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ASSESSING THE DIAGNOSTIC ACCURACY OF AI-POWERED MOBILE APPLICATIONS FOR PLANT DISEASE IDENTIFICATION

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ABSTRACT

Plant diseases causes of several critical threats to global Plant flora and food production, and their early and precise identification is an issue. Although visual inspection may be inaccurate, laboratory-based methods although reliable but are very expensive, time-consuming, and demand special technical knowledge. Since AI-based Applications are increasingly becoming more worldwide in their presence as the world gets faster, cheaper, yet at other times, the results of these Applications are not as precise as we desire. Hence, the proposed research aims at exploring the possibility of AI-driven mobile applications in the diagnosis of plant diseases. We evaluated the accuracy, ease of use, and required precautions to get the best results with applications, such as Plantix, Agrio, Blossom and DoctorP. Survey sites are Matiari, Kandiaro, Dadu, Tando Muhammad Khan, and Botanical Garden of the Institute of Plant Sciences, University of Sindh, Jamshoro, Pakistan. We evaluated infected leaves of *Capsicum annuum* (chili pepper), *Solanum lycopersicum* (tomato), *Solanum tuberosum* (potato), *Mangifera indica* (mango), and *Triticum aestivum* (wheat). Plantix properly identified powdery mildew during both morning and evening tests. Agrio, on the other hand, was right in detecting powdery mildew in the morning but wrong in identifying root-knot nematodes in the evening. These results indicate the promise of mobile applications, specifically Plantix in making effective and accurate diagnosis of plant disease (5 out of 5 correct). According to our findings, Plantix has shown better behavior in proper disease diagnosis. It was also found during the research that these mobile applications must be used in proper lighting conditions, i.e, daylight, to increase the accuracy. Also, close-up pictures of the affected parts of the plant should be clear since blurred images might influence the results of the diagnosis adversely. These results may be of use to researchers, students, and farmers for fast and effective disease detection.

Keywords: Artificial Intelligence (AI), Plant Disease Detection, Mobile Applications, Diagnostic Accuracy, Precision Agriculture

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INTRODUCTION

Plant diseases are described as deviant physiological conditions of a vegetation, as a result of plant infection by diverse pathogens, such as bacteria, fungi, and viruses (Fones et al., 2020). Plant diseases have a significant impact on agriculture by altering the normal physiological processes of plants, making them unable to be used to their full potential. Crop diseases are a major challenge to agricultural output in Pakistan because of poor management. The annual cost of agriculture due to plant diseases is 25% less productive (FAO, 2021), and wheat is under threat.

Rust diseases (yellow, leaf, and black stem) and spot blotch *Bipolaris sorokiniana* are widespread in Punjab, with spot blotch registering the highest prevalence of 60% and the disease index of 24.8% (Memon et al., 2024). Nevertheless, potato fields experience early blight due to *Alternaria solani* throughout the country, with the highest percentage up to 66.4% in such areas as Gilgit-Baltistan (Aqleem Abbas et al., 2018).

Detection and diagnosis of plant diseases are an important process in the identification of plant diseases to help in controlling and protecting crops. This is done by

understanding symptoms, causal agents, i.e., fungi, bacteria, viruses, or environmental factors, and the choice of control measures. Identification of plant diseases is conducted using different methods that include both the traditional methods and modern and sophisticated molecular techniques. These are traditional methods, which are not expensive, like visual inspection, microscopy, and culturing, which can be inaccurate. Laboratory-based techniques, such as biochemical tests, such as Gram staining, catalase tests, and serological tests, such as ELISA and immune strip tests, are more accurate but need specialized equipment. Moreover, the molecular techniques, including PCR, LAMP, NGS, and DNA barcoding, allow pathogens to be detected on a genetic level, giving an accurate and early diagnosis.

AI-based Plant disease identification methods, which are machine learning-based and deep learning-based methods to identify and classify plant diseases using images or sensor data. They are faster and more scalable than traditional visual inspection (Khakimov et al., 2022). Artificial intelligence (AI) is the ability of computation systems to carry out tasks that are usually related to human intelligence, including learning, reasoning, problem-solving, perception, and decision-making (Fetzer, 1990). Detection of plant diseases has been transformed by the use of AI-powered applications, which provide farmers with an efficient and fast means of diagnosing problems in crops. Such sophisticated applications are able to detect an assortment of plant diseases and pests within several seconds via artificial intelligence and give an immediate response on what to do to cure and prevent them. These serve as all-inclusive crop production and management tools not only to determine the severity of diseases (pathometry), but also to reduce subsequent losses (Tao et al., 2023).

