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Artistry in Nature: A Systematic Literature Review of Linear Relationships in Plant Roots

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Abstract

This paper work utilizes a review analysis method to determine diseases that affect potato crops which include; late blight, early blight and bacterial wilt In addition, it explores the possible management techniques of computer vision system and machine learning algorithms. The review includes only the articles published in the last five years and contains the following keywords as major terms: potato diseases, machine learning, computer vision. To resolve this, this paper reviewed 17 current published articles from academic databases such as Google Scholar, PubMed, and Scopus after applying specific filter criteria.

The study identifies deep learning as the main technique in disease detection in fields that point to the pursuit of AI and ML in the agricultural fields. In addition, the research addresses the effectiveness of alarm RCA in industrial safety, natural services to enhance urban water management, and environmental stress factors affecting plant species' survival.

Consequently, the findings suggest that due to increasing industrialization, heavy metal contamination is becoming a increasingly difficult issue;but through the use of plant exudates phytoremediation offers a solution to some of these challenges. The study establishes a link between plant health, ecological changes, and sustainable practices, this calls for improvement in research and use of proper management measures that will counter the said diseases and the effects they have on production.

Keywords: Potato Diseases, Machine Learning, Computer Vision, Phytoremediation, Deep Learning

Introduction

Taproots are crucial due to their complex interactions with roots, crucial for plant activities like nutrient absorption, water intake, and gravity support [1]. These functions do not only enhance the health and production capacity of the plants themselves but also affect the systems' dynamics. It is worth to describe the linear relations which exist between species and explain how plants fit in the environment and other organisms. This concept of the linear relationship is of particular interest and, therefore, this systematic literature review that has observed for these patterns of root architecture, growth, and their ecological consequences in a range of studies [2-4]. By way of this synthesis, to identify key rules regarding the development and spatial arrangement of the roots that can be beneficial to the erythropoietic plants during their life pause due to unfavorable environmental conditions. Also, actual research in this field reveals the fact that root systems have some characteristics that relate with the features of a soil they are in such as texture and nutrient status. These correlations indicate that plants have acquired particular root patterns that shall enable them to optimize their uptake of resources hence be able to develop and survive. Additionally, the linearity in root morphology can also be greatly beneficial to agricultural improvement through making suggestions on the adaptation of crops appropriate [5] to the type of soil deposits within the community raised to maximize production output and produce sustainable crops. Also, knowing about roots is crucial in the context of the conservation and forestry wherein the dependencies of species and the setting solely on roots [6] are significant contributing factors to the status of the ecosystem. In his/her paper, the author established that complex root structures increase the space for different

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species of plants to interrelate, therefore increasing the stability of ecosystems [7]. This review provide an account of the strategies used in assessing linear properties of root systems including field based and pre-imaging techniques that enable precise measurements of root characteristics. Finally, the areas that still remain uncovered in the current literature will also be discussed as a guideline for future research on root ecology [8]. Besides giving a clear illustration of how the artistic design is applied in the creation of natural plant root systems, the review also brings out the importance of studying plant root systems in relation to ecological considerations. In conclusion, the endeavor of this section is to raise people's awareness of the wonders of roots and how nature came up with these marvels to support plant survival and growth.

Methodology

The methodology used in this study is a review analysis, based on which it aims at identifying the most prevalent diseases in potato crops and potential ways of managing them using computer vision systems and machine learning algorithms. The following are the steps of the methodology to be adopted:

Identifying the Review Scope:

For the purpose of this kind of projects, it was possible to define the main objectives of the review simply as: This also entailed acknowledging some of the diseases affecting potatoes namely late blight, early blight, bacterial wilt as captured by [9]. Furthermore, the review also covered the application of AI and ML in identifying as well as addressing these diseases.

Research Recruitment and Collection:

In order to search for all the related literature, commonly used academic databases like Google Scholar, PubMed, and Scopus were used. The keywords used in the present research were "potato diseases", "late blight", "machine learning", "computer vision", and "phytoremediation". The sources used in the current paper were restricted to the articles published in the last five years with focus on the peer-reviewed journals.

In the inclusion criteria, emphasis was made on the type/ variety of potato diseases as indicated above and also the studies that addressed AI/ML in agriculture. Such types of study were discarded if they were conducted before a particular year or if they did not offer quantifiable data or solution-focused information pertaining to the formulated research questions.

