MAS Journal of Applied Sciences
Uygulamalı Bilimler Dergisi
ISSN: 2757-5675
masjaps.com

OPEN ACCESS

DOI: http://dx.doi.org/10.5281/zenodo.15082178

Review Article

Role of Giberellic Acid (GA3) in Seed Germination and Early Seedling Development in Some Field Crops: A Review

Nilüfer KOÇAK ŞAHİN [1*], Onur OKUMUŞ [2], Ahmet SAY [3]
[1] Ankara University, Faculty of Agriculture, Department of Field Crops, Ankara
[2] Erciyes University, Faculty of Agriculture, Department of Field Crops, Kayseri
[3] Erciyes University, Faculty of Agriculture, Department of Agricultural Biotechnology, Kayseri
*Corresponding author: nkocak@ankara.edu.tr

Received: 18.11.2024 **Accepted**: 30.12.2024

Abstract

Seed development and germination are of significant importance in life cycle of both monocotyledonous and dicotyledonous seeds. Germination begins with the absorption of water by a dormant seed, and a radicle emerges from the seed coat. The distribution of germination is influenced by environmental factors that regulate dormancy and germination potential, as well as the genetic characteristics of the plant. Abcisic acid (ABA) and gibberellins (GAs) are considered phyto-hormones that regulate and seed dormancy inversely. Uniformity in germination and initial growth are the functions of seeds, which are mainly affected by excessive fertilizer use of fertilizers, wrong cultural practices soil quality. Various seed coating methods, including GA, have been used to reduce salinity and drought in field crops. Many studies establish that GA_3 doses positively affect plant growth and development under various stress factors. This study is expected to summarize GA_3 studies and serve as an example for future research.

Keywords: Gibberellic acid (GA3), field crops, dormancy, germination

1. Introduction

The survival and spread of plant species depend fundamentally on seed development and germination. The main function of the seed is the protection of embryos with the help of external signals to synchronize for the correct start of life (Bhatla and Lal, 2023). Germination commences when the dormant, desiccated seed absorbs water, culminating in the emergence of the radicle from seed (Okumuş and Kahraman, 2024). Germination is the most important stage of seedling formation plays and an important role in plant production (Kocak Sahin, 2024). The germination is dependent on the interaction between the environmental factors and genetic characteristics of the plant. Seeds produced by plants subjected to low temperatures exhibit elevated dormancy levels, whilst those provided with nitrate demonstrate reduced dormancy. Initially, it optimizes dispersion, thereby reducing competition among resources among the progeny and the parent plants (Carrera–Castaño et al., 2020). Carbohydrates, protein, lipids, and nutrients, which are accessible to the seed embryo via the action of certain enzymes and metabolic pathways must be available to seeds in the pre germination period. For instance, cystatins or phytocystatins, inhibit the activity of cysteine proteinases, and inhibit protein degradation, (Miransari and Smith, 2014). Bassel et al. (2011) have explained the distribution of genes in several sections of seed. Seed dormancy and germination are influenced by the interactive effects of several signals that may induce seed hibernation (Miransari and Smith, 2014). The seed absorbs moisture before seed germination. The process of seed germination is complete when the radicle emerges from the protective seed coverings (Huss and Gierlinger, 2021). Environmental variables govern endogenous components, influencing seed germination (Gong et al., 2022). Hormonal control is essential in this process. It modulates gene expression and signal transductions, among seed plants (Nonogaki, 2014). Moreover, all other categories of phytohormones modulate seed dormancy and germination, presumably by engaging in the abscisic acid (ABA) or gibberellin (GA_3) mechanism (Shu et al., 2016). Uniformity in germination, along with initial growth and development, constitutes the primary factor influencing plant yield. Gibberellic acid is one of the growth hormone that has a role in seed germination. Previous research indicated that low-temperature stress adversely affected seedling emergence; however, seed treatment with $GA_3$3 significantly enhanced seedling emergence (Chen et al., 2005; Aziz and Peşen, 2020). Gibberellins are diterpenoids that regulate plant development. They, which are frequently utilized in contemporary agriculture, were initially extracted from the metabolic byproducts of the rice pathogenic fungus, Gibberella fujikuroi, in 1938 (Yamaguchi, 2008; Santner et al., 2009). Germination is depend on the physiological condition (dormancy) of the seed, which is influenced by the interaction between the plant genotype and several environmental conditions, including temperature, soil moisture, light, and nutrient availability. This is primarily accomplished through the regulation of the metabolism and signaling of gibberellins (GA_3s) and abscisic acid (ABA), two phytohormones that exhibit antagonistic functions. Their spatio-temporal equilibrium is crucial in seed biology, promoting dormancy over germination when the ABA/GA_3 ratio is elevated, and vice versa when it is diminished (Holdsworth et al., 2008). Giberelic acid has been used in field crops to ameliorate the damages of many abiotic stress factors (Okumuş and Kahraman, 2024; Turan and Samur, 2024). This review reports influence of gibberellic acid to induce seed germination.

