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ESTIMATION OF WEED GERMINATION (*Eleusine indica and Amaranthus spp.*) USING PROXIMAL REMOTE SENSING

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Abstract.

Weeds are significant obstacles to the yield of commercial crops, leading to considerable economic losses worldwide. These plants compete directly with desired crops for essential resources such as water, light, and nutrients, and they can complicate agricultural management practices. In this context, early identification and understanding of the initial stages of weed development, such as germination, are crucial for enhancing management strategies and reducing both economic and environmental impacts. Given this scenario, the present study aimed to estimate the germination of certain weed species, particularly Eleusine indica (goosegrass) and Amaranthus spp. (purple amaranth). This study employed proximal remote sensing with different reading heights of a proximal remote sensor (10 cm and 20 cm) and utilized the NDRE (Normalized Difference Red Edge) vegetation index. The experiment was conducted at the Weed Science Laboratory of the Federal Technological University of Paraná (UTFPR), located at the Santa Helena campus in Paraná, Paraná State, Brazil. The experimental design followed a completely randomized design (CRD) in a 2 × 2 factorial arrangement, considering weed species (Eleusine indica and Amaranthus spp.) and the reading heights of the proximal sensor (10 cm and 20 cm) as factors. The database consisted of 64 experimental samples, with four replications. The variables analyzed included the seed germination test and the NDRE vegetation index. Data acquisition for the germination test took place over six days, during which no seedling emergence was observed on the first and last days of evaluation. Data processing and analysis were conducted using AgroEstat® statistical software, utilizing analysis of variance (ANOVA) with the F-test. When statistical significance was identified, means were compared using Tukey's test at a 5% significance level. To visualize the data distribution and mean behavior, boxplots were created in Microsoft Excel®. The estimation of the number of germinated weed seeds was conducted based on the NDRE (Normalized Difference Red Edge) vegetation index and the reading period from the proximal sensor. This was performed using polynomial regression in Microsoft Excel®. The quality of the regression fits was evaluated using the coefficient of determination (R^2). The results indicated that the NDRE vegetation index was effective in estimating weed germination, particularly for Eleusine indica. The models exhibited better fit when the readings were taken at a height of 10 cm and between the second and third days after sowing. In conclusion, integrating spectral indices with statistical methods provides accurate estimates of weed germination, representing a promising approach for integrated weed management research.

Keywords. *Precision Agriculture. Weed Science. Active Optical Remote Sensing.*

Introduction

Weeds represent one of the main limiting factors of agricultural productivity, causing reduced crop yields, increased production costs, and favoring the occurrence of herbicide-resistant biotypes (OERKE, 2006; OWEN, 2016). Among the most important species are goosegrass (Eleusine indica) and purple amaranth (*Amaranthus hybridus* L.), both recognized for their high growth rates, reproductive capacity, and adaptation to diverse environmental conditions (LOVELL et al., 1996; CHAUHAN; JOHNSON, 2008). In this context, proximal remote sensing (PRS) emerges as a promising, sustainable, and non-destructive alternative for weed monitoring, contributing to integrated management and more efficient decision-making (PEÑA et al., 2015; OLIVEIRA et al., 2020). The hypothesis was that the germination of these species can be estimated using the NDRE (Normalized Difference Red Edge) vegetation index, obtained by a proximal sensor. Thus, the objective of this study was to estimate germination of E. indica and A. hybridus using the NDRE index, evaluate different sensor reading heights, and identify the most suitable conditions for early detection and monitoring of their emergence. Therefore, this study had the general objective of estimating the germination of the weeds goosegrass and purple amaranth using the NDRE vegetation index, considering different sensor reading heights.

Material and Methods

The experiment was conducted at the Federal Technological University of Paraná (UTFPR), Santa Helena campus, in Santa Helena, Paraná (24°50'52.0"S, 54°20'47.3"W). The activities were carried out in a controlled environment at a constant temperature of 25 °C. A completely randomized design (CRD) was adopted in a 2 × 2 factorial scheme, with four replications, totaling 16 experimental units. The factors evaluated were two weed species, goosegrass (*Eleusine indica*) and purple amaranth (*Amaranthus hybridus*), and two heights of proximal sensor placement (10 and 20 cm). The variables analyzed were the daily number of germinated seeds and the NDRE vegetation index.

