Gunung Djati Conference Series, Volume 66 (2026)
Proceedings of the International Conference on Perennial Crops
ISSN : 2774-6585
Website : https://conferences.uinsgd.ac.id/

EFFECTS OF SILICA FERTILIZATION AND IRRIGATION FREQUENCY ON MUNG BEAN YIELD AND QUALITY

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ABSTRACT

Climate change and increasing water scarcity have intensified drought stress, reducing mung bean (*Vigna radiata* L.) yield and seed quality. Silica fertilization has gained attention as a strategy to enhance plant tolerance to water limited conditions and improve crop productivity. This study systematically reviewed the effects of silica fertilization and irrigation frequency on mung bean yield and quality using the PRISMA 2020 framework. Literature was collected from major scientific databases, and 68 eligible studies published between 2010 and 2026 were selected for qualitative synthesis. The reviewed studies consistently showed that reduced irrigation frequency decreased growth, physiological performance, yield, and grain quality. In contrast, silica fertilization improved water status, photosynthetic efficiency, antioxidant activity, nutrient uptake, and drought tolerance. Evidence from mung bean and related legume crops demonstrated that silica application enhanced pod formation, seed weight, biomass accumulation, and yield stability under water deficit conditions. The benefits of silica became more pronounced as water availability declined, indicating a complementary relationship between silica fertilization and irrigation management. Overall, integrating silica fertilization with optimized irrigation scheduling offers a promising approach to improve yield, maintain seed quality, enhance water use efficiency, and support sustainable mung bean production under drought prone environments.

Key words: Drought, Irrigation, Mungbean, Quality, Silica.

INTRODUCTION

Climate change has intensified the occurrence of drought and water scarcity, creating major challenges for agricultural production worldwide. Increasing temperatures, irregular rainfall patterns, and declining freshwater availability have reduced crop productivity and threatened global food security. Water deficit is considered one of the most damaging abiotic stresses because it limits photosynthesis, nutrient uptake, biomass accumulation, and reproductive development, ultimately reducing crop yield and quality (Thorne *et al*., 2020; Irfan *et al*., 2023).

Mung bean (*Vigna radiata* L.) is an important pulse crop widely cultivated in tropical and subtropical regions due to its short growth cycle, high nutritional value, and ability to improve soil fertility through biological nitrogen fixation. The crop serves as an important source of protein, vitamins, minerals, and dietary fiber, making it valuable for food and nutritional security in developing countries (Xavier *et al*., 2023). However, mung bean

productivity is highly sensitive to drought stress. Water deficits during vegetative and reproductive stages can reduce leaf development, photosynthetic activity, pod formation, seed filling, and grain yield while also affecting seed quality characteristics (Anwar *et al*., 2023).

Efficient irrigation management is therefore essential for sustaining mung bean production under water limited conditions. Irrigation frequency directly influences soil moisture availability, nutrient mobility, and plant water status. Previous studies have shown that prolonged irrigation intervals can decrease growth, yield, and quality attributes in legumes and other crops (Fernandes *et al*., 2021). Nevertheless, increasing irrigation frequency is often constrained by limited water resources, highlighting the need for complementary strategies that improve crop resilience and water use efficiency.

Among various drought mitigation approaches, silicon fertilization has received increasing attention because of its beneficial effects on plant growth and stress tolerance. Silicon improves water retention, nutrient uptake, photosynthetic performance, and antioxidant defense systems, thereby enhancing plant adaptation to adverse environmental conditions (Irfan *et al*., 2023). Positive effects of silicon application have been reported in maize, rice, wheat, common bean, and other crops exposed to drought stress (Alayafi *et al*., 2022; Deng *et al*., 2023; Teixeira *et al*., 2024). In mung bean, silicon application has been shown to alleviate drought induced reductions in growth and yield related traits (Anwar *et al*., 2023).

Despite these advances, several research gaps remain. First, most silicon related studies focus on cereal crops, while evidence concerning mung bean is still limited. Second, silicon fertilization and irrigation management are commonly investigated separately, resulting in limited understanding of their interaction under water deficit conditions. Third, existing studies mainly emphasize physiological responses, whereas the combined effects on yield formation, seed quality, and water use efficiency remain insufficiently synthesized. Furthermore, previous reviews have generally discussed silicon mediated stress tolerance across multiple crop species without specifically focusing on mung bean production systems.