2. Materials and Methods

The researchers who examined the effects of various doses of GA_3, salts such as NaCl, pure water, and their interactions on various agricultural characteristics of field crops, which are the subject of this review, and the findings of these researchers will be examined in more detail in the following parts, which are summarized in Table 1 and discussed in detail thereafter.

Table 1. Gibberellic acid application on seed germination in some field crops

Plant material	Methods and Findings	Reference
Triticosecale Wittmack	Four doses (0, 100, 200, and 300 mg l^{-1}) of GA_3 and (3) doses of salt (NaCl) (50, 100, and 200 mM) were used. The best germination ratio was found at 300 mg l^{-1} gibberellic acid + 0 mM (Control) salt combination.	(Altuner et al., 2019)
Cicer arietinum	(5) doses (Namely, 0, 5 µM, 10 µM, 15 µM, and 20 µM GA_3) were used. Seeds were germinated at 9 ºC. Degrees for cold stress and 10 µM increasing final emergence percentage.	(Aziz and Pekşen, 2020)
Sorghum bicolor	FourGA_3doses (0, 100, 200, and 300 mg l^{-1}) were used for 24 hours, and seeds were normally germinated at (0, 2500, 5000, 7500, and 10000 mg l^{-1}) NaCl doses.	(Yıldırım et al., 2022)
Linum usitatissimum	Seeds were treated with pure water, 500 ppm, 250 ppm, and 100 ppm GA_3 doses for 12 hours and germinated at 25 ºC room temperature. As a result of the study, the best results were obtained from 250 ppm and 500 ppm GA3 applications compared to the control group. The results of the study show that gibberellic acid applications generally have a positive effect on germination and seedling growth in flax varieties.	(Çiçek et al., 2022)
Brassica napus	Four different doses (0, 25, 50, and 100 mg l^{-1}) of GA_3 were applied to the seeds of 3 rapeseed varieties. It was reported that all traits were increased as the doses of the applications increased, the highest values were determined at the dose of 100 mg l^{-1}.	(Gürsoy, 2023)
Helianthus annuus	Its seeds were treated with (GA_3) and they were pretreated firstly with glycine betaine (GB) (0, 15, 30, and 45 mg l^{-1}) as biostimulant for 12 hours, and salt and drought stress were applied (4) doses of (NaCl (0, 6, 9 and 12 dS m^{-1}) and PEG 6000 chemical (0, –0.4, –0.8 and –1.2 Mpa), relatively. It was found that a 30 mg l^{-1} GA_3 dose has an ameliorative effect on salt stress.	(Yağcı, 2023)
Triticum avestivum	In their study, GA_3 was applied at concentrations of 0, 100 and 200 ppm to reduce the negative effects of salt stress. The results showed that GA_3 decreased the germination percentage, shootlength and root length significantly increased. It was found that Demirhan cultivar showed more pronounced responses at higher salt stress. They reported that 100 ppm GA_3 application reduced the negative responses of salt stress.	(Kahraman and Okumuş, 2024)
Hordeum vulgare	In their study, GA_3 was applied at concentrations of 0, 100 and 200 ppm to reduce the negative effects of salt stress. In their study, GA_3 was applied at concentrations of 0, 100 and 200 ppm to reduce the negative effects of salt stress. As a result of the study, they reported that 100 ppm GA3 dose positively affected the initial growth and development under saline conditions.	(Okumuş and Kahraman, 2024)
Vicia sativa	In their study, GA3 was applied at concentrations of 0, 100 and 200 ppm to reduce the negative effects of salt stress. In their study, GA_3 was applied at concentrations of 0, 100 and 200 ppm to reduce the negative effects of salt stress. As a result of the study, they reported that GA_3 applications decreased wet and dry weight but increased shoot and root length.	(Okumuş and Yaman, 2024)