However, Artificial intelligence (AI)-based applications sometimes do not generate that much accurate results (Gao, Tao, Jie, & Lu, 2019). Therefore, it's very crucial to know about the accuracy of these applications for efficiently taking care of Plants. That's why there is a need to assess the accuracy of AI-based applications for the accurate use of AI-based applications in the need of better identification of plant diseases. This study focuses on assessing the accuracy of AI-powered mobile applications for plant disease identification, including Agrio, Plantix, Blossom, and Doctor P. These applications are known for identifying plant diseases. We used these plants in different locations and various plants. The findings of the accuracy will contribute to helping in the better identification of plant diseases at a very low cost by using these applications.

MATERIALS AND METHODS

Field and Locations

Plants & Crops were systematically surveyed across multiple locations, encompassing both academic and agricultural Sites. Field assessments of *Solanum lycopersicum* (tomato) were conducted in Dadu, *Capsicum annuum* (chili pepper) in Matiari, *Triticum aestivum* (wheat) in Tando Muhammad Khan, *Solanum tuberosum* (potato) leaves in Kandiaro, and *Mangifera indica* (mango) at the Botanical Garden of the Institute of Plant Sciences, University of Sindh, Jamshoro, Pakistan.

Use of Mobile Applications for Plant Disease Identification

Agrio, Plantix, Blossom, and Doctor P are AI-based mobile applications that were downloaded using the Google Play Store and systematic procedures were used to achieve consistency. The Images of the affected parts of the plant were taken in high resolution and uploaded into the apps, and the AI algorithms analyzed the images to identify the symptoms, the disease, and provide management solutions. To generate correct diagnoses, Agrio and Plantix resorted to substantial AI-based image databases, and DoctorP offered specifics of the disease and treatment advice. Blossom, in a similar manner, integrated the disease detection and plant species recognition.

Data Analysis

The data was organized and cleaned using Microsoft Excel and a simple tabulation of the findings across the crops and time periods. Besides, the Data were interpreted through R Studio with the help of the ggplot2 package. Good quality bar graphs were obtained.

RESULTS

Result Chili Pepper Disease Identification

The observation of *Capsicum annuum* (chili pepper) with three AI-based diagnostic instruments, Agrio, Plantix and Blossom revealed that the uniformity and accuracy were not equal in the morning and evening sessions. Plantix correctly identified the occurrence of *Cercospora* leaf spots during the two times that exhibited high levels of diagnostic reliability. Blossom was also stable because it could always detect *Alternaria* leaf spots in the morning and the evening. Agrio, on the other hand, had time-varying behaviour: it correctly diagnosed *Cercospora* leaf spots in the morning and incorrectly diagnosed Pepper yellow leaf curl virus in the evening (Table 1, Figure 1).

Tomato Disease Identification

Leaf samples of *Solanum lycopersicum* (tomato) were examined by using plantix, Blossom and agrio applications.

Plantix and Blossom largely demonstrated temporal consistency since both consistently identified Powdery mildew in the morning and evening. On the other hand, Agrio was able to diagnose Powdery mildew correctly at the morning but incorrectly identified the disease as the Root-knot nematodes at the evening session (Table 2, Figure 2).

Table 1: Chilli pepper, locations and AI apps used for identification of diseases.

Location and time	App used	Plant species	Visible symptoms	Diagnoses by App	Treatment	Mobile version
Matiari Morning 8:00am	Agrio	<i>Capsicum annuum</i> (Chilli pepper)	Circular brown spots on leaves Yellowing or chlorosis of leaves	Cercospora leaf spots	Use chlorothalonil copper oxychloride	InfniX hot 30 version
Evening 6:00pm				Pepper yellow leaf curl virus	Use pesticides & fertilizers	13 pixel 1080 x2460
Matiari During morning 8:00am	Plantix	<i>Capsicum annuum</i> (Chilli pepper)	brown spots with whitish centre and yellow leaves brown spots with whitish centre and yellow leaves	Cercospora leaf spots	Use tribasic copper sulphate 34.5% SC	InfniX hot 30 version
Evening 6:00pm				Cercospora leaf spots	Use tribasic copper sulphate 34.5% SC	13 pixel 1080 x2460
Matiari Morning 8:00am	Blossom	<i>Capsicum annuum</i> (Chilli pepper)	Yellow leaves & mold, rotting Yellow leaves & mold, rotting	Alternaria leaf spots	Use Myclobutanil directly on plants	InfniX hot 30 version
Evening 6:00pm				Alternaria leaf spots	Use Myclobutanil directly on plants	13 pixel 1080 x2460

