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Estimation, forecasting, and prediction of arecanut yield considering the effect of external parameters: A systematic review

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Abstract: Intensive agriculture necessitates precise yield forecasting or yield prediction methods, which is technically challenging due to the dependence of yield productivity on the climatic, ecological and agronomic aspects and their effects. Various big data analytics framework has been used to forecast the arecanut crop yield considering hydrological, soil and meteorological datasets. This survey examines the existing literature on arecanut yield forecasting and also explores the widely used prominent methodologies and the effect of different attributes on the same. The study emphasises the problems and recent research developments in the Areca cropping system concerning the effect of weather, soil and crop genotype external parameters. By paving the route for future agricultural research, it also strengthens the substantial impact of these parameters on Arecanut diseases.

Keywords: Arecanut, yield, prediction, systematic literature review, external parameters, Arecanut diseases.

1. Introduction

Plantation Agriculture is a type of commercial farming, where the farmer grows a single commercial crop throughout the year. Arecanut also termed “betel nut” is a valuable commercial plantation crop which is grown in many districts of Karnataka (Raghavendra, B., Naik, 2021).The nut belongs to a family of “Arecaceae” or the genus of “Areca-L”. India stands as the world’s largest producer and consumer of Arecanut, accounting for half of global production and a huge number of people in the state of Karnataka rely solely on their income from their Arecanut form. (Hegde & Deal, 2014). Forecasting of crop productivity(Geoffrey Allen, 1994) is an important part of the agricultural sector where agricultural economists predict by considering the quantifiable characteristics of a growing crop.

The yield forecasting mainly depends on many factors where Bruno Basso et al., 2019 highlighted that field surveys, and historical yield data concerning seasonal variables play a vital role in building a crop simulation model. Apart from that the agro-meteorological conditions such as soil type, temperature, usage of fertilizers and water availability also play a fundamental role in any crop yield production(Xu et al., 2019). According to Van Kloppenburg et al., 2020, crop yield forecasting is one of the most challenging tasks in Precession Agriculture. The usage of various crop yield estimation/simulation models can give a reasonable result on yield production(Filippi et al., 2019).

The adoption of Precession Agriculture(Nowak, B. 2021) practises along with revolutionary technologies(Iaksch et al., 2021)has brought a significant implication on techno agricultural sustainability and yield improvement. Several studies have been identified wherein crop yield prediction models are constructed to overcome major agricultural issues. Many strategies are employed to develop an effective yield prediction model for various types of plantation crops. de Oliveira Aparecido et al., 2022 developed a model to predict the arabica coffee yield considering air temperature, solar radiation, water surplus and soil water storage as variables. They used the penman–Monteith method to handle the climatic data and implemented a data model using multiple linear regression and machine learning to predict the yield. Apart from this Corrales et al., 2022 also proposed a non-destructive time series model based on weather-crop management data. The combination of time series and machine learning based on regression trees such as Extreme Gradient Boosting XGBOOST, TR, RF) provided the best result for XGBoost model.

Another prominent prediction task in agriculture concerns the estimation of Oil Palm Yield based on Vegetation and Humidity Indices generated from Satellite Images and Machine learning techniques by Watson-Hernández F et al., 2022. Jui SJJ et al., 2022 have developed a novel spatiotemporal hybrid DSR-RF model with a dragonfly optimization algorithm and support vector regression to forecast tea yield considering hydro-meteorological variables. The review of Jayasinghe, S. L., & Kumar, L. (2021) on yield prediction of tea based on present and future climatic impact showed that the interaction between the environmental factors and the plantation crop influences yield quality. A forecasting work by Vergel et al., 2022 on Coca yield proved that environmental factors are a key parameter for any yield prediction.

A study by Ma, Yuchi, et al., 2021 highlighted the importance of the effect of environmental stress factors on yield estimation and agricultural productivity. Rodrigues, Paulo C., et al., 2021 in their work simulated a crop model considering seven genotype-specific inputs. Hence this study observed that crop genotype is also an effective parameter in yield prediction. Hara et al., 2021 emphasized the most commonly used independent variables in agricultural crop yield prediction based on Artificial Neural networks. In their analysis particular attention was paid to environmental variables such as Climate data, insolation, soil parameters, air temperature etc. Apart from this, a dynamic yield forecasting system was developed by Li, Linchao, et al., 2021 where the study insight into the yield response towards the environmental conditions and soil properties. These observations regarding yield forecasting indicate that crop yield is majorly dependent on multiple environmental factors including the crop genotype too.

The formulation of simulation models that predicts the areca crop yield is a demanding task which could benefit many farmers and the decision makers at the national and regional level. Being one of the major commercial crops of the country, Arecanut stands as a valuable commodity in the global market. According to the National Horticulture