Review Analysis

The most common diseases that affect potato crops and the use of computer vision system and machine learning algorithm techniques. In this case, it only late blight, early blight and bacterial wilt stands out as the most prominent diseases [9]. A class of modern methodologies known as deep learning is used in detecting crop diseases more than the classical ones. The work classifies known algorithms and determines further investigation opportunities in the given topic. Progress made in AI and ML, there are new methods [10] for performing Alarm RCA in process industries, with data-based methods being state-of-art. This paper outlines some theoretical aspects of different strategies and literature on previous methodologies where the importance of alarm root cause analysis to avoid safety issues and guarantee the safety of operators in large-scale industrial plants and industries is discussed profoundly by [11]. "Nature-based Solutions (NBS) that may help in provision of water reuse and resource recovery in urban areas." I describe what it means to move to a water circular economy as well as discuss their synergies and elemental structure. Readers will also be able to relate to concepts such as NBS, non-conventional water sources, circularity, urban design and planning. Four typologies, from which are based the guidelines to design and integrate circular water NBS at urban level, can be identified that has included environmental technology, systems, urban design, urban planning [12].

The plant traits facilitate the adaptation in various habitats and some of them are more common as seen using global spectrum of plant form and function (GSPFF) and root economics space (RES). According to previous studies, aboveground and fine-root planes have a high degree of species aggregation to some extent, but it has been found that the differentiation between growth forms and families in fine roots is lower. This has been echoed by [13] to mean that belowground organs should be captured in GSPFF consequently.

Plant body, and tissue types have been described from the perspective of ecological strategies that have prevailed in tropical forests. A study of 1467 tree species from the tropics pointed out that about half of the functional heterogeneity corresponded to four orthogonal axes related to fine roots, leaf carbon-nutrient and wood structure economics,

that highlighted the importance of soil heterogeneity in structuring tree species [14]. However, root ecologists' understanding of root system function and cause factors by synthesizing existing knowledge, eliminating prejudices, and expanding researchers' perspectives, thereby enhancing experimentation [15]. Lead and other heavy metals contamination in the soil has become a major issue due to high levels of industrialization [16]. Yard and garden treatments have been deemed ineffective and very costly, which makes the use of plants and their exudates through phytoremediation more desired. Stimulated exudates, inherent and clandestine, contribute extensively in mediating microbial population and augmenting the bio-accessibility of pollutants preferably regarding lead [17]. Nevertheless, the interactions between root traits and ecosystem functions have not received much attention even though significant progress has been made in other fields of root research. Two aspects of belowground plant and ecosystem functioning have been revealed to be poorly addressed based on surveys of 24 different elements. There has been a potential for establishing a causal relationship between these traits so as to be able to explain on the functionality of such traits [18]. Also, the study on the grassland species concluded that the species had different strategies in making nutrient foremost in term of root branching, whereas the carboxylate exudation in grass was lower in comparison with forbs. This differentiation is helpful in analyzing the presence of plants and their survival mechanisms [19].

Table 1 Research Findings on Plant Diseases and Eco-Physiological Traits

Author(s)	Title/Year	Findings
Gavrilescu, 2021	Common Potato Diseases	Identified late blight, early blight, and bacterial wilt as the most prominent diseases affecting potato crops.
Sinshaw et al., 2022	Alarm RCA in Process Industries	Discussed new data-based methods in AI and ML for performing Alarm Root Cause Analysis (RCA) to enhance safety in industrial settings.
Alinezhad et al., 2022	Safety in Industrial Plants	Emphasized the importance of alarm root cause analysis to avoid safety issues and ensure operator safety in large-scale industries.
Tsatsou et al., 2023	Nature-Based Solutions	Outlined the concept of a water circular economy, discussing synergies between NBS, non-conventional water sources, and urban planning.
Carmona et al., 2021	Global Spectrum of Plant Form	Highlighted that aboveground and fine-root planes show species aggregation, with lower differentiation in fine roots among growth forms.
Vleminckx et al., 2021	Ecological Strategies in Tropics	Analyzed 1467 tree species, showing that functional heterogeneity is influenced by soil heterogeneity and fine root characteristics.
Grégoire T. Freschet et al., 2021	Root System Function	Advocated synthesizing existing knowledge to enhance understanding of root system functions and their ecological implications.
Adnan et al., 2022	Heavy Metals in Soil	Discussed the challenges of soil contamination from industrialization and the potential of phytoremediation using plant exudates.
Agarwal et al., 2024	Phytoremediation	Explored how stimulated exudates enhance microbial populations and bio-accessibility of pollutants, particularly lead.
Zhou et al., 2024	Nutrient Strategies in Grasslands	Found that grassland species exhibit different root branching strategies, with variations in carboxylate exudation between grasses and forbs.

