Indus Journal of Animal and Plant Sciences
https://induspublishers.com/IJAPS
Volume 1, Issue 2 (2023)

Exploring the Impact of Plant Growth Regulators on Growth Dynamics and Yield of Potatoes (Solanum tuberosum)

Dr. Rakesh Singh[1], Prof. Zainab Ali[2], Dr. Vivek Kumar[3]

[1]Department of Plant Molecular Biology, National Institute of Plant Genome Research, New Delhi, India
[2]Department of Horticulture, University of Veterinary and Animal Sciences, Lahore, Pakistan
[3]Division of Animal Physiology and Reproduction, Indian Veterinary Research Institute, Izatnagar, India

ARTICLE INFO

Key Words:

PGR,

Potato,

Auxins,

Gibberellins,

Cytokinens

ABSTRACT

This study explores the complex connection between plant growth regulators (PGRs) and the growth patterns and crop production of potatoes (*Solanum tuberosum*). The study aims to explore the impact of selected PGRs on different growth parameters and tuber development, with the goal of promoting sustainable agricultural practices and improving crop productivity. A randomized control trial was conducted, incorporating commonly used plant growth regulators, including auxins, gibberellins, and cytokinins, applied at critical stages of potato development. Thorough evaluations included measurements of plant height, leaf area, root development, and tuber characteristics. The study also examined tuber yield, quality attributes, and biochemical composition to gain a comprehensive understanding of how plant growth regulators affect the overall growth and development of potatoes. Initial findings indicate varied responses to different PGRs, showing changes in growth patterns, root structure, and tuber traits. The study's findings will provide valuable insights into optimising PGR applications for sustainable potato cultivation, offering a scientific basis for informed decision-making among agronomists, researchers, and stakeholders in the agricultural community. This investigation aims to connect PGR applications with potato growth, with the goal of enhancing agricultural practices to increase yield and optimise resource usage.

Introduction

Potato (Solanum tuberosum) stands as a cornerstone in global agriculture, serving as a staple food source for billions of people worldwide [1]. The quest for increased potato yield and enhanced quality continues to be a focal point in agricultural research, necessitating a comprehensive understanding of factors influencing its growth dynamics [2,3]. Among these factors, plant growth regulators (PGRs) emerge as pivotal players, offering the potential to modulate key physiological processes and optimize crop performance. Potatoes are integral to global food security, providing a rich source of energy, essential nutrients, and dietary diversity [4]. The versatility of potatoes in various culinary applications, coupled with their adaptability to diverse climates, renders them indispensable for both subsistence and commercial agriculture [5,6]. The growing demand for potatoes underscores the need for sustainable cultivation practices that maximize yield while minimizing environmental impact [7].

Plant growth regulators, a diverse group of endogenous and synthetic compounds, intricately regulate plant growth and development [8]. Their influence extends to processes such as cell division, elongation, and differentiation, impacting various physiological aspects of plant life. PGRs encompass auxins, gibberellins, cytokinins, abscisic acid, and ethylene, each contributing to specific facets of plant growth [9,10]. Manipulating these regulators presents an avenue to tailor crop responses, potentially optimizing productivity under varying environmental conditions [11]. Despite the recognized impact of PGRs in crop production, their specific influence on potato growth dynamics remains a fertile area for exploration. Understanding how PGRs modulate key aspects of potato development, from initial sprouting to tuber formation, holds promise for optimizing cultivation practices and elevating yield outcomes. Moreover, elucidating the biochemical and physiological responses of potatoes to PGR applications is critical for advancing sustainable agricultural practices.

The overarching objective of this research is to systematically explore the impact of selected PGRs on the growth dynamics and yield of potatoes. Specific goals include:

- Assessing the influence of PGRs on plant height and leaf area, elucidating their role in above-ground biomass development.
- Investigating the effects of PGR applications on root architecture and below-ground biomass, recognizing their potential impact on nutrient uptake and water utilization.
- Evaluating the overall yield outcomes, considering both quantitative and qualitative aspects of potato production.

By addressing these objectives, the study aspires to provide nuanced insights into the complex interplay between PGRs and potato growth, offering practical implications for potato farmers, agronomists, and researchers engaged in enhancing crop performance.

Materials and Methods:

1. Experimental Site:

The research was conducted at DI Khan, where soil and climatic conditions are conducive to potato cultivation. The experimental plots were prepared in accordance with standard agricultural practices, ensuring uniformity in soil texture, fertility, and drainage.

2. Potato Variety and Planting:

A widely cultivated potato variety, Subhani-2005, known for its adaptability and market desirability, was chosen for the experiment. Seeds were obtained from a reputable source to ensure genetic uniformity. Planting was carried out in rows with consistent spacing, following recommended guidelines.

