that there is a significant relationship between boron and IAA, and boron deficiency is balanced by IAA by IAA. The yield of O1 and O2 parcels, which were applied IAA, was statistically lower than the other parcels. The statistical difference between low-dose applications and high-dose O3, supports that hormones may have effects on the response to environmental factors or on quantitative heredity.

Duca et al. (2003) conducted five-year research on different sunflower genotypes and found significant changes in phytohormones in different organs of sunflower under the influence of the environment. The auxin hormone showed the greatest variation in sunflower leaves under environmental conditions, and the differences were significant at a rate of 33%.

Kireçci and Yürekli (2018) in their study, *Helianthus annuus* L. cv. TARSAN-1018 stated that signal molecules act together against stress in sunflower plant leaves, hormones have effects on signal molecules, and the plant's internal adaptation and defense mechanisms in the regulation of signal responses try to protect themselves from negative situations by giving complex responses.

Özel and Sağlam (2022) stated that the auxin hormone applied to the cotyledon leaves of sunflower accelerated aging, but delayed aging under salt stress in their study conducted in the laboratory environment.

Yu et al. (2022) that lncRNAs found in the endosperm of sunflower may be effective on seed yield and may vary under stress conditions.

Bhatla et al. (2014) The relations of the flowers in the sunflower capitulum with each other; They stated that fertilization, environmental factors between pollen and stigma, and the distribution of auxin and gibberellin in the sunflower capitulum are important, and that reactive oxygen signals are effective on the chemical structure of fertilization and flower structure.

No sunflower with a phyllody appearance was found in the plots where IAA was applied. The positive and negative effects of different IAA doses on grain yield maintains the hypothesis that phyllodies may be caused by the IAA found in sunflower disc flowers, and it is thought that different doses of IAA may create phyllodes.

Salehi et al. (2015) took the 16srII strain that causes phyllody, which is specific to the sesame plant, and infected sunflowers and expressed the change in sunflower as phyllody.

Kitazawa et al. (2017) they observed flower differentiation such as phyllodies in different flowers that they applied phylogeny.

Zaccai et al. (2009) stated in their study on roses that there was a change in the phyllody like petal leaves in roses with flower neck bending and this bending was induced by IAA.

Fambrini et al. (2006), the stem fascia in sunflower can be induced by exogenous IAA and is governed by mutant recessive genes.

Conclusions

Boron and IAA application was statistically significant at $p<0.05$ probability level on live seed setting. According to the results of the LSD test, while the boron-applied plots provided the highest yield potential, B3 toxic, the highest dose, had an effect. Statistically significant differences in the number of filled seeds were found between the plots treated with IAA. The highest dose of O3 was found to be more important than the other IAA doses at the $p<0.05$ probability level. Research shows that the IAA doses applied to the sunflower on the subject will have negative effects as well as positive effects on yield.

The development of soil tillage methods for reduced tillage and carbon emission reduction in the world and mechanization to reduce field traffic is gaining momentum like direct to stubble sowing seeder. However, the most important observations made in the farm where the experiment was carried out were the field traffic caused by the harvesting machines and transport vehicles and the heavy tonnage of the harvesting vehicles, which caused the emergence issue of the field due to the lack of a good seed bed during the planting period. The second crop of sunflower is suitable for cultivation in Central Anatolian conditions. However, the yield may not be at the desired level due to the pre-plant stubble and seed bed being unsuitable for good homogeneous germination. For the growth of second crop oil sunflower, research can be done in terms of yield difference between stubble direct sowing and soil preparation fields.

Acknowledgments

This article has been edited from Samet Gölkaya's master's thesis. I would like to thank Mevlüt GEDIKKAYA, the owner of this field, for his suppor

References

Barut, H., Aykanat, S., Aşıklı, S., & Selim, E. (2018). Bitkisel üretimde bor. *International Journal of Eastern Mediterranean Agricultural Research*, *1*(1), 33-46.

Bernardo, B., & Atamian, H. S. (2019). The Effects of Gibberellic Acid and Auxin Hormones on Heliotropism in Sunflowers. https://digitalcommons.chapman.edu/cusrd_abstracts/328

Bhatla, S. C., Sharma, B., & Shakya, R. (2014). *Floral biology of Sunflowers: a histological and physiological analysis*

Bozca Donbaloğlu, F. (2020). *Ayçiçeği bitkisinde (Helianthus annuus L.) kombine uygulanan borik asit ve sıcaklık stresinin bazı ekolojik parametreler, antioksidan enzimler ve gen ifadeleri üzerine etkisi* Bilecik Şeyh Edebali Üniversitesi, Fen Bilimleri Enstitüsü].