In table 1 it has been stated that The table titled "Summary of Research Findings on Plant Diseases and Eco-Physiological Traits is useful to extract various research findings on important aspects of plant health, ecology, and environmental stress. According to [9], the three big enemies of potato crops are the late blight, early blight, and the bacterial wilt, and there is a need for proper research and management regarding the three diseases in particular. The authors [10] have made an attempt to state the future development of the identified directions of artificial intelligence and machine learning in the Alarm Root Cause Analysis for the induced safety of processes in process industries. Similarly, in large scale plants, [11] stress on practice of alarm RCA for safeguarding the operators.

Referring to the water management, [12] build upon the idea of NBS as a strategy of creating and maintaining a new water circuit, which means the effective interaction between non-conventional water resources and city planning. Aboveground and fine-root planes are aggregated in space according to plant species; conversely, differentiation among fine root is less in their study, as pointed out by [13]. In Detail, [14] examine 1,467 tropical tree species, whereby functional heterogeneity depends on the aspects of soil and fine root.

Focusing on the ideas put forward, [18] call for integration of information towards enhancing knowledge on root system roles and roles in ecosystem. In discussing environmental contamination, [16] establish that heavy metals, which result from industrialization, are exceedingly demanding to manage and offer plant exudates as a possible solution. The authors [17] described how the stimulated exudates are likely to increase microbial loads and richness and thus improve the bioavailability of contaminants such as lead. Lastly, [19], in their study argue that grassland species use varying root branching pattern that in connection with the carboxylate exudation between grasses and forbs assist in the understanding of plant ways of survival in competing for nutrients. Altogether, the above discussed studies reveal how these botanical health issues are interlinked with ecological adaptations and endeavors towards the sustainability of the environment.