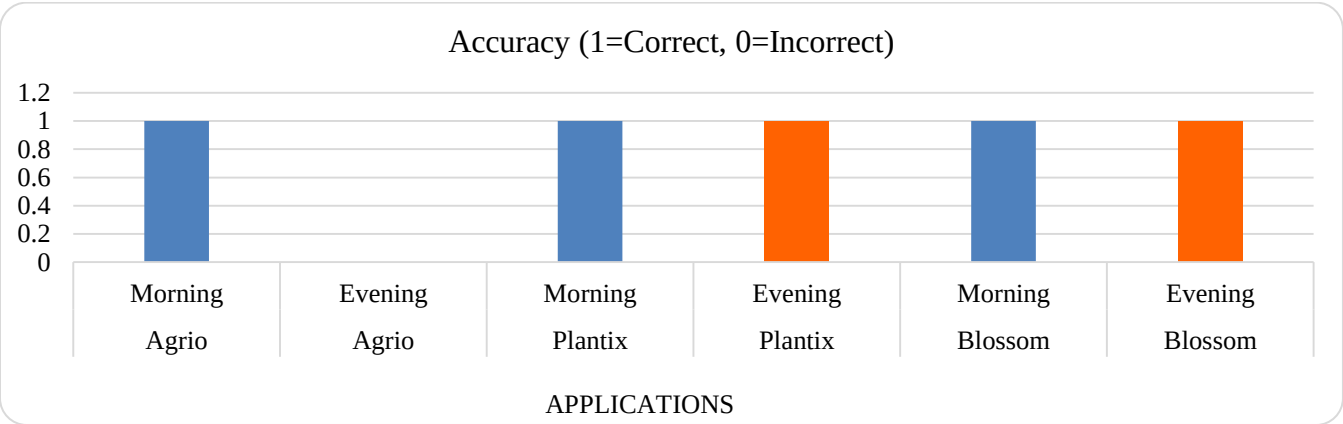


Figure 1: Chili pepper disease identification accuracy: morning vs evening.

Table 1: Tomato, locations and AI apps used for identification of diseases.

Location and time	App used	Plant species	Visible symptoms	Diagnosis by App	Treatment	Mobile version
Dadu Morning 8:00 am	Agrio	<i>Solanum lycopersicum</i> (tomato)	White powdery patches Plants may wiltting	Powdery Mildew	Sulfur & potassium bicarbonate	OppoA17K version 12 pixel
Evening 6:00pm				Rot-knot nematodes	Use pasteuria penetrans	1080x2460
Morning 8:00 am	Plantix	<i>Solanum lycopersicum</i> (tomato)	Whitish spots on the upper side Whitish spots on the upper side	Powdery mildew	Use pyraclostrobin 25.0% SC	OppoA17K version 12 pixel
Evening 6:00pm				Powdery mildew	Use pyraclostrobin 25.0% SC	1080x2460

