Research, Society and Development, v. 14, n. 10, e21141049394, 2025
(CC BY 4.0) | ISSN 2525-3409 | DOI: http://dx.doi.org/10.33448/rsd-v14i10.49394

Use of sunscreen in soybean cultivation: A scientific note

Uso de protetor solar na cultura da soja: Uma nota científica

Uso de protector solar en el cultivo de soja: Una nota científica

Received: 08/13/2025 | Revised: 09/30/2025 | Accepted: 10/03/2025 | Published: 10/04/2025

Lucas Aparecido Manzani Lisboa
ORCID: https://orcid.org/0000-0001-9013-232X
Universidade Estadual de Ponta Grossa, Brasil
E-mail: lucaslisboa@uepg.br
Hiago Rocha Siqueira
ORCID: https://orcid.org/0009-0006-3557-7055
Universidade Estadual de Ponta Grossa, Brasil
E-mail: 23342222@uepg.br
Marcos Vinícius Jonack
ORCID: https://orcid.org/0009-0002-2576-7489
Universidade Estadual de Ponta Grossa, Brasil
E-mail: 22020022@uepg.br
Fernando Takayuki Nakayama
ORCID: https://orcid.org/0000-0002-6405-7685
Agência Paulista de Tecnologia dos Agronegócios, Brasil
E-mail: fnakayama1980@gmail.com

Abstract
This study aimed to understand the development and productivity of soybeans after foliar sunscreen application. The experimental design was a completely randomized block design, with two sunscreens: Surround®, Sundown®, and absence (Control), resulting in three treatments. Four plots were used per treatment, totaling 16 plots. The plots were 2.7 m wide and 8.0 m long, totaling 21.6 m^2. The Surround® and Sundown® sunscreens showed similar responses for leaf number, pod number, and grain yield in soybean crops. The use of sunscreen may be an alternative to mitigate light stress in soybean crops. Further studies are needed to understand the physiological and developmental responses of soybeans grown after sunscreen application.
Keywords: *Glicyne max* L.; Luminous stress; Plant growth; Grain production.

Resumo
Este trabalho teve como objetivo compreender o desenvolvimento e a produtividade da soja após a aplicação foliar de protetor solar. O delineamento experimental foi o de blocos casualizados, com dois protetores solares: Surround®, Sundown® e ausência (Controle), perfazendo três tratamentos. Foram utilizadas quatro parcelas por tratamento, totalizando 16 parcelas. As parcelas tinham 2,7 m de largura e 8,0 m de comprimento, perfazendo uma área total de 21,6 m^2. Os protetores solares Surround® e Sundown® apresentaram respostas semelhantes para o número de folhas, número de vagens e produtividade de grãos na cultura da soja. O uso de protetor solar pode ser uma alternativa para amenizar o estresse luminoso na cultura da soja. São necessários mais estudos para entender as respostas fisiológicas e de desenvolvimento da soja quando cultivada após a aplicação de protetor solar.
Palavras-chave: *Glicyne max* L.; Estresse luminoso; Crescimento da planta; Produção de grãos.

Resumen
Este estudio tuvo como objetivo comprender el desarrollo y el rendimiento de la soja tras la aplicación de protector solar foliar. El diseño experimental fue un diseño de bloques al azar con dos protectores solares: Surround®, Sundown® y sin protector solar (Control), que comprendió tres tratamientos. Se utilizaron cuatro parcelas por tratamiento, totalizando 16 parcelas. Las parcelas tenían 2,7 m de ancho y 8,0 m de largo, cubriendo un área total de 21,6 m^2. Los protectores solares Surround® y Sundown® mostraron respuestas similares en cuanto al número de hojas, número de vainas y rendimiento de grano en soja. El uso de protector solar puede ser una alternativa para mitigar el estrés lumínico en la soja. Se requieren más estudios para comprender las respuestas fisiológicas y de desarrollo de la soja cultivada tras la aplicación de protector solar.
Palabras clave: *Glycine max* L.; Estrés lumínico; Crecimiento vegetal; Producción de granos.