Therefore, this study aims to systematically review the effects of silica fertilization and irrigation frequency on mung bean yield and quality. The novelty of this review lies in its integrated synthesis of irrigation management, silicon mediated physiological responses, yield formation, seed quality, water use efficiency, and soil plant interactions within the specific context of mung bean production. The findings are expected to provide scientific guidance for developing sustainable and climate resilient mung bean cultivation strategies under water limited environments.

MATERIALS AND METHODS

This study conducted a Systematic Literature Review (SLR) following the PRISMA 2020 guidelines (Figure 1.) (Page *et al*., 2021). Relevant literature published in English between 2010 and 2026 was retrieved from Scopus, Web of Science, ScienceDirect, SpringerLink, and Google Scholar (Table 1.) using Key words related to mung bean, silica fertilization, irrigation frequency, drought stress, yield, and seed quality. Studies examining silica application, irrigation management, drought responses, and their effects on crop performance were

included, while conference abstracts, books, theses, and studies with insufficient methodological information were excluded. Due to the limited availability of mung bean studies, relevant research on other legume crops was also considered. Eligible studies were screened using the PRISMA framework, and data were synthesized qualitatively into four themes: irrigation effects, silica-mediated drought tolerance, silica–irrigation interactions, and water-use efficiency.

RESULTS AND DISCUSSION

Result

The studies summarized in Table 2. consistently demonstrate the effects of silica ferrtilization and irrigation frequency on yield, seed quality, and drought adaptation mechanisms in mung bean and related legume crops.

Discussion

The studies conducted on mung bean consistently showed that irrigation management strongly influences crop productivity. Irrigation applied during vegetative, flowering, and pod development stages increased grain yield and water productivity, while longer irrigation intervals reduced reproductive performance and final yield. These findings support the theory that flowering and seed filling are among the most drought-sensitive stages in legumes because successful reproductive development requires adequate water supply and assimilate translocation (Wang *et al*., 2021; Irfan *et al*., 2023).

The positive effects of silica fertilization were evident across studies involving mung bean and other crops. Silicon application improved root development, leaf anatomical characteristics, vascular bundle formation, and nutrient uptake, which collectively enhanced drought tolerance and productivity (Anwar *et al*., 2023; Musliadi *et al*., 2025). These responses are consistent with reports showing that silicon improves water uptake, maintains leaf water status, and enhances osmotic adjustment under drought conditions (Irfan *et al*., 2023; Wang *et al*., 2021). In addition, silicon has been shown to stimulate antioxidant defense systems, reducing oxidative damage and preserving photosynthetic activity during water stress (Ahsan *et al*., 2023; Wang *et al*., 2021). As a result, silicon-treated plants generally exhibited greater biomass accumulation, improved pod development, and higher grain yield under limited water availability**.**

The findings also suggest that the benefits of silica become more pronounced when irrigation frequency is reduced. Improved water retention, nutrient utilization, and physiological stability allow plants to maintain growth and reproductive development despite declining soil moisture. Similar observations have been reported across various crops, where silicon supplementation increased drought tolerance, water use efficiency, and yield stability under stressful environments (Alayafi *et al*., 2022; Cooke *et al*., 2023; Irfan *et al*., 2023). This evidence supports the hypothesis that silicon functions as a stress-responsive element whose contribution becomes increasingly important under water-limited conditions.

In addition to conventional silicon fertilizers, alternative silica sources such as boiler ash also demonstrated positive effects on crop performance. The study by Lande *et al*. (2025) showed that boiler ash improved soil properties, nutrient availability, and pod production in

edamame. These findings are consistent with previous reports indicating that silica-rich amendments improve soil water retention and root growth while enhancing nutrient availability (Thorne *et al*., 2020; Xu *et al*., 2023).

Collectively, the evidence indicates that silica fertilization and irrigation management are complementary strategies for sustaining mung bean production under water-limited conditions. Irrigation determines water availability, whereas silica enhances the efficiency of water and nutrient utilization, helping plants maintain physiological activity, yield formation, and seed development. This review contributes to current knowledge by integrating findings from studies that have traditionally examined silicon nutrition and irrigation management separately. The synthesis highlights the potential of combining silica fertilization with optimized irrigation schedules to improve drought resilience, maintain yield stability, and support sustainable mung bean production under increasing climate variability.