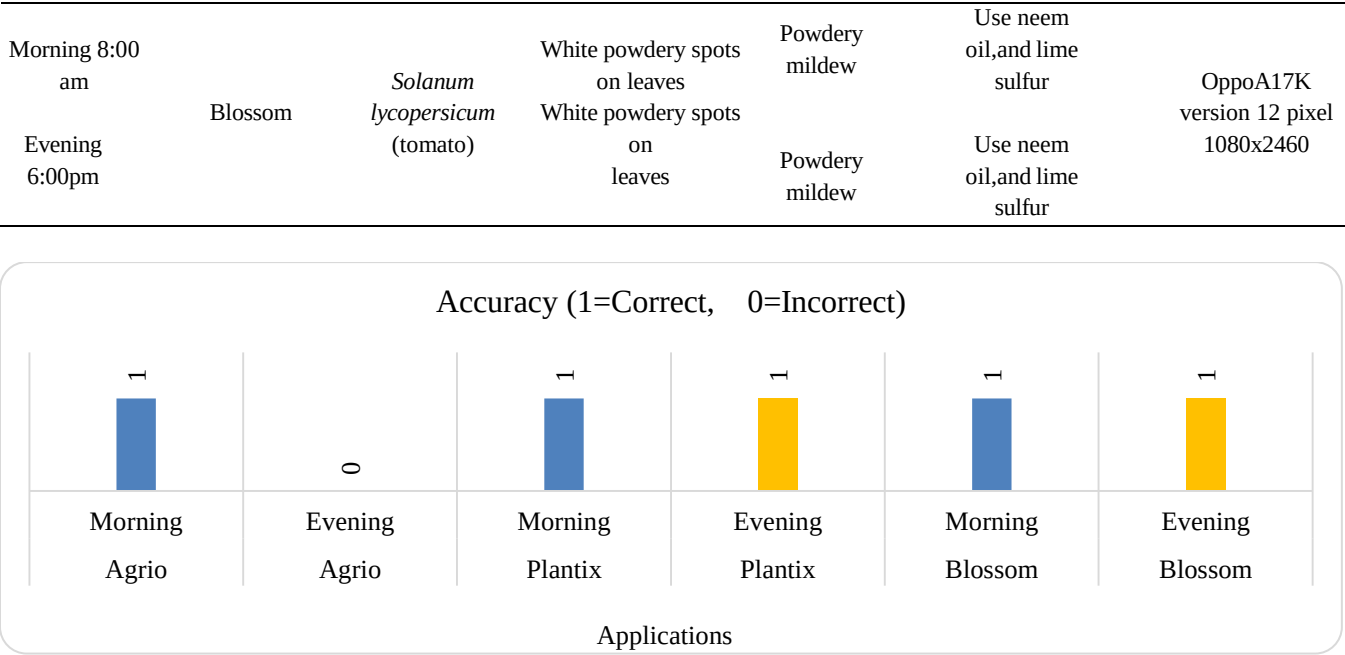


Figure 1: Tomato Disease Identification Accuracy: Morning vs Evening.

Potato Disease Diagnosis

The tests of *Solanum tuberosum* (potato) made in the Plantix, Agrio, and DoctorP showed different degrees of diagnostic accuracy. Alternaria brown spots were observed in both morning and evening by both Plantix and Agrio with high temporal reliability. But DoctorP delivered unstable results with brown to black spots in the morning and cherry leaf spots in the evening, which require less accuracy and stability (Table 3, Figure 3).

Identification

Samples of *Mangifera indica* (mango) analyzed with three

mobile applications, namely, Plantix, Agrio, and DoctorP, were compared in terms of diagnostic performance at the time of 11:00 AM and 4:00 PM. The results indicated that Potassium deficiency was diagnosed with the same accuracy in both time periods by Plantix, and Ascochyta blight was diagnosed consistently with a high level of accuracy in both sessions by DoctorP, which indicates that the diagnostic test has a high diagnostic stability. Agrio on the other hand was inconsistent with Powdery mildew, as it was detected in the morning but was inaccurate in the evening check (Table 4, Figure 4).

Table 3: Potato, locations and AI apps used for identification of diseases.

Location and time	App used	Plant species	Visible symptoms	Diagnoses by App	Treatment	Mobile version
Kandiario Morning 7:50 am	Plantix	<i>Solanum tuberosus</i> (potato)	Brown to black spots	Alternaria brown spots	Chlorothalanil & azoxystrobin	Infnix zero 30 version 14 pixels 1080x2400
Evening 6:40pm			Brown to black spots	Alternaria brown spots	chlorothalanil & azoxystrobin	
Morning 7:50 am	Agrio	<i>Solanum tuberosus</i> (potato)	Irregular or circular necrotic areas	Alternaria brown spots	Copper based potassium bicarbonate.	Infnix zero 30 version 14 pixels 1080x2400
Evening 6:40pm			Irregular or circular necrotic areas	Alternaria brown spots	Copper based potassium bicarbonate.	
Morning 7:50 am	Doctorp	<i>Solanum tuberosus</i> (potato)	Dark spots with yellow halos on young fruits	Black to brown spots	Use Copper oxichloride	Infnix zero 30 version 14 pixels 1080x2400
Evening 6:40pm			Purple spots on upper surface of leaves	Cherry leaf spots	Spray with ash solution	