1. Introduction

Soybean (*Glicyne max* L.) Is important to the Brazilian economy, as it is the most widely produced crop in Brazil, leading in both cultivated area and volume of grains harvested. This makes the country one of the world's largest exporters of soybeans, both in the form of fresh grains and processed products such as meal and oil, with the main destinations being China, the European Union, and other Asian countries. In the 2024/25 harvest, estimated production is approximately 169.49 million tons (Oliveira et al., 2024), with a planted area of 47.61 million hectares (Fabião et al., 2025) and an average productivity of 3,200 kg ha^{-1} (Nakatani et al., 2024).

Soybeans, when exposed to unfavorable conditions in the environment in which they are grown, may experience growth restriction and low productivity. These responses occur at the physiological level through the expression of antioxidant enzymes and morphologically, with changes in the conformity of the internal structures of the tissues of the plant organs (Cunha et al., 2023).

Plant sunscreens refer to products that protect leaves from excess solar radiation, heat, and water loss, thus improving plant resilience to climate change by aiding in thermal regulation and water use efficiency (Barnes et al., 2016; Frioni et al., 2019). They are not sunscreens like those used by humans, but they have similar functions. They act to reduce heat stress, minimizing damage caused by high temperatures and intense solar radiation, protecting against sunburn, spots, or necrosis on leaves and fruits exposed to strong sunlight, preventing fruits such as apples, mangoes, grapes, and coffee from becoming stained or having an appearance that reduces their market value (Silva et al., 2019; Rosati, 2007).

The use of sunscreen on plants can provide stability in photosynthesis by preventing the acceleration of chlorophyll degradation due to excessive UV light and maintaining photosynthetic balance. It reduces water loss (transpiration) by creating a reflective barrier that reduces evaporation, important during periods of drought (Glenn, 2016; Brito et al., 2018). Leading to increased productivity and reduced stress, the plant develops better, resulting in higher production (Soela et al., 2023).

The main products available on the market are Surround WP®, composed of 95% purified kaolin, which forms a white film that protects against sunburn and heat stress; Fotoflex®, composed of hydrated kaolin enriched with additives; Solar Protek®, composed of a concentrated calcium suspension with adjuvants; and Sun Protector®, which features a calcium-enriched formulation with nanoparticle technology. It is applied by foliar spraying, diluted only in water. It can be applied with backpack sprayers, agricultural machinery, or drones.

This study aimed to understand the development and productivity of soybeans after foliar sunscreen application.

2. Materials and Methods

Characteristics of the experimental área

The experiment was carried out in December 2024, at the "Capão da Onça" School Farm of the State University of Ponta Grossa (UEPG), in the South-Central region of the State of Paraná, with geographic coordinates 25°05'34" South latitude and 50°02'53" West latitude, with an altitude of 1027 m. The climate of the region, according to Köppen, is classified as Cfb (mesothermal, humid, subtropical), as it presents uniformly distributed rainfall and no defined dry season. The maximum and minimum temperatures are 22 and 13°C respectively, with an average annual rainfall of 1550 mm.

The soil was classified as Red Latosol, medium texture (Embrapa, 2013) and presented the following chemical attributes as shown in Table 1.

Table 1 - Chemical attributes of the soil at the time of experiment installation. Source: Research data, 2025.

pH	OM	P	K	Ca	Mg	H+Al	Al	SB	CEC	V%	m%
$CaCl_2$	gdm^{-3}	$mgdm^{-3}$			---------------------- $mmol_c\ dm^{-3}$ ---------------------						
4.7	21	43	2.5	19	8	38	8	29.5	67.5	44	21

OM = Organic matter; SB: Sum of bases; CEC: Cation exchange capacity; V%: Base saturation; m%: Aluminum saturation.
Source: Research data (2025).