3. Results and Discussion

As known, gibberellic acid (or GA_3) is one of the phytohormones that have a major and starter role in all field crops and seed germination processes. Previous research has indicated that low–temperature stress adversely affects seedling emergence (Aziz and Peşen, 2020). Gibberellins are diterpenoids that regulate plant development, and are extracted from rice pathogenic fungus, *Gibberella fujikuroi*, (Yamaguchi, 2008). Paradoxically, germination is due to change in the seed physiological conditions (e.g. dormancy), which is influenced by the interaction between the genotypes and temperature, light, and nutrient(s) soil moisture etc. (Holdsworth et al., 2008). The dormancy related and germination indicated in Arabidopsis mutants showed genes associated with gibberellin (GA) and abscisic acid (ABA) signalling, percetion and production, (Carrera–Castaño et al., 2020). Therefore, gibberelic acid has been used in field crops to ameliorate the damages of many abiotic stress factors (Okumuş and Kahraman, 2024). When Table 1 is analyzed, the effects of different field crops on using gibberellic acid in the early period were examined. When the table is examined, 0, 100, 200, and 300 mg l^{-1} GA_3 were used to reduce salt stress in *Triticosecale Wittmack*. Therefore, the 300 mg l^{-1} GA_3. GA had a positive effect (Altuner et al., 2019). To reduce cold stress in *Cicer aritenum*, 4 different doses of control, 5 µM, 10 µM, 15 µM, and 20 µM GA_3 were used. They determined that 10 µM GA_3 reduced the negative effect of cold stress (Aziz and Pekşen, 2020). Sorghum bicolor control, 0, 100, 200, and 300 300 mg l^{-1} GA_3. GA_3 to reduce salt stress. No significant difference was found as a result of the study (Yıldırım et al., 2022). They used 100, 250 and 500 ppm GA (12 h) in *Linum usitatissimum*. As a result of the study, they reported that 250 and 500 ppm GA positively affected plant growth and development (Çiçek et al., 2022). The researchers used GA_3 at 0, 125, 250, 250, 375, and 500 300 mg l^{-1} GA_3 doses in *Lavandula* spp. Thereafter, they reported that 375 mg l^{-1} GA_3. GA_3 application positively affected the germination (Cantürk, 2023). *Brassica napus* was treated with 0, 25, 50, and 100 mg l^{-1} GA_3. Consequently, they reported that a 100 mg l^{-1} GA_3 dose had a positive effect (Gürsoy, 2023). *Helianthus annuus* was treated with control 0, 15, 30, and 45 mg l^{-1} of GA_3. The study was conducted to reduce the negative effects of salt and drought stress. It was reported that a 30 mg l^{-1} GA_3 dose reduced the negative effect of stress (Yağcı, 2023). *Triticum avestivum, Hordeum vulgare* and *Vicia sativa* was treated with control, and 100 and 200 mg l^{-1} GA were used to reduce salt stress in plants. As a result of the study, they reported that 100 mg l^{-1} GA dose significantly reduced the negative stress of salt (Okumuş and Yaman, 2024).

4. Conclusion

The study investigated the impact of different GA_3 doses on plant growth and development in field crops, highlighting the potential of GA_3 in reducing stress factors like salinity and drought, and is expected to be a pioneering scientific study.

Declaration of Author Contributions

The authors declare that they have contributed equally to the article. All authors declare that they have seen/read and approved the final version of the article ready for publication.

Declaration of Conflicts of Interest

All authors declare that there is no conflict of interest related to this article.

References

Altuner, F., Oral, E., Tunçtürk, R., Baran, İ., 2019. Gibberellik asit ön uygulamasına tabi tutulmuş triticale (x *Triticosecale wittmack*)' de tuz (NaCl) stresinin çimlenme üzerine etkisi. *Kahramanmaraş Sütçü İmam Üniversitesi Tarım ve Doğa Dergisi*, 22 (Ek Sayı 2): 235–242.

Aziz, T., Pekşen, E., 2020. Seed priming with gibberellic acid rescues chickpeas (*Cicer arietinum* L.) from chilling stress. *Acta Physiologiae Plantarum*, 42: 1–10.

Bassel, G.W., Lan, H., Glaab, E., Gibbs, D.J., Gerjets, T., Krasnogor, N., Bonner, A.J., Holdsworth, M.J., Provart, N.J., 2011. Genome-wide network model capturing seed germination reveals coordinated regulation of plant cellular phase transitions. *Proceedings of the National Academy of Sciences*, 108(23): 9709-9714.

Bhatla, S.C., Lal, M.A., 2023. Seed Dormancy and Germination. Singapore: Springer Nature Singapore.

Cantürk, A., 2023. Fotoperiyot, potasyum nitrat ve giberellik asidin lavanta *(Lavandula angustifolia)* tohumlarında dormansinin kırılması ve çimlenme üzerine etkisi. Yüksek Lisans Tezi, Ordu Üniversitesi, Fen Bilimleri Enstitüsü, Ordu.

