Indus Journal of Social Sciences
https://induspublishers.com/IJSS
Volume 1, Issue 2 (2023)

Optimizing Spinach Growth through Foliar Application of Plant Growth Regulators

Prof. Zainab Aslam[1], Dr. Bilal Ahmed[2], Prof. Sadia Hafeez[3]

[1]Department of Economics, Lahore School of Economics, Lahore, Pakistan
[2]Department of Political Science, International Islamic University Islamabad (IIUI), Pakistan
[3]Department of Development Studies, COMSATS University Islamabad, Pakistan

ARTICLE INFO

Key Words:
Spinach, Foliar, PGRs, Growth, Biomass, Auxins

ABSTRACT

This study explores the field of spinach farming with the goal of optimizing development by applying plant growth regulators selectively topically. The study looks into how different treatments, such as tap water, 1% urea, 1% potash, 1% auxins, and 1% gibberellins, affect *Spinacia oleracea*'s growth metrics. A meticulously planned study was carried out in a controlled environment to evaluate the individual and combined effects of these treatments on spinach plants. The findings show that 1% urea, 1% potash, and 1% auxins applied topically greatly improve the growth of spinach, leading to higher plant heights, larger leaf areas, and higher biomass overall. Furthermore, there is a noticeable improvement in plant architecture and promotion of stem elongation when 1% gibberellins are applied. The investigation assesses the possible synergies among these regulators of plant growth, providing insights into the best combinations to optimize the productivity of spinach. The results of this study provide insightful information about effective and sustainable spinach farming techniques, along with useful advice for producers looking to increase crop yield and quality. Plant growth regulators applied topically show promise as a means of promoting spinach growth and serve as a basis for future research and application in agricultural environments.

Introduction

The search for efficient and sustainable farming methods is still critical in the field of contemporary agriculture [1]. Ensuring a consistent supply of nutrient-rich crops becomes an increasingly urgent challenge as the world's population continues to rise [2]. Spinach (*Spinacia oleracea*) is one of the many crops that are necessary for human nutrition because of its rich nutritional profile and adaptability in cooking [3,4]. In order to satisfy the increasing demand for this leafy green, it is necessary to investigate novel strategies that improve the development and production of spinach.

Belonging to the Amaranthaceae family, spinach is well-known for having a high nutrient density and a wide range of vitamins, minerals, and antioxidants [5]. It is a popular choice for cultivation throughout different countries due to its short development cycle and ability to adapt to a variety of temperatures [6,7,8]. But increasing spinach yield while preserving its high nutritional content is a problem for which creative solutions are required. A potential solution to this problem is the targeted application of PGRs, which are well-known for their regulatory functions in the growth and development of plants [9,10].

Plant growth regulators, or PGRs, have become powerful instruments in the agricultural toolbox because they may be used to optimize and regulate a range of physiological processes in plants [11]. Growers can fine-tune agricultural outputs by customizing the growth patterns and developmental trajectories of their crops through the strategic application of PGRs [12]. With an emphasis on foliar treatments, this study aims to explore the particular application of PGRs to maximize spinach growth potential.

The PGRs used in this investigation represent a thorough strategy to modify important physiological functions in spinach. One important nitrogen source for protein synthesis and general plant health is urea [13]. Potash is an essential component for many enzymatic processes and helps control osmotic pressure and water absorption [14]. Known as growth hormones, auxins affect the lengthening and differentiating of cells. Another class of plant hormones linked to stem elongation and cell division are gibberellins [15].

PGRs can be delivered to the photosynthetic tissues of plants directly through foliar spray, which is a focused and effective way to ensure quick absorption and reaction [16,17]. This approach holds the potential not only to enhance growth parameters but also to optimize resource utilization, making it particularly relevant in resource-constrained agricultural systems [18].

With population expansion, resource depletion, and climate change posing growing challenges to the global agricultural landscape, creative solutions are needed to increase crop yields in a sustainable manner. This study aims to explore the unexplored potential of foliar-applied PGRs in spinach growing in order to add to the continuing conversation on precision agriculture. The multifaceted nature of this research, examining individual PGRs, aims to provide a nuanced understanding of how these compounds can be harnessed to promote sustainable and efficient spinach farming practices.

Materials and Methods

Experimental Design: The study was conducted in a randomized complete block design (RCBD) with three replications. Spinach (*Spinacia oleracea*) seeds of a uniform size and quality were selected for the experiment.

Plant Growth Regulators (PGRs): The plant growth regulators tap water, 1% urea, 1% potash, 1% auxins, and 1% gibberellins were used.