Experimental design

The experimental design was a completely randomized block design (RBC), with two sunscreens: Surround®, Sundown® and absence (Control), making up three treatments. Four plots were used per treatment, totaling 16 plots. The plots were 2.7 m wide and 8.0 m long, making up a total area of 21.6 m^2.

Implementation and conduction of the experimente

The soil was amended and fertilized according to the nutritional needs of the soybean crop, as per Cantarella et al. (2022). The Zeus IPRO Brasmax® cultivar was sown at a density of 18 seeds per meter and with a spacing of 0.45 m between rows. Base fertilization at sowing was carried out by applying 315 kg ha^{-1} of the formulation 0-20-20 (N-P_2O_5-K_2O). The soybean seeds had a germination power of 80% and a purity of 99%. At sowing, the liquid inoculant Gelfix 5 with Bradyrhizobium elkanii (SEMIA 587 and SEMIA 5019) was used at a concentration of 5.0 × 109 CFU mL^{-1}, at a dose of 600 mL ha^{-1} via furrow.

All cultural treatments were performed as needed, with the fungicides copper oxychloride 588 g L^{-1} active ingredient (a.i.) applied at a dose of 1.0 L ha^{-1}, and on another occasion, Pyraclostrobin (167 g L^{-1} a.i.) + Fluxapyroxad (333 g L^{-1} a.i.) at a dose of 350 mL ha^{-1} of the commercial product. Applications were made with the aid of a motorized backpack pump, at constant pressure, with a spray volume of 150 L ha^{-1}, with a cone-type nozzle. There was no need to apply insecticides during the soybean crop cycle.

Sunscreens were applied at the V7, R1, and R3 soybean development stages. The Surround® and Sundown® doses were 4.0 kg ha^{-1}, and a motorized, constant-pressure backpack sprayer was used to apply a spray volume of 150 L ha^{-1} with a cone-type nozzle.

Carrying out assessments

Within each plot, five plants were sampled, totaling 20 plants per treatment. Plants were sampled at the R5.5 development stage, where they exhibited maximum leaf development and pod formation. A final population of 320,000 plants ha^{-1} was estimated.

Development parameters

The following variables were determined in the sampled plants: leaf number, number of pods obtained by direct counting on the plant and plant height with the aid of a ruler graduated in millimeters.

Production parameter

At the R8 stage, five plants were randomly collected from the three central rows of each plot, totaling 20 plants per treatment. The pods were threshed, and the grains were weighed and converted to 14% moisture content. The Productivity of grain in kg ha^{-1} was estimated.

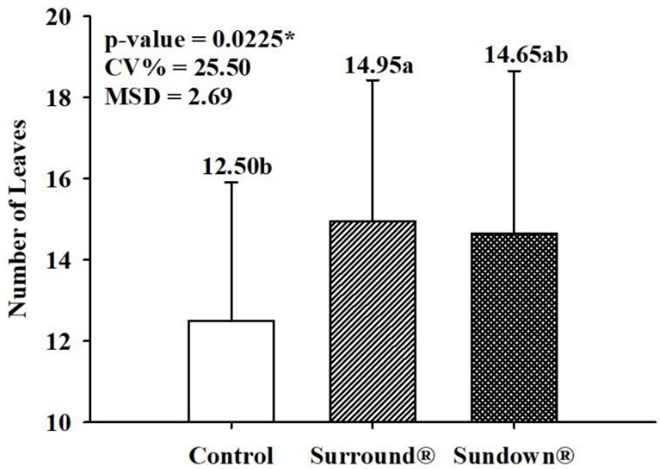
Statistical analysis

For statistical evaluation, the variables were subjected to normality tests using the Shapiro-Wilk test. After complying with the test precepts, analysis of variance was performed using the F test ($p<0.05$) and their means were compared using the Tukey test at 5% probability (Banzatto and Kronka, 2013) and the RStudio statistical program was used (RStudio Core Team, 2019).