3. Plant Growth Regulators (PGRs):

Three commonly used PGRs were selected for the experiment: auxin (indole-3-acetic acid), gibberellin (gibberellic acid), and cytokinin (kinetin). Each PGR was obtained in pure form from reputable suppliers, ensuring the highest quality and concentration.

4. Experimental Design:

The study employed a randomized complete block design to minimize potential spatial variations. Experimental plots were arranged in blocks, with each block representing a treatment group corresponding to one of the selected PGRs. Control plots without PGR application were included for baseline comparison.

5. PGR Application Protocol:

PGRs were applied at key growth stages, including germination, vegetative growth, and tuberization, reflecting critical points in the potato life cycle. Application rates were determined based on previous studies and manufacturer recommendations, ensuring optimal concentrations for each growth stage. Care was taken to apply PGRs uniformly across each treatment plot.

6. Data Collection - Growth Parameters:

Throughout the growth period, data were collected on various growth parameters. Plant height was

measured regularly using a graduated ruler, and leaf area was determined using non-destructive methods such as digital imaging. Root architecture was assessed through soil excavation and root imaging techniques.

7. Tuber Characteristics:

Tuber development was closely monitored from initiation to maturity. The number, size, and weight of tubers were recorded, providing insights into the impact of PGRs on the critical phase of tuberization. Tuber quality attributes, including starch content and specific gravity, were also analyzed using standardized laboratory methods.

8. Yield Assessment:

At harvest, the total yield per plot was quantified by carefully harvesting and weighing all mature tubers. Marketable yield, representing tubers meeting commercial standards, was differentiated from non-marketable yield. These measurements allowed for a comprehensive evaluation of PGR effects on overall potato yield.

9. Statistical Analysis:

Collected data were subjected to statistical analysis using appropriate software. Analysis of variance (ANOVA) was employed to identify significant differences among treatment groups, and post-hoc tests, such as Tukey's multiple comparison test, were conducted to discern specific variations. Statistical analyses aimed to provide robust conclusions regarding the influence of each PGR on different growth parameters and yield components.

Results:

1. Effect on Plant Growth Parameters:

- *Plant Height and Leaf Area:* The application of auxin, gibberellin, and cytokinin resulted in varying effects on plant height and leaf area throughout different growth stages. Notably, gibberellin-treated plants exhibited increased height, while auxin and cytokinin treatments influenced leaf area positively. These variations indicate the selective impact of specific PGRs on above-ground biomass development.
- *Root Architecture:* Examination of root architecture revealed subtle but discernible alterations in response to PGR applications. Gibberellin-treated plants exhibited enhanced root branching, while auxin and cytokinin influenced lateral root development. These findings suggest PGR-induced modifications in root systems that may influence nutrient uptake and overall plant health.

Table 1. Effect of PGRs application of plant and root parameters of potato

PGRs	Plant Parameters		Root Characteristics	
	Plant Height (cm)	Leaf Area (cm^2)	Root Length (cm)	Branches
Control	46.13	11.38	34.21	13.19
Auxins	52.31	15.21	40.67	31.67
Gibberellins	63.21	13.72	46.34	22.34
Cytokinens	49.82	15.63	38.23	32.89

2. Tuber Characteristics:

- *Tuber Number, Size, and Weight:* Gibberellin application correlated with an increase in tuber number, size, and overall weight, signifying a positive impact on tuberization. Auxin-treated plants exhibited a moderate increase, while cytokinin had a more pronounced effect on tuber size than on tuber number. These variations highlight the differential influence of PGRs on the critical phase of tuber development.
- *Tuber Quality Attributes:* Analysis of tuber quality attributes revealed nuanced responses to PGR treatments. Gibberellin-treated tubers exhibited higher starch content, while auxin and cytokinin treatments influenced specific gravity. These quality parameters underscore the potential of PGRs to influence not only tuber quantity but also biochemical composition.

Table 2. Effect of PGRs application on Tuber parameters of potato

PGRs	Quantity Attributes	Quality Attributes

	Number	Size (cm)	Weight (kg)	Starch	Specific Gravity
Control	5.3	11.48	39.57	L	L
Auxins	11.76	17.11	108.45	M	H
Gibberellins	7.21	11.74	49.67	H	M
Cytokinens	14.82	16.69	99.86	M	H

H, High, M, Medium, L, Low

3. Yield Assessment:

- *Total Yield and Marketable Yield:* The cumulative effect of PGR applications on total yield varied among treatments. Gibberellin-treated plots demonstrated the highest total yield, primarily attributed to increased tuber size and number. Auxin and cytokinin treatments resulted in comparable but slightly lower total yields. Marketable yield closely mirrored total yield trends, reinforcing the positive impact of specific PGRs on commercial potato production.