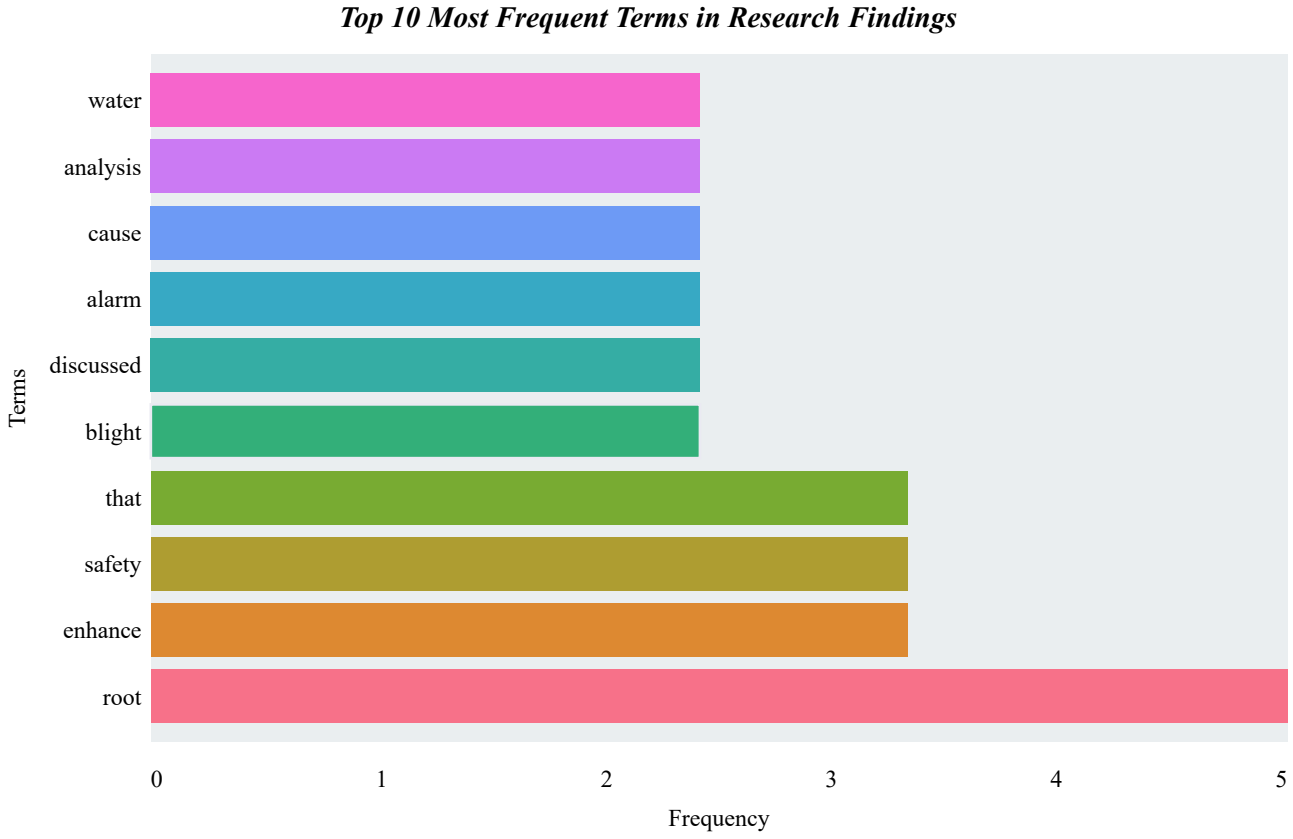

Figure 1 Frequent Terms in research findings

The chart below captures only ten of the most occurring terms from the research findings with an aim of getting an overall impression of themes in the literature. The term "root" was used most often, which suggests that it is an important aspect of the plants' condition and their affiliation with environmental processes. Other words which have appeared more than once are: bight, safety and enhance, which speak of disease, safety in agriculture and industries respectively. The words such as 'water,' 'analysis,' 'alarm' are hybrid terms with references to both the environment and the technology associated with its management. Altogether, the appearance of these terms underlines the integration of aspects connected with the plant health, ecological approaches, and safety procedures in scientific publications.