3. Results and Discussion

A statistical difference was observed in the number of sheets where the absence of protector use presented a lower average, with 16.38% lower in relation to Surround which presented a higher average as shown in Figure 1.

Figure 1 – Mean values of the number of leaves after foliar application of sunscreen sources.

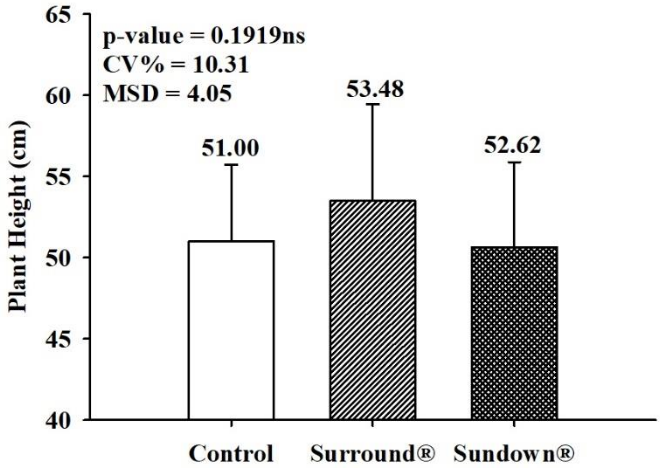


* = Significant at the 5% probability level (0.01 =<p<0.05). Lowercase letters do not differ statistically from each other. Tukey's test was applied at the 5% probability level. CV: Coefficient of Variation. MSD = Minimum Significant Difference. Source: Research data (2025).

Plants have the ability to synthesize flavonoids and related phenylpropanoid derivatives that function as "UV sunscreens" and antioxidants, and also to accumulate these protective UV-absorbing compounds and alter their leaf optical properties (Barnes et al., 2016). The presence of the sunscreen in the leaves enabled a better photosynthetic rate of the leaves, which reflected in greater carbon accumulation and thus ensured a greater number of leaves in soybean plants.

No statistical difference was observed for plant height as observed in Figure 2.

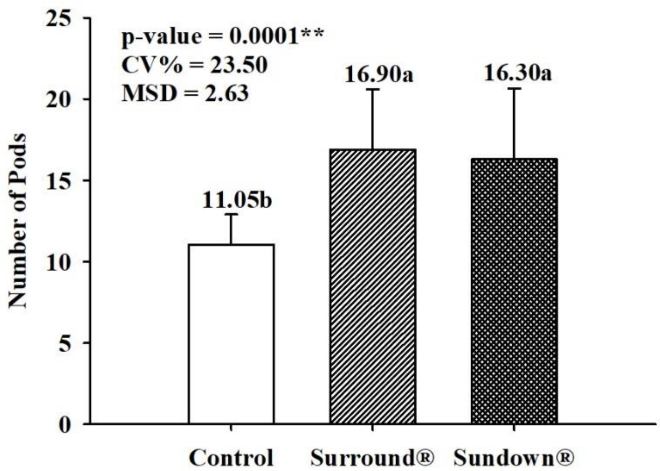
Figure 2 – Mean values of soybean plant height (PH) after foliar application of sunscreen sources.



Ns = Not significant (p>0.05). CV= Coefficient of Variation. MSD = Minimum Significant Difference. Source: Research data (2025).

A statistical difference was observed for the number of pods, the non-use of protector presented a lower average, which reflected a difference of approximately 35.61% lower in relation to the use of Sundown protector as shown in Figure 3.

Figure 3 – Mean values of the number of soybean pods after foliar application of sunscreen sources.