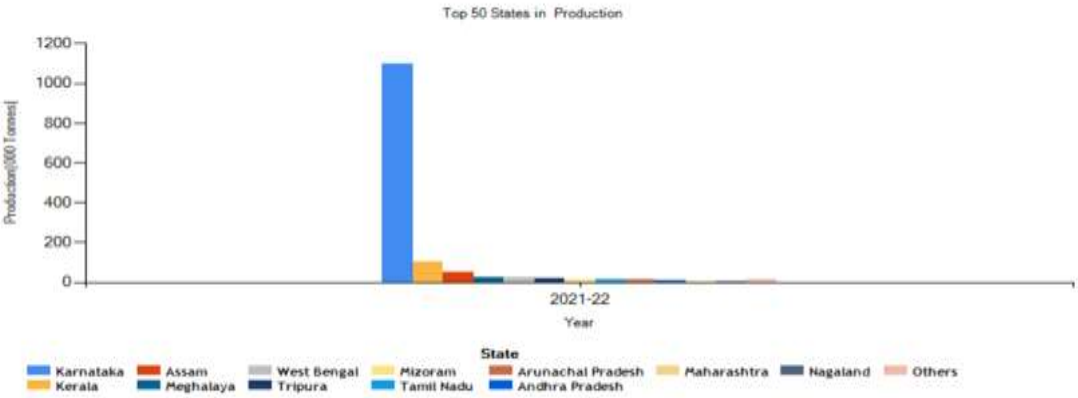
Board(NHB), Karnataka is a leader in producing this cash crop about 1100 tonnes per year(Figure 1).

Figure 1. Arecanut Production in India.

Indian Production of ARECANUT

Production(000 Tonnes)

Sr No.	State	2021-22 Production	Share(%)
1	Karnataka	1,100.00	78.98
2	Kerala	104.24	7.48
3	Assam	50.67	3.64
4	Meghalaya	24.09	1.73
5	West Bengal	23.28	1.67
6	Tripura	20.51	1.47
7	Mizoram	14.10	1.01
8	Tamil Nadu	13.49	0.97
9	Arunachal Pradesh	11.56	0.83
10	Andhra Pradesh	10.00	0.72
	Page Total	1,371.94	



Source: National Horticulture Board(NHB) (http://apeda.in/agriexchange/India%20Production/India_Productions.aspx?hscode=1092)

The influence of the major environmental factors and the market volatility necessitates the development of significance arecanut yield forecasting. This survey aims to investigate the Arecanut yield forecasting models and the impact of significant environmental factors on them by examining the more recent literature to highlight the previous studies & present strategies. Owing to the fact that there has been less investigation in this area, our review focuses on the major challenges as well as the effect of multiple attributes in arecanut yield forecasting by identifying research strategies for future research developments.

The paper is structured as follows: Section 1 "Introduction" provides a brief introduction to crop yield prediction and its dependence on multiple environmental factors. Section 2 "Methodology" stated the actual method or the research methodology which is employed in the review process. Next, Section 3 "Result" presents the outcome of the reviewed articles and Section 4 "Discussion" presents the highlights of the arecanut forecasting concerning the external parameters. It states the effect of multiple environmental parameters on the particular Areca crop yield including Arecanut pests and diseases. Section 5 "Conclusion" gives out the summary of the review work followed by the future research outline.

2. METHODOLOGY

To examine the available literature on Arecanut yield forecasting concerning the external parameters, we performed a Systematic literature review (Xiao, Yu, and Maria Watson, 2019;

Cooper, Chris, et al., 2018) of the pertinent literature. Kitchenham et al., 2007, indicated that the most important stage of a Systematic Literature review process is defining a valid research question. Hence, the review process was started by framing the specified research questions which were subsequently addressed by the primary studies. Since the authors wanted to identify the significance and the major effect of external environmental factors like weather, soil etc., on arecanut crop yield forecasting, we have defined the research questions focusing on these attributes and the techniques used in arecanut yield prediction process. Hence the research questions are as follows:

1. What is the impact of the 'Weather(agri-climatic conditions)' parameter on Arecanut yield forecasting models?
2. How does the external parameter 'Soil Sustainability' influence Arecanut yield production?
3. What effect does 'Crop-genotype' have on Arecanut yield performance?
4. How does Arecanut diseases and Pest are related to Weather, Soil and Genotype external parameters?
5. What strategies are employed for the Arecanut yield prediction models in various domain applications?

The authors have used the digital data repository to find the answer to the above research questions. A key-word based search was carried out on six different platforms, ACM, IEEE, SPRINGER LINK, MDLP, and SCOPUS. The search strings used in the research work are: "Arecanut", ("Arecanut yield prediction" OR "Arecanut yield estimation"), ("Arecanut forecasting" AND "diseases"). The searching process was carried out considering Title, Abstract and Keywords.

Since there is a very limited study on "Arecanut yield forecasting" concerning external environmental parameters, we have tried to include most of the relevant studies with a well-thought-out search strategy. Many studies from the search were found to be irrelevant and the authors found that major research has been done on Health and Medical science areas which were out of scope for the review process. Hence the authors used some standard selection criteria to filter the studies. The key points followed in the inclusion criteria are as follows:

- Papers that focus only on "Arecanut yield forecasting" concerning agri-climatic conditions.
- Papers that propose a Soil sustainability effect on Arecanut yield production
- Papers that generalise the Arecanut Crop genotypes and their effect on crop production.
- Papers focusing on the major disease and Pests of Arecanut yield forecasting.

The exclusion criteria included mainly two facts, one is, that duplicate and irrelevant articles which are not in English languages were excluded from the study and the second point was, that the articles which are not published in journals were excluded. The review process included the final 38 relevant journal papers on Arecanut yield forecasting. The primary study of these selected articles was done in a qualitative way using criteria like the effects of different variables on arecanut yield production and challenges in it. Further analysis was done by reading the full text of the papers based on their purpose, clarity and context.

3. RESULT

This section demonstrates the outline of the primary study followed by the results corresponding to the research questions. The statistics of the reviewed articles are presented such as year-wise analysis and attribute-wise analysis. Below diagram Fig. 2. represents the year-wise classification with respect to the significant research in Arecanut Crop.