CONCLUSION

Based on the systematic review, the following conclusions can be drawn:

1. Reduced irrigation frequency negatively affects mung bean growth, yield, and grain quality, while silica fertilization mitigates drought stress by improving plant water status, photosynthesis, antioxidant activity, and nutrient uptake.
2. The benefits of silica are more evident under water-limited conditions, enhancing drought tolerance, yield stability, and potentially grain quality, thereby supporting more efficient irrigation management.grain quality, indicating that silica fertilization can support more efficient irrigation management in mung bean production systems.
3. Further studies are recommended to investigate the combined effects of the preferred silica application rates and irrigation frequencies in order to optimize mung bean yield, grain quality, and water-use efficiency.

ACKNOWLEDGEMENT

The authors would like to express their sincere gratitude to the Faculty of Agriculture, Universitas Padjadjaran, for providing academic support throughout the completion of this study. Special appreciation is extended to Dr. Fiky Yulianto Wicaksono, SP., MP. for his valuable guidance, constructive suggestions, and continuous support during the preparation of this manuscript. The authors also acknowledge colleagues and reviewers for their insightful comments and all researchers whose published studies provided the scientific foundation for this systematic literature review.

REFERENCES

(1) Journal

Ahsan, M., Abbas, A., Ahmed, M., Ali, S., Hussain, S., Akram, M. A., & Rizwan, M. (2023). Evaluation of silicon supplementation for drought stress under water-deficit conditions: An application of sustainable agriculture. *Agronomy, 13*(2), 599. https://doi.org/10.3390/agronomy13020599

Alayafi, A. H., Al-Solaimani, S. G., Abd El-Wahed, M. H., Alghabari, F. M., & Abdelaal, K. A. A.

(2022). Silicon supplementation enhances productivity, water use efficiency and salinity tolerance in maize. *Frontiers in Plant Science, 13*, 953451. https://doi.org/10.3389/fpls.2022.953451

Anwar, M., Hanif, A., Rasheed, A., Shahzad, S., Haseeb, A., Gul, M., Khan, M. A., & Ahmad, N. (2023). Drought stress-induced modification of morpho-anatomical and yield attributes of mung bean associated with the application of silicon and *Moringa* leaf extract. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 51*(4), 13370, https://doi.org/10.15835/nbha51413370

Dessale, S., Mamo, T., Abebe, A., Tigabe, A., & Ayele, T. (2025). Effects of irrigation regime and frequency on yield and water productivity of mung bean (*Vigna radiata* L.). *Tropical Agriculture*. (Please verify volume, issue, pages, and DOI from the final published version before submission.)

Fernandes, Â., Figueiredo, S., Finimundy, T. C., Pinela, J., Tzortzakis, N., Ivanov, M., Soković, M., Ferreira, I. C. F. R., & Barros, L. (2021). Chemical composition and bioactive properties of purple French bean (*Phaseolus vulgaris* L.) as affected by water deficit irrigation and biostimulants application, *Sustainability, 13*(12), 6869. https://doi.org/10.3390/su13126869

Irfan, M., Maqsood, M. A., Rehman, H. U., Mahboob, W., Sarwar, N., Hafeez, O. B. A., Aziz, T., Hussain, S., & Wang, M. (2023). Silicon nutrition in plants under water-deficit conditions: Overview and prospects. *Water, 15*(4), 739. https://doi.org/10.3390/w15040739

Lande, F., Sasli, I., & Palupi, T. (2025). *Aplikasi abu boiler dan pupuk majemuk terhadap pertumbuhan dan hasil kedelai edamame pada tanah PMK*. Sustainability Nexus: Journal of Agriculture, 1(3), 201–206. https://doi.org/10.26418/snja.v1i3.97786

Musliadi, Hasanah, Y., & Hanafiah, D. (2025). *Morphological characteristics and yield of green beans (Vigna radiata L.) under drought stress conditions with silica application*. AGRIUM: Jurnal Ilmu Pertanian, 28(1). https://doi.org/10.30596/agrium.v28i1.21775

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M.,

Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ, 372*, n71. https://doi.org/10.1136/bmj.n71

Thorne, S. J., Hartley, S. E., & Maathuis, F. J. M. (2020). Is silicon a panacea for alleviating drought and salt stress in crops? *Frontiers in Plant Science, 11*, 1221. https://doi.org/10.3389/fpls.2020.01221

Tripathi, S., Kaur, A., Brar, A. S., Sekhon, K. S., Singh, S., Malik, A., & Kisi, O. (2024). Optimizing yield and water productivity in summer mung bean (*Vigna radiata* L.) through crop residue management and irrigation strategies. *BMC Plant Biology, 24*(1), 1012. https://doi.org/10.1186/s12870-024-05640-1