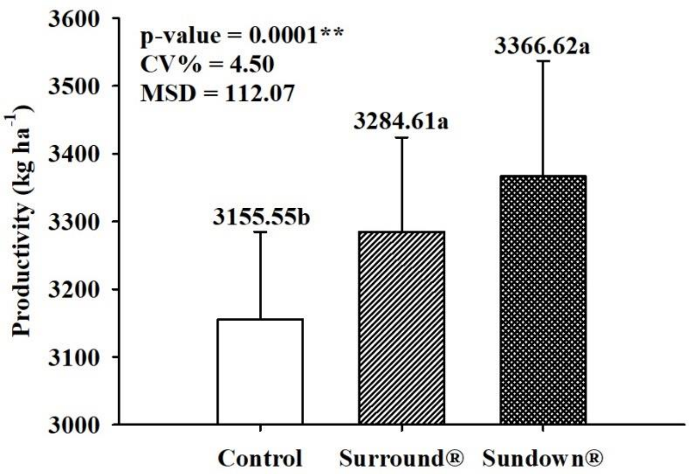


** = Significant at the 1% probability level (p<0.01). Lowercase letters do not vary statistically. Tukey's test was applied at the 5% probability level. CV= Coefficient of Variation. MSD = Least Significant Difference. Source: Research data (2025).

To prevent damage to the photosynthetic apparatus, the use of calcium carbonate applied to the leaves can result in protection against thermal and light stress and, consequently, improve the plant's performance in the field. This occurs due to the increased adaptation of the plant to adverse climates through the control of photooxidative and respiratory stress (Soela et al., 2023; Brito et al., 2018). With the better photosynthetic response of the leaves in the presence of the sunscreen, the plant may have directed a greater amount of photoassimilates to the development of pods in the reproductive phase.

A statistical difference was observed for productivity of grain (kg ha^{-1}), where again the non-use of protector presented a lower average, which implied a difference of 6.26% lower in relation to the use of Sundown, as observed in Figure 4.

Figure 4 – Mean values grain productivity of grain of soybean following foliar application of sunscreen sources.



** = Significant at the 5% probability level (p<0.01). Lowercase letters do not differ statistically from each other. Tukey's test was applied at the 5% probability level. CV: Coefficient of Variation. MSD = Minimum Significant Difference. Source: Research data (2025).

With a greater number of leaves, the photosynthetic rate may have enabled a higher rate of carbon assimilation, resulting in greater synthesis of primary sugars that may have been directed to pod and grain production (Figure 1). Providing ideal environmental conditions for plant development allows for a greater productive response of the crop, demonstrating that the presence of sunscreen on the leaves may have enabled these benefits in plant physiology, which resulted in increased grain production (Abuel-Leil et al., 2024; Frioni et al., 2019).

New studies are needed to deeply understand the responses of plants under conditions of sunscreen use, to understand the developmental responses of organs, tissues and especially physiological actions, since any change in the environmental conditions to which the plant is subjected will present different responses, as each species is more or less adapted under those adverse environmental conditions.

4. Final Considerations

The Surround® and Sundown® sunscreens showed similar responses for leaf number, pod number, and grain yield in soybean crops.

The use of sunscreen may be an alternative to mitigate light stress in soybean crops.

Further studies are needed to understand the physiological and developmental responses of soybeans grown after sunscreen application.

References

Abuel-Leil, E. F., Abdelrahman, M.A. E. & Desoukey, S. F. (2024). Effect of kaolin on productivity, anatomical and biochemical responses to water deficit in Pelargonium graveolens grown in sandy soil. *Bmc Plant Biology*, 24(1), 1-17. http://dx.doi.org/10.1186/s12870-024-05814-x

Banzatto, D. A. & Kronka, S. do N. (2013). *Experimentação Agrícola*. 4.ed. Funep, 237.

Barnes, P. W., Flint, S. D., Tobler, M. A. & Ryel, R. J. (2016). Diurnal adjustment in ultraviolet sunscreen protection is widespread among higher plants. *Oecologia*, 181(1), 55-63. http://dx.doi.org/10.1007/s00442-016-3558-9

Brito, C., Dinis, L., Ferreira, H., Rocha, L., Pavia, I., Moutinho-Pereira, J. & Correia, CM. (2018). Kaolin particle film modulates morphological, physiological and biochemical olive tree responses to drought and rewatering. *Plant Physiology and Biochemistry*, 133, 29-39. http://dx.doi.org/10.1016/j.plaphy.2018.10.028

Cantarella, H., Quaggio, J. A., Mattos Jr., D., Boaretto, R.M. & Raij, B. (2022). *Boletim 100: Recomendações de adubação e calagem para o estado de São Paulo.* 3ed. Campinas: Instituto Agronômico de Campinas, 500.