Carrera–Castaño, G., Calleja–Cabrera, J., Pernas, M., Gómez, L., Oñate–Sánchez, L., 2020. An updated overview of the regulation of seed germination. *Plants*, 9(6): 703.

Chen, D., Gunawardena, T., Naidu, B., Fukai, S., Basnayake, J., 2005. Seed treatment with gibberellic acid and glycinebetaine improves seedling emergence and seedling vigour of rice under low temperature. *Seed Science Technology*, 33: 471–479.

Çiçek, Ş., Yalınkılıç, N.A., Başbağ, S., Bayram, A., 2022. Farklı gibberellik asit konstanstrasyonlarının bazı keten (*Linum usitatissimum* L.) çeşitlerinin çimlenme ve fide gelişimi üzerine etkileri. *Publishing Editors*, 57.

Gong, D., He, F., Liu, J., Zhang, C., Wang, Y., Tian, S., Sun C., Zhang, X., 2022. Understanding of hormonal regulation in rice seed germination. *Life*, 12(7): 1021.

Gürsoy, M., 2023. Kolza (*Brassica napus* L.) çeşitlerine uygulanan farklı giberellik asit dozlarının çimlenme ve fide gelişimine etkileri. *12th Internatıonal Zeugma Conference on Scientific Research*, Kongre Bildiriler Kitabı, p. 264-369.

Holdsworth, M., Bentsink, L., Soppe, W.J.J., 2008. Molecular networks regulating Arabidopsis seed maturation, after-ripening, dormancy and germination. *New Phytologist*, 179: 33–54.

Huss, J.C., Gierlinger, N., 2021. Functional packaging of seeds. *New Phytologist*, 230(6): 2154-2163.

Miransari, M., Smith, D.L., 2014. Plant hormones and seed germination. *Environmental and Experimental Botany*, 99: 110–121.

Nonogaki, H., 2014. Seed dormancy and germination—Emerging mechanisms and new hypotheses. *Frontiers in Plant Science,* 5: 233.

Okumuş, O., Kahraman, N.D., 2024. Effect of gibberellic acid on germination and seedling growth of barley under NaCl–induced salinity. *International Journal of Agricultural and Natural Sciences*, 17(3): 330–337.

Okumuş, O., Yaman, M., 2024. The effect of the gibberellic acid application on germination characteristics of common vetch (*Vicia sativa* L.) under salt stress. *Current Trends in Natural Sciences*, 13(25): 28–33.

Şahin, N.K., 2024. Stimulatory effects of different seed priming treatments on germination and early seedling growth *of Sugar beet. ISPEC Journal of Agricultural Sciences*, *8*(4): 1056-1067.

Santner, A., Calderon-Villalobos, L., Estelle, M., 2009. Plant hormones are versatile chemical regulators of plant growth. *Nature Chemical Biology*, 5: 301–307.

Shu, K., Liu, X. D., Xie, Q., He, Z.H., 2016. Two faces of one seed: hormonal regulation of dormancy and germination. *Molecular Plant*, *9*(1): 34-45.

Turan, F., Samur, S., 2024. Kolza (*Brassica napus* L.) tohumuna borik asit ve gibberellik asit ön uygulamalarının kuraklık stresine karşı etkisinin incelenmesi. *ISPEC Journal of Agricultural Sciences*, 8(3):756-765.

Yağcı, E., 2023. Farklı tuz konsantrasyonları ve kuraklık stresi uygulamalarının ayçiçeği (*Helianthus annuus* L.)'nde çimlenme ve fide gelişimine etkileri. Yüksek Lisans Tezi, Sakarya Uygulamalı Bilimler Üniversitesi, Lisansüstü Eğitim Enstitüsü, Sakarya.

Yamaguchi, S., 2008. Gibberellin metabolism and its regulation. *Annual Review of Plant Biology*, 59: 225–251.

Yıldırım, C., Başak, M., Aydınoğlu, B., 2022. Gibberellik asit (GA_3) uygulamalarının farklı tuz yoğunluklarında sorgum [*Sorghum bicolor* (L.) Moench] tohumlarının çimlenme ve fide gelişimi üzerine etkileri. *Türkiye Tarımsal Araştırmalar Dergisi*, *9*(3):323–333.

To Cite: Koçak Şahin, N., Okumuş, O., Say, A., 2025. Role of Giberellic Acid (GA3) in Seed Germination and Early Seedling Development in Some Field Crops: A Review. *MAS Journal of Applied Sciences*, 10(1): 39-44.
DOI: http://dx.doi.org/10.5281/zenodo.15082178.