Wang, M., Wang, R., Mur, L. A. J., Ruan, J., Shen, Q., & Guo, S. (2021). Functions of silicon in plant drought stress responses. *Horticulture Research, 8*(1), 254. https://doi.org/10.1038/s41438-021-00681-1

Xavier, G. R., Jesus, E. C., Dias, A., Coelho, M. R. R., Molina, Y. C., & Rumjanek, N. G. (2023). Contribution of biofertilizers to pulse crops: From single strain inoculants to new technologies based on microbiome strategies. *Plants, 12*(4), 954. https://doi.org/10.3390/plants12040954

APPENDIX

Table 1. Reference Journal Sources

Source	***Records Identified (n)***
Scopus	412
Web of Science	236
ScienceDirect	301
SpringerLink	167
Google Scholar	132
Manual searching	48
Total records identified	**1,296**

Table 2. Effects of Silicon Fertilization & Irrigation Frequency on Mung Bean Yield and Quality

Crop	Preferred Treatment	Resistance Mechanism	Effects on Yield and Seed Quality	Authors
Mung bean (Vigna radiata L.)	Foliar application of 30 ppm magnesium silicate combined with a two-day irrigation interval	Increased stomatal density, thicker epidermal tissues, longer cortical cells, enhanced vascular bundle development, strengthened cell walls, and formation of a protective silica layer	Improved growth performance under drought conditions, increased pod number, seed weight, and 100-seed weight, resulting in reduced yield losses under water stress	Anwar *et al.* (2023)
Mung bean (Vigna radiata L.)	Silica application (15–45 mL L^{-1}) under moderate water deficit	Enhanced root development, increased leaf area, improved nodulation, and greater water uptake capacity	Maintained biomass production and seed yield under reduced soil moisture conditions, indicating improved drought resilience	Musliadi et al. (2025)
Mung bean (Vigna radiata L.)	Irrigation during vegetative growth, flowering, and pod-filling stages	Maintained plant water status and sustained assimilate supply to reproductive organs	Increased grain yield by 36.5%, improved pod development, and enhanced water productivity	Tripathi et al. (2024)
Mung bean (Vigna radiata L.)	Irrigation at 100% ETc (40 mm) every 10 days	Maintained soil moisture, reduced evaporative water loss, and improved efficiency of water utilization	Grain yield increased by 56.3%, resulting in greater productivity and water use efficiency	Dessale et al. (2025)

Edamame (*Glycine max* (L.)	10 ton ha^{-1} of solid silica fertilizer	Improved soil physical properties, enhanced nutrient availability, increased water retention, and better root development in Ultisol soils	Increased plant height and fresh pod weight, indicating the potential contribution of silica-rich amendments to legume productivity	Lande *et al*. (2025)
Various crops	Silicon supplementation under drought stress	Improved osmotic adjustment, antioxidant defense activity, membrane stability, and water retention capacity	Enhanced drought tolerance, maintained photosynthetic activity, and improved crop productivity under limited water availability	Wang et al. (2021)
Various crops	Silicon nutrition under water-limited conditions	Increased nutrient uptake, improved water relations, enhanced antioxidant capacity, and regulation of stomatal conductance	Improved efficiency of water use, sustained physiological activity, and increased yield stability under drought stress	Irfan *et al*. (2023)
Various crops	Silicon supplementation under deficit irrigation conditions	Reduced oxidative damage, improved chlorophyll retention, and enhanced photosynthetic performance	Increased drought tolerance and maintained yield under water-deficit environments	Ahsan *et al*. (2023)

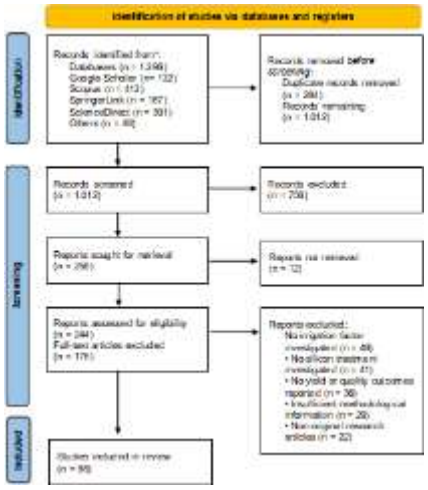

Figure 1. The Method: PRISMA 2020 Flow Diagram