Cunha, M. L. O., Oliveira, L. C. A., Mendes, N. A. C., Silva, V. M., Vicente, E. F. & Reis, A. R. (2023). Selenium Increases Photosynthetic Pigments, Flavonoid Biosynthesis, Nodulation, and Growth of Soybean Plants (*Glycine max* L*.)*. *Journal Of Soil Science and Plant Nutrition*, 23, 1397-1407. http://dx.doi.org/10.1007/s42729-023-01131-8

Embrapa – Empresa Brasileira de Pesquisa Agropecuária. (2013*). Sistema brasileiro de classificação de solos*. 3.ed. Brasília, 353.

Fabião, M. B., Heidrich, M., Batista, V. R. K., Silva, J. A. G., Spinelli, V. M., Magano, D. A., Pinto, L. B. & Panozzo, L. E. (2025). Produtividade e peso de mil sementes em função de inoculação e coinoculação em cultivares de soja (*Glycine max* L.) cultivadas em terras baixas. *Revista de Gestão e Secretariado*, 16(1), e.4620. http://dx.doi.org/10.7769/gesec.v16i1.4620

Frioni, T., Saracino, S., Squeri, C., Tombesi, S., Palliotti, A., Sabbatini, P., Magnanini, E. & Poni, S. (2019). Understanding kaolin effects on grapevine leaf and whole-canopy physiology during water stress and re-watering. *Journal of Plant Physiology*, 242, e153020. http://dx.doi.org/10.1016/j.jplph.2019.153020

Glenn, D. M. (2016). Effect of highly processed calcined kaolin residues on apple productivity and quality. *Scientia Horticulturae*, 201, 101-108, 2016. http://dx.doi.org/10.1016/j.scienta.2016.01.035

Nakatani, A. S., Gato, I. M. B., Sandini, I. E. & Sandini, A. H. (2024). Consórcio de *Azospirillum* e *Pseudomonas* aumenta o desenvolvimento vegetal e produtividade da cultura da soja. Revista Delos, 17(62), e3176. http://dx.doi.org/10.55905/rdelosv17.n62-093

Oliveira, Z. B., Spies, V. M., Silva, C. E., Baranzelli, L. F., Costa, M. S.& Rathke, B. (2024). Estimativa e espacialização da produtividade final da soja em anos de La Niña no Rio Grande do Sul. *Ciência e Natura*, 46(3), e86829. http://dx.doi.org/10.5902/2179460x86829

Rosati, A. (2007). Physiological effects of kaolin particle film technology: A review. Functional Plant Science and Biotechnology, 1(1), 100-105.

Rstudio Team. (2019). *RStudio: Integrated Development for R.* RStudio, Inc., Boston, MA. URL: http://www.rstudio.com/

Silva, P. S. O., Oliveira, L. F. G., Gonzaga, M. I. S., Sena, E. O. A., Maciel, L. B. S., Fiaes, M. P., Mattos, E. C. & Carnelossi, M. A. G. (2019). Effects of calcium particle films and natural shading on ecophysiological parameters of conilon coffee. Scientia Horticulturae, 245, 171-177. http://dx.doi.org/10.1016/j.scienta.2018.10.010

Soela, D. M., Vitória, E. L., Falqueto, A. R., Ribeiro, L. F. O., Simon, C. A., Sigismondi, L. R., Jegeski, R. F. & Pereira, L. D. B. (2023). Photosystem II Performance of Coffea canephora Seedlings after Sunscreen Application. *Plants*, 12(7), 1467. http://dx.doi.org/10.3390/plants12071467