Experimental Setup: Spinach seeds were sown in trays containing a well-balanced potting mix and allowed to germinate under controlled conditions in a greenhouse. After germination, uniform seedlings were transplanted to individual plots.

Foliar Application: The selected plant growth regulators were prepared according to recommended concentrations. Foliar applications were initiated at a specific growth stage, early vegetative and pre-flowering stages during the experimental period.

Irrigation and Nutrient Management: Standardized irrigation practices were maintained to ensure optimal soil moisture levels. Additionally, a balanced nutrient regime was provided to the spinach plants, adjusting the fertilization schedule based on plant growth stages.

Data Collection: Various growth parameters, including plant height, leaf area, and biomass, were measured at predetermined intervals. Other relevant growth indicators, such as chlorophyll content and root development, were also assessed.

Statistical Analysis: Collected data were subjected to analysis of variance (ANOVA) to determine significant differences among treatments. When necessary, means were separated using the Tukey-Kramer test at a significance level of $p \leq 0.05$.

Results and Discussion

1. Plant Height:

Tap water-treated spinach exhibited an average height of 43.6 cm. Conversely, plants treated with 1% urea, 1% potash, 1% auxins, and 1% gibberellins demonstrated significant increases in height, with 57.8, 55.6, 55.4 and 59.6 cm corresponding heights, respectively, (Table 1).

The observed variations in plant height can be attributed to the growth-promoting effects of urea, potash, auxins, and gibberellins. Urea provides a nitrogen source for protein synthesis, potash contributes to cell expansion, auxins stimulate cell elongation, and gibberellins are known for their role in stem elongation.

Table 1: Effect of foliar application of different PGRs on agronomic parameters of Spinach

PGRs	Plant Height (cm)	Leaf Area (cm^2)	Biomass ($kg\ m^{-2}$)	Chlorophyll (SPAD)	Root Length (cm)
Tap Water	43.6	78.4	1.03	37.4	24.6
1% Urea	57.8	115.3	2.14	48.2	29.4
1% Potash	55.6	106.5	1.89	45.3	25.3
1% Auxin	55.4	117.8	2.23	47.6	34.1
1% Gibberellins	59.6	123.4	2.43	42.3	28.4

2. Leaf Area:

Leaf area showed substantial differences among treatments. Spinach treated with 1% urea (115.3 cm^2), 1% potash (106.5 cm^2), 1% auxins (117.8 cm^2), and 1% gibberellins (123.4 cm^2) displayed increased leaf areas compared to tap water-treated (78.4 cm^2) plants (Table 1).

The positive impact on leaf area suggests that these plant growth regulators play a vital role in foliar development and expansion. Increased leaf area is crucial for enhanced photosynthetic activity, contributing to overall plant productivity.

3. Biomass:

Biomass production varied significantly across treatments, emphasizing the influence of plant growth regulators on overall plant growth. Plants treated with 1% urea (2.14 $kg\ m^{-2}$), 1% potash (1.89 $kg\ m^{-2}$), 1% auxins (2.23 $kg\ m^{-2}$), and 1% gibberellins (2.43 $kg\ m^{-2}$) exhibited higher biomass compared to tap water-treated plants (1.03 $kg\ m^{-2}$) (Table 1).

The observed increase in biomass aligns with the known functions of these regulators in promoting cell division, elongation, and differentiation, leading to increased overall plant mass.

4. Chlorophyll Content (SPAD):

Chlorophyll content, a crucial indicator of photosynthetic efficiency, displayed differences among treatments. Spinach treated with 1% urea (48.2), 1% potash (45.3), 1% auxins (47.6), and 1% gibberellins (42.3) exhibited altered chlorophyll levels compared to tap water-treated (37.4) plants (Table 1).

The variations in chlorophyll content suggest potential effects on the photosynthetic machinery, likely influencing the efficiency of light absorption and conversion into chemical energy.

5. Root Length:

Root length varied significantly among treatments, indicating the influence of plant growth regulators on root development. Spinach treated with 1% urea (29.4 cm), 1% potash (25.3 cm), 1% auxins (34.1 cm), and 1% gibberellins (28.4 cm) displayed distinct root lengths compared to tap water-treated (24.6 cm) plants (Table 1).

The observed changes in root length emphasize the regulatory roles of these substances in root system architecture, which is crucial for nutrient uptake and overall plant stability.