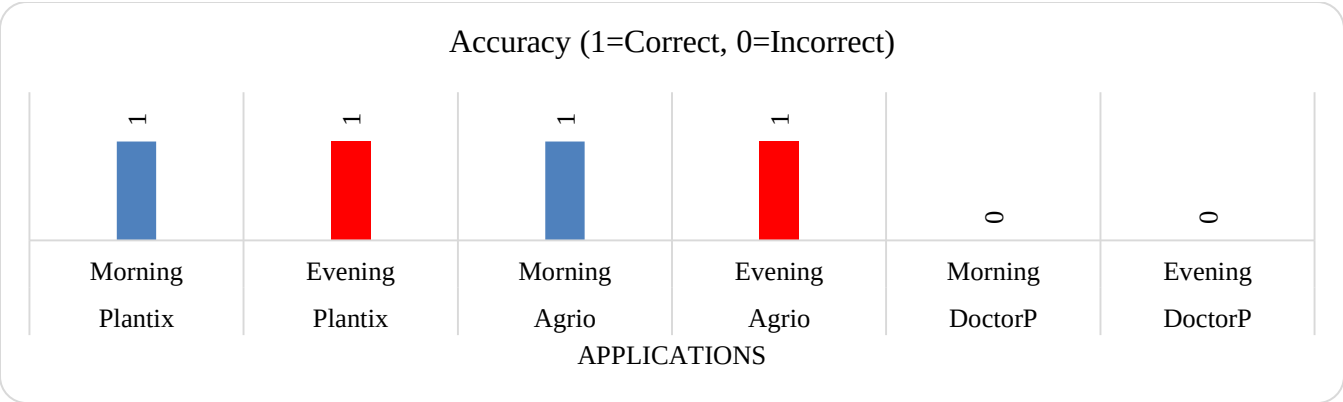


Figure 3: Potato Disease Identification Accuracy: Morning vs Evening.

Table 4: Mango, locations and AI apps used for identification of diseases.

Location and time	App used	Plant species	Visible symptoms	Diagnosis by App	Treatment	Mobile version
IPS Morning 11:00am	DoctorP	Mangifera indica (Mango)	Small circular dark spots on leaves	Ascochyta blight	Azoxystrobin + difenoconazole	Vivoy17 version 13 pixels 1612x720
Evening 4:00pm			Small circular dark spots on leaves	Ascochyta blight	Azoxystrobin + difenoconazole	
Morning 11:00am	Plantix	Mangifera indica (Mango)	Main veins remain dark	Potassium deficiency	Apply potassium rich fertilizer and proper PH	Vivoy17 version 13 pixels 1612x720
Evening 4:00pm			Main veins remain dark	Potassium deficiency	Apply potassium rich fertilizer and proper PH	
Morning 11:00am	Agrio	Mangifera indica (Mango)	White patches on leaves	Powdery mildew	Potassium bicarbonate + sulfur	Vivoy17 version 13 pixels 1612x720
Evening 4:00pm			White patches on leaves	Powdery mildew	Potassium bicarbonate + sulfur	

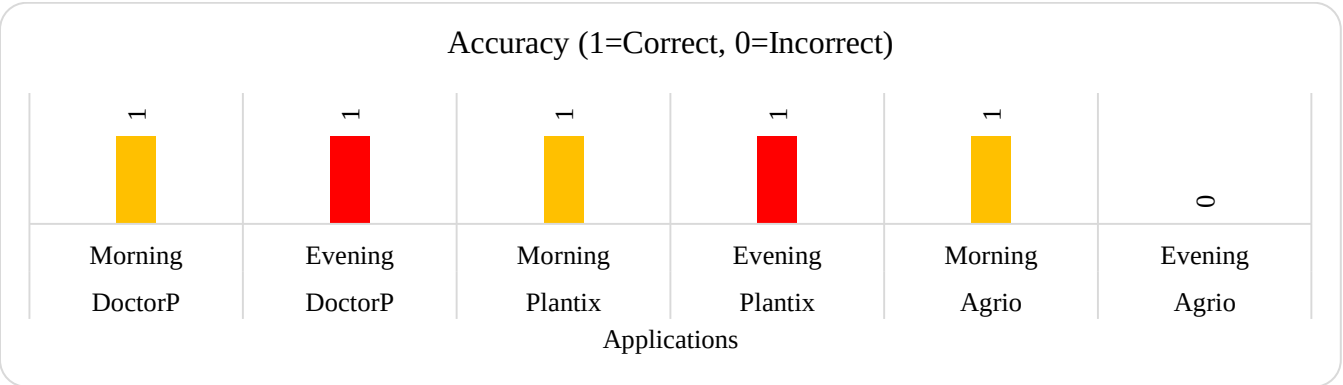


Figure 4: Mango Disease Identification Accuracy: Morning vs Evening.