4. Table 2. Effect of PGRs application on Tuber parameters of potato

PGRs	Total Yield (t ha^{-1})	Marketable Yield (t ha^{-1})
Control	36.68	25.43
Auxins	87.45	64.28
Gibberellins	48.34	38.74
Cytokinens	87.46	64.96

Discussion:

The selective impact of each PGR on growth parameters aligns with their distinct physiological roles [12]. Gibberellin's role in promoting stem elongation and tuberization is reflected in increased plant height and tuber size. Auxin, known for its influence on root development, demonstrated notable effects on lateral root growth. Cytokinin, associated with cell division, contributed to increased leaf area and tuber size. These selective responses underline the importance of tailored PGR applications to achieve desired outcomes [13].

The observed variations in tuber characteristics and quality attributes emphasize the potential of PGRs to modulate key aspects of potato development. Gibberellin's positive impact on tuberization and starch content aligns with its role in cell elongation and division. Auxin's influence on lateral root development may indirectly contribute to tuber size. Cytokinin's effects on leaf area and specific gravity indicate multifaceted roles in potato physiology [14].

Gibberellin emerges as a promising PGR for enhancing potato yield, primarily through increased tuber size and number. Auxin and cytokinin also exhibit positive effects, albeit to a slightly lesser extent. The selective application of PGRs, considering specific growth stages and desired outcomes, holds implications for optimizing commercial potato production. These findings offer practical insights for potato growers seeking strategies to enhance yield and quality [15,16].

The study's results underscore the potential of PGRs as tools for sustainable potato cultivation. By influencing growth dynamics and yield components, PGRs can contribute to resource efficiency and environmental sustainability. However, careful consideration of PGR type, application rates, and environmental factors is essential to ensure balanced and responsible use.

While this study provides valuable insights, further research is warranted to delve deeper into the specific mechanisms underlying PGR effects on potatoes. Understanding the molecular and biochemical pathways influenced by PGRs can inform targeted interventions and advance precision agriculture practices. Additionally, investigations into potential interactions between PGRs and environmental factors will contribute to refining application guidelines.

Conclusion

In this exploration of the impact of plant growth regulators (PGRs) on potatoes (*Solanum tuberosum*), distinct responses were observed, highlighting the selective influence of auxin, gibberellin, and cytokinin on growth dynamics and yield components. Gibberellin emerged as a key player, positively influencing tuberization and yield. Auxin and cytokinin also demonstrated significant effects, albeit with nuanced variations. These findings contribute to the optimization of PGR applications in potato cultivation, offering insights for sustainable practices and enhanced commercial production. The study underscores the need for tailored PGR interventions, considering specific growth stages and desired outcomes, and encourages further research to unravel the molecular mechanisms underlying PGR effects on potatoes, paving the way for precision agriculture advancements in potato cultivation.

References

1. Bajaj YP. Potato. Springer Science & Business Media; 2013 Mar 7.
2. Zaheer K, Akhtar MH. Potato production, usage, and nutrition—a review. Crit. Rev. Food Sci. Nut. 2016;56(5):711-21.
3. De Jong H. Impact of the potato on society. Am. J. Potat. Res. 2016;93:415-29.
4. Hawkes JG. History of the potato. InThe potato crop: The scientific basis for improvement 1992 (pp. 1-12). Dordrecht: Springer Netherlands.
5. Camire ME, Kubow S, Donnelly DJ. Potatoes and human health. Crit. Rev. Food Sci. Nut. 2009;49(10):823-40.
6. Hijmans RJ. Global distribution of the potato crop. Am. J. Potat. Res. 2001;78:403-12.
7. Harris PM, editor. The potato crop: the scientific basis for improvement. Springer Science & Business Media; 2012 Dec 6.
8. Gaspar T, Kevers C, Penel C, Greppin H, Reid DM, Thorpe TA. Plant hormones and plant growth regulators in plant tissue culture. In vitro Cel. Dev. Biol. Plant. 1996;32:272-89.
9. Rademacher W. Plant growth regulators: backgrounds and uses in plant production. J. Plant Grow. Reg. 2015;34:845-72.
10. Roberts JA. Plant growth regulators. Springer Science & Business Media; 2012 Dec 6.
11. E1-Otmani M, Coggins Jr CW, Agustí M, Lovatt CJ. Plant growth regulators in citriculture: World current uses. Crit. Rev. Plant Sci. 2000;19(5):395-447.
12. Basra A, editor. Plant growth regulators in agriculture and horticulture: their role and commercial uses. CRC press; 2000 Dec 13.
13. Nickell LG, Louis NG. Plant growth regulators: Agricultural uses. New York: Springer-Verlag; 1982.
14. Gaba VP. Plant growth regulators in plant tissue culture and development. Plant Dev. Biotech. 2005:87-99.
15. Coggins Jr CW, Lovatt CJ. 14 Plant Growth Regulators. Cit. Prod. Man. 2014;3539:215.
16. Ferguson L, Lessenger JE. Plant growth regulators. Agric. Med. A Prac. Guid. 2006:156-66.