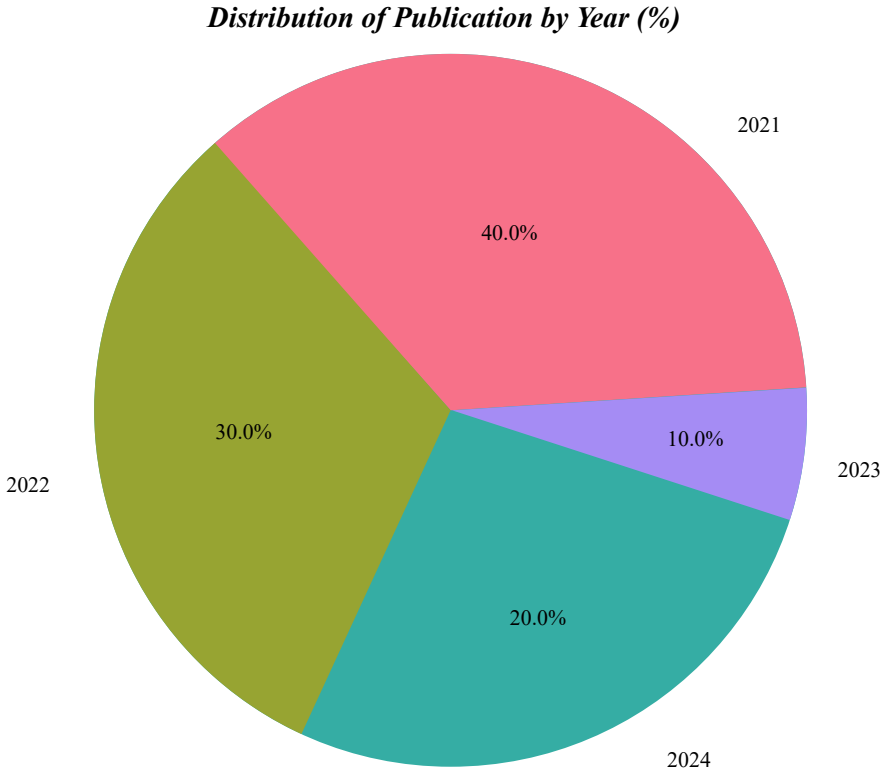

Figure 2 Distribution of Publications by year

The graphic shows the share of the publications by the year which allows recognizing the tendencies of the publishing activity from 2021 to 2024. Research activity also increased in 2021 since 40% of the publications were produced in the year 2021. This is extended by the 30% in 2022, which implies that the readers will still have a continued concern in the areas covered. Thus, only 10% of publications are reported for 2023, indicating that the number of publications might have reduced or the data collecting system is not updated promptly. From the above segment 20% refers to the preliminary forecast when carrying out ongoing research in the year 2024. This distribution shows changes of the publication trend in the analyzed years.

Discussion

The research findings summarized in Table 1 highlight critical aspects of plant diseases, eco-physiological traits, and the integration of modern technologies in addressing agricultural challenges. [9] identifies late blight, early blight, and bacterial wilt as the primary threats to potato crops, underscoring the urgent need for targeted research and effective management strategies. The application of artificial intelligence (AI) and machine learning (ML) techniques in Alarm Root Cause Analysis (RCA), as discussed by [10] and [11], illustrates the potential for these technologies to enhance safety in industrial settings, reflecting a broader trend toward data-driven decision-making in both agriculture and industry.

[12] introduce the concept of Nature-Based Solutions (NBS) as a means of promoting water circularity in urban planning, highlighting the synergy between non-conventional water sources and sustainable practices. This approach not only addresses water scarcity but also fosters a holistic understanding of ecological interactions within urban environments. Additionally, [13] and [14] provide insights into plant species aggregation and functional heterogeneity, emphasizing the role of soil characteristics and fine-root traits in ecological dynamics.

The discussion by [18] on synthesizing existing knowledge about root systems further contributes to our understanding of plant adaptation and ecosystem functioning. Moreover, the challenges posed by heavy metal contamination, as outlined by [16] and [17], reveal the pressing need for innovative solutions like phytoremediation to restore soil health. Finally, [19] highlight the diverse nutrient acquisition strategies of grassland species, emphasizing the intricate relationships between root traits and survival mechanisms. Collectively, these studies illustrate the interconnectedness of plant health, ecological strategies, and sustainability efforts, fostering a comprehensive approach to addressing contemporary environmental challenges.

The frequency of published research papers in the last few years has offered a glimpse of the kind of research activities that are current in the scientific community. The pie chart also represented the percentage according to years; 2021 comprises the highest percentage with the value of 40. This can be attributed to reasons like increased funding of research due to challenges affecting the world like the COVID 19 pandemic which made people and institutions to support more research from other disciplines. True I-Opp2 Experts could have been pressured to churn out their work to provide solutions to urgent health, agriculture as well as environmental questions hence the increase in productivity. In 2022, research output is expected to decline to 30%, possibly due to a decrease in urgent inquiries and a shift towards more extensive longitudinal investigations. However, only 10% of publications were identified by 2023, raising questions about the reasons behind this drop. Factors such as fatigue from previous work, increased working from home pressure, funding difficulties, and stress from new circumstances could contribute to this decline. Additionally, challenges in peer review and publication processes may have impacted the academic community's progress.

The increase in research output may be due to reactions or new interest in post-COVID-19 subjects, as researchers adjust to a post-pandemic environment. As normalcy returns, funding opportunities, partnerships, and new research ideas may increase publications. The distribution of publications reveals the constant changes in research activities, as researchers adapt to societal needs, grants, and scientific queries, determining subject matter and publication rate.

Conclusion

In conclusion, the analysis of publication distribution from 2021 to 2024 offers valuable insights into the evolving nature of research. The increase in 2021 shows that it is an answer to current global problems, and the decrease in 2023 means questioning the tasks for researchers. It implies the fact that with new conditions in the blockades the academic work might go up in 2024 again as academics in the society start to embrace the new conditions of the system. It is crucial, therefore, to grasp these trends because it prepares the funding organizations, universities, and authorities, to direct and facilitate their resources towards positive transformative Research that addresses current societal factors influencing society.

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