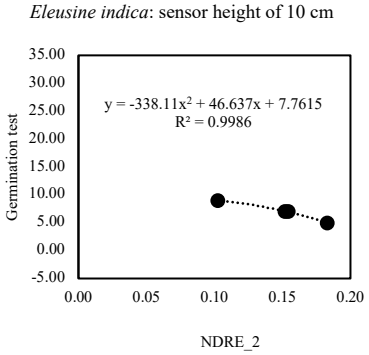
For the experiment, seeds of both species were distributed in previously sterilized Gerbox-type containers, each containing two sheets of Germitest paper and 25 seeds per experimental unit. Germination assessments and spectral readings were performed daily for six days, considering, for the analyses, the number of seeds germinated on each evaluation day, without cumulative effect. The spectral data used to calculate the NDRE were obtained using the RapidSCAN® proximal active optical sensor (model CS-45). Subsequently, the data were subjected to analysis of variance (ANOVA) using the F-test in AgroEstat®. When a significant effect of the treatments was found, the means were compared using Tukey's test at a 5% probability level. Additionally, boxplots were created in Microsoft Excel® to visualize the data distribution, and polynomial regression models were fitted to estimate germination as a function of NDRE values and evaluation periods, using the coefficient of determination (R^2) as an indicator of fit quality.

Results and Discussion

Analysis of the results demonstrated that the reading height of the proximal sensor was the most influential factor in estimating germination, with a height of 10 cm standing out due to its greater sensitivity in detecting spectral variations associated with seedling development. The effects of weed species varied throughout the evaluations, while the second and third days after germination showed the best performance for data acquisition. This result indicates that the shorter distance between the sensor and the seedlings allows for more precise reflectance capture, reducing background reflectance and increasing the sensor's sensitivity to variations in plant vigor (NOVO, 2008; FORMAGGIO; SANCHES, 2017). Estimates made using the NDRE vegetation index showed high precision, with coefficients of determination greater than 99%, evidencing a strong association between spectral values and germination test results. The best fit was observed on the second evaluation date ($NDRE_2$), with an R^2 of 99.86% (Fig 1), confirming

the potential of proximal remote sensing as a fast, accurate, and non-destructive tool for monitoring seed germination.

Fig 1. Estimates of the germination test of the weeds Eleusine indica (goosegrass) and Amaranthus hybridus (purple amaranth), together with the NDRE (Normalized Difference Red Edge) vegetation index values, obtained on the second evaluation date (NDRE_2), as a function of the reading height of the proximal sensor.



Conclusion

It was concluded that the NDRE vegetation index has high potential for estimating weed germination, especially for Eleusine indica. The best estimates were obtained on the second and third evaluation dates, using a reading height of 10 cm, which provided greater sensitivity and precision in capturing spectral responses. The regression models demonstrated high performance, confirming NDRE's efficiency as a non-destructive tool for monitoring germination and highlighting its applicability for weed management and early detection.

References

Formaggio, A. R., & Sanches, I. D. *Técnicas de Sensoriamento Remoto para a Agricultura*. 2. ed. São José dos Campos: INPE, 2017. p. 200.

Lovell, S. T., Holt, J. S., & Powles, S. B. (1996). Ecological fitness of triazine-resistant and -susceptible *Amaranthus species*. *Weed Science, 44*, 87–93.

Novo, E. M. L. M. *Sensoriamento Remoto:* princípios e aplicações. 3. ed. São Paulo: Blucher, 2008. 398 p.

Oerke, E. C. (2006). Crop losses to pests. The Journal of Agricultural Science, 144, 31-43.

Oliveira, A. J., Silva, G. F. da, Silva, G. R. da, Santos, A. A. C. dos, Caldeira, D. S. A., Vilarinho, M. K. C., Barelli, M. A. A., & Oliveira, T. C. de. Potencialidades da utilização de drones na agricultura de precisão. *Brazilian Journal of Development*, *6*, 64140-64149, 2020.

Owen, M. D. K. (2016). Diversas abordagens para o manejo de plantas daninhas resistentes a herbicidas. *Weed Science, 64*, 570-584.

Chauhan, B.S., & Johnson, D. E. (2008). Germination ecology of goosegrass (Eleusine indica): an important grass weed of rainfed rice. *Weed Science*, *56*, 699-706.

Peña, J. M., Torres-Sánchez, J., Serrano-Pérez, A., Castro, A. I. de, & López-Granados, F. (2015). Quantifying efficacy and limits of unmanned aerial vehicle (UAV) technology for weed seedling detection as affected by sensor resolution. *Sensors*, *15*, 5609-5626.