Chen, M., Mishra, S., Heckathorn, S. A., Frantz, J. M., & Krause, C. (2014). Proteomic analysis of Arabidopsis thaliana leaves in response to acute boron deficiency and toxicity reveals effects on photosynthesis, carbohydrate metabolism, and protein synthesis. *Journal of Plant Physiology*, *171*(3-4), 235-242. https://doi.org/https://doi.org/10.1016/j.jplph.2013.07.008

Çil, A., Çil, A. N., ŞAhİN, V., & Akkaya, M. R. (2016). Çukurova Koşullarında II. Üründe Yetiştirilecek Yağlık Ayçiçeğinde (Helianthus annuus L.) En Uygun Ekim Zamanının Belirlenmesi Üzerine Bir Araştırma. *Tarla Bitkileri Merkez Araştırma Enstitüsü Dergisi*, *25*(ÖZEL SAYI-2), 1-1. https://doi.org/10.21566/tarbitderg.281545

Duca, M., Port, A., & Rotaru, T. (2003). Influence Of Dıverse Factors On The Varıabılıty In Auxın And Gıbberellın Contents In Helianthus annuus L. *Helia*, *26*(38), 121-126. https://doi.org/https://doi.org/10.2298/HEL0338121D

Fambrini, M., Bonsignori, E., Rapparini, F., Cionini, G., Michelotti, V., Bertini, D., Baraldi, R., & Pugliesi, C. (2006). stem fasciated, a recessive mutation in sunflower (Helianthus annuus), alters plant morphology and auxin level. *Annals of Botany*, *98*(4), 715-730. https://doi.org/https://doi.org/10.1093/aob/mcl153

Gül, V., Öztürk, E., & Polat, T. (2016). Günümüz Türkiye'sinde bitkisel yağ açığını kapatmada ayçiçeğinin önemi/the importance of sunflower to overcome deficiency of vegetable oil in Turkey. *Alinteri Journal of Agriculture Science*, *30*(1), 70-76.

Kireçci, O. A., & Yürekli, F. (2018). Helianthus annuus L. Yapraklarında Tuz Stresi, Bazı Bitki Hormonları ve SNP Uygulamalarının Sinyal Moleküllerine Etkisi. *Kahramanmaraş Sütçü İmam Üniversitesi Tarım ve Doğa Dergisi*, *21*(5), 665-671. https://doi.org/10.18016/ksudobil.397612

Kitazawa, Y., Iwabuchi, N., Himeno, M., Sasano, M., Koinuma, H., Nijo, T., Tomomitsu, T., Yoshida, T., Okano, Y., & Yoshikawa, N. (2017). Phytoplasma-conserved phyllogen proteins induce phyllody across the Plantae by degrading floral MADS domain proteins. *Journal of Experimental Botany*, *68*(11), 2799-2811. https://doi.org/https://doi.org/10.1093/jxb/erx158

Kurşun, İ., Gürbüz, M. A., Günay, E., Evci, G., Pekcan, V., Kaya, Y., & SÜZer, S. (2016). Bor gübrelemesinin Trakya yöresinde ayçiçeği verimi üzerine etkisi. *BOR DERGİSİ*, *1*(2), 74-85. http://search/yayin/detay/254391

Lamichhane, J. R., Wojciechowski, A., Bourgeois, C., & Debaeke, P. (2022). Genetic Variability for Early Growth Traits in Second Season Sunflower. *Frontiers in Agronomy*, *4*. https://doi.org/10.3389/fagro.2022.822456

Öktüren, F., & Sönmez, S. (2005). Bitki Besin Maddeleri İle Bazı Bitki Büyüme Düzenleyicileri (Hormonlar) Arasındaki İlişkiler. *Derim*, *22*(2), 20-32.

Özel, H., & Sağlam, S. (2022). Strigolactone and Auxin Applications on Cotyledon Senescence in Sunflower Seedlings under Salt Stress. *European Journal of Biology*, *81*(2), 190-196. https://doi.org/10.26650/EurJBiol.2022.1187517

Salehi, M., Esmailzadeh, S., & Salehi, E. (2015). Characterisation of a phytoplasma associated with sunflower phyllody in Fars, Isfahan and Yazd provinces of Iran. *New Disease Reports*, *31*, 6-6. https://doi.org/https://doi.org/10.5197/j.2044-0588.2015.031.006

Schneiter, A., & Miller, J. (1981). Description of sunflower growth stages 1. *Crop Science*, *21*(6), 901-903. https://doi.org/https://doi.org/10.2135/cropsci1981.0011183X002100060024x

Vandenbrink, J. P., Brown, E. A., Harmer, S. L., & Blackman, B. K. (2014). Turning heads: the biology of solar tracking in sunflower. *Plant Science*, *224*, 20-26. https://doi.org/https://doi.org/10.1016/j.plantsci.2014.04.006

Yu, S., Zhang, Z., Li, J., Zhu, Y., Yin, Y., Zhang, X., Dai, Y., Zhang, A., Li, C., & Zhu, Y. (2022). Genome-wide identification and characterization of lncRNAs in sunflower endosperm. *BMC Plant Biology*, *22*(1), 1-14. https://doi.org/https://doi.org/10.1186/s12870-022-03882-5

Zaccai, M., Ackerman, R., Genis, O., Riov, J., & Zik, M. (2009). The bent peduncle phenomenon in roses is a developmental process involving auxin. *Plant Science*, *176*(6), 736-743. https://doi.org/https://doi.org/10.1016/j.plantsci.2009.02.014