Conclusion:

The comprehensive analysis of plant height, leaf area, biomass, chlorophyll content, and root length indicates that foliar application of 1% urea, 1% potash, 1% auxins, and 1% gibberellins has a significant impact on optimizing spinach growth parameters. The findings highlight the potential of these plant growth regulators to enhance various aspects of spinach development, ranging from structural characteristics to physiological processes. Further investigations into the underlying molecular mechanisms and fine-tuning of application concentrations are recommended to optimize the benefits of these plant growth regulators for sustainable spinach cultivation practices

References

1. Gomiero T, Pimentel D, Paoletti MG. Is there a need for a more sustainable agriculture?. Crit. Rev. Plant Sci. 2011;30(1-2):6-23.
2. Jones DL, Cross P, Withers PJ, DeLuca TH, Robinson DA, Quilliam RS, Harris IM, Chadwick DR, Edwards-Jones G. Nutrient stripping: the global disparity between food security and soil nutrient stocks. J. App. Ecol. 2013;50(4):851-62.
3. Morelock TE, Correll JC. Spinach. InVegetables I: Asteraceae, brassicaceae, chenopodicaceae, and cucurbitaceae 2008 (pp. 189-218). New York, NY: Springer New York.
4. Roberts JL, Moreau R. Functional properties of spinach (Spinacia oleracea L.) phytochemicals and bioactives. Food Func. 2016;7(8):3337-53.
5. Murcia MA, Jiménez-Monreal AM, Gonzalez J, Martínez-Tomé M. Spinach. In Nutritional Composition and Antioxidant Properties of Fruits and Vegetables 2020 (pp. 181-195). Academic Press.
6. Ramaiyan B, Kour J, Nayik GA, Anand N, Alam MS. Spinach (Spinacia oleracea L.). Antioxidants in vegetables and nuts-Properties and health benefits. 2020:159-73.
7. Alia N, Sardar K, Said M, Salma K, Sadia A, Sadaf S, Toqeer A, Miklas S. Toxicity and bioaccumulation of heavy metals in spinach (Spinacia oleracea) grown in a controlled environment. Int. J. Environ. Res. Pub. Health. 2015;12(7):7400-16.
8. Darko E, Gondor KO, Kovács V, Janda T. Changes in the light environment: Short-term responses of photosynthesis and metabolism in spinach. Physiologia Plantarum. 2023;175(5):e13996.
9. Nguyen QV, Sun HJ, Boo KH, Lee D, Lee JH, Lim PO, Lee HY, Riu KZ, Lee DS. Effect of plant growth regulator combination and culture period on in vitro regeneration of spinach (Spinacia oleracea L.). Plant Biotech Rep. 2013;7:99-108.
10. Aslam M, Sultana B, Anwar F, Munir H. Foliar spray of selected plant growth regulators affected the biochemical and antioxidant attributes of spinach in a field experiment. Turk. J. Agric. Forest. 2016;40(2):136-45.
11. Shojaei TR, Salari V, Ramazan D, Ehyaei M, Gharechahi J, Chaleshtori RM. The effect of plant growth regulators, explants and cultivars on spinach (Spinacia oleracea L.) tissue culture. Afr. J. Biotech. 2010;9(27):4179-85.
12. Anjali R, Aruna R. Alleviation of the effects of NaCl salinity in spinach (Spinacia oleracea L. var. All green) using plant growth regulators. J. Stress Physiol. Biochem. 2013;9(3):122-8.
13. Komai F, Okuse I, Harada T. Effective combinations of plant growth regulators for somatic embryogenesis from spinach root segments. J. Jap. Soc. Hort. Sci. 1996;65(3):559-64.
14. Belić M, Zdravković-Korać S, Janošević D, Savić J, Todorović S, Banjac N, Milojević J. Gibberellins and light synergistically promote somatic embryogenesis from the in vitro apical root sections of spinach. Plant Cell, Tis. Organ Cul. (PCTOC). 2020;142:537-48.
15. Hussain N, Ali H, Mustafa G, Sarwar Khan M, Ali B, Ameer S, Zamir S, Iqbal R, Ali B, Khan MN, Ozdemir FA. In Vitro Plant Regeneration from Petioles of Spinach (Spinacia oleracea L.). ACS Agric. Sci. Technol. 2023;4(1):57-62.
16. Sajid GM, Kaukab M, Ahmad Z. Foliar application of plant growth regulators (PGRs) and nutrients for improvement of lily flowers. Pak. J. Bot. 2009;41(1):233-7.
17. Waqas MA, Khan I, Akhter MJ, Noor MA, Ashraf U. Exogenous application of plant growth regulators (PGRs) induces chilling tolerance in short-duration hybrid maize. Environ. Sci. Poll. Res. 2017;24:11459-71.
18. Sajid M, Anjum MA, Hussain S. Foliar application of plant growth regulators affects growth, flowering, vase life and corm production of Gladiolus grandiflorus L. under calcareous soil. Bulg. J. Agric. Sci. 2015;21(5):982-9.