Detection of Wheat Diseases

Plantix, DoctorP, and Agrio applications were used to analyze the leaf samples of *Triticum aestivum* (wheat). Plantix had the highest diagnostic consistency with a high hit upon Wheat leaf rust in the morning as well as in the

evening. Agrio was also similar, and it was able to distinguish Leaf rust at both instances. DoctorP, however, was variable: it detected Leaf rust in the morning, but Black chaff in the evening, implying that it was less accurate in low-light conditions (Table 5, Figure 5).

Table 5: Wheat, locations and AI apps used for identification of diseases.

Location and time	App used	Plant species	Visible symptoms	Diagnosis by App	Treatment	Mobile version
T.M.K Morning 8:00am	Plantix	<i>Triticum aestivum</i> (wheat)	Small orange to brown pustules on leaves	Wheat leaf rust	Use Azoxystrobin 18.2% Use Azoxystrobin 18.2%	Vivo y100 verion 13 pixels 1080x2400
Evening 7:00pm			Small orange to brown pustules on leaves	Wheat leaf rust		
Morning 8:00am	DoctorP	<i>Triticum aestivum</i> (wheat)	Spots surrounded by yellow margins Dark streks & spots on glumes	Leaf rust Black chaff	Calcium hydroxide + copper sulfate No effective treatment for black chaff	Vivo y100 verion 13 pixels 1080x2400
Evening 7:00pm						
Morning 8:00am	Agrio	<i>Triticum aestivum</i> (wheat)	Rust-colored spots on leaves	Leaf rust Leaf rust	Use myclobutanil, azoxystrobin are effective	Vivo y100 verion 13 pixels 1080x2400
Evening 7:00pm			Rust-colored spots on leaves		Use myclobutanil, azoxystrobin are effective	

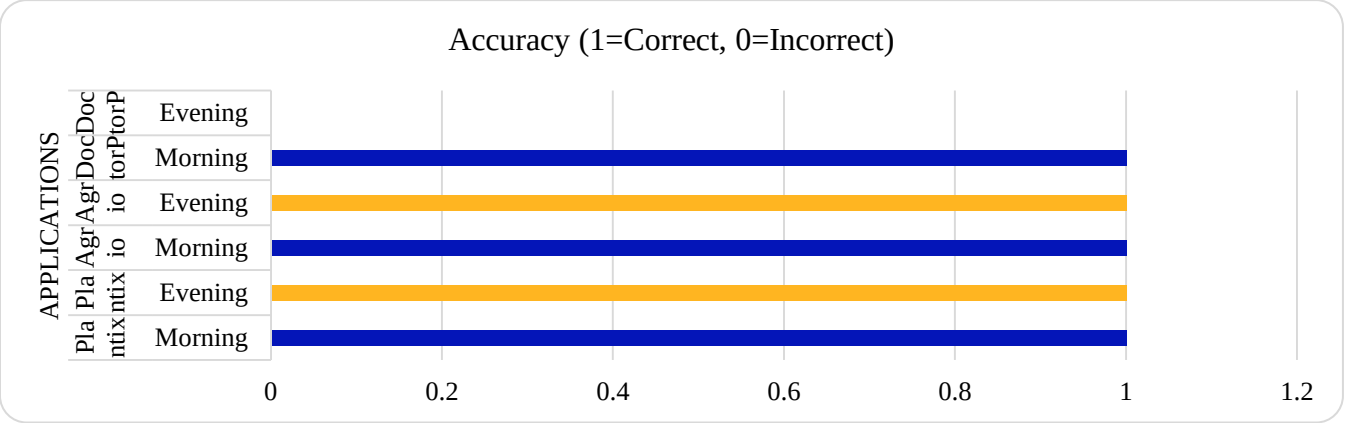


Figure 5: Wheat Disease Identification Accuracy: Morning vs Evening.

DISCUSSION

We meticulously surveyed a diverse range of plants and crops, including tomato, mango, chili, wheat, onion, potato, and cherry, from the agricultural regions of Matiar, Kandiaro, Dadu, Tando Muhammad Khan as well as at institute of plant sciences university of Sindh, Jamshoro, Pakistan. To aid in diagnosis, we systematically employed several mobile applications: Plantix, Doctor P-, Blossom, and Agrio, conducting our analyses during both the morning

and evening periods to observe any temporal variations in their performance (Plantix – Your Crop Doctor, n.d.; Blossom app, n.d.; DoctorP – Your Plant Doctor, n.d.; Agrio Plant Diagnosis App, 2018). Our comprehensive results indicated a notable consistency in Plantix, which consistently gave accurate diagnoses for plant problems at any time (Aamir et al., 2024; Abbas et al., 2023). When diagnosing chili pepper issues, Plantix accurately identified Cercospora leaf spots in both morning and evening analyses.

In contrast, while Agrio demonstrated excellent diagnostic capabilities during the morning hours, its accuracy appeared to diminish in the evening. Notably, Agrio accurately diagnosed fungal diseases in chili pepper during morning hours but incorrectly diagnosed viral diseases in the evening. Furthermore, our observations revealed that Blossom and Doctor P-Plant exhibited fluctuating results depending on whether the analysis was performed in the morning or the evening. These useful apps also provided details on symptoms, suggested treatments, and offered advice for maintaining healthy plants in our region (Ng et al., 2021; Siddiqua et al., 2022).

We examined infected tomato leaf samples from Dadu and used Plantix, Blossom, and Agrio apps for diagnosis. Plantix and Blossom showed consistent results in both morning and evening, with Plantix being highly accurate. Agrio's diagnoses varied, identifying powdery mildew in the morning and root-knot nematodes in the evening. These apps provided valuable insights into symptoms, treatments, and plant care, highlighting their potential as practical tools for agricultural health management in our region (Khakimov et al., 2022; Lévesque, 2001). We observed potato (*Solanum tuberosum*) foliar samples from Kandiaro and used DoctorP, Plantix, and Agrio apps for diagnosis. Plantix and Agrio consistently diagnosed *Alternaria* brown spots, while DoctorP showed varying results, identifying brown to black spots in the morning and cherry leaf spots in the evening, highlighting mobile apps' potential (Koduan, 2018; Anticull Melligence, 2018).

We surveyed in Institute of Plant Sciences University of Sindh, Jamshoro, botanical garden, and collected mango leaf samples exhibiting noticeable symptoms. We systematically employed several mobile applications, including Plantix, Agrio, and DoctorPlant, to conduct analyses during both morning and evening periods. This allowed us to assess variations in the apps' performance and diagnostic accuracy. Notably, Plantix and DoctorP showed high accuracy in their diagnoses during both morning and evening sessions. However, Agrio's diagnoses differed between the morning and evening periods. Furthermore, we visited Tando Muhammad Khan and scanned wheat (*Triticum aestivum*) leaf samples displaying noticeable indicators. We utilized several mobile applications, including Plantix and Doctor P, to perform evaluations both in the morning and evening intervals in this app's functionality and precision. Significant Plantix and Agrio evaluations reflected similar analyses during both morning and evening periods; however, DoctorP revealed different evaluations during the evening timeframe. (Mahlein, 2016;

Atiq-ur-Rehman Rattu et al., 2011; Bashir et al., 2022)

CONCLUSION

Several mobile-based applications, including Plantix, Agrio, DoctorP-Blossom and Plant disease identifier utilized in the study. Among these, Plantix was determined to be the most effective. These mobile applications work best during daylight hours, particularly in the morning, although Plantix also performed well in the evening. For the most accurate and rapid diagnoses, farmers and pathologists should attempt to capture live photographs of the affected portions of plants and crops. Detaching the diseased parts may lead to variations in the results provided by these applications compared to assessments made at the location of the plant. Clear, close-up photographs of the diseased areas of plants are essential, as blurred images may hinder the applications' ability to provide accurate results.

AUTHORS' CONTRIBUTIONS

All authors contributed equally in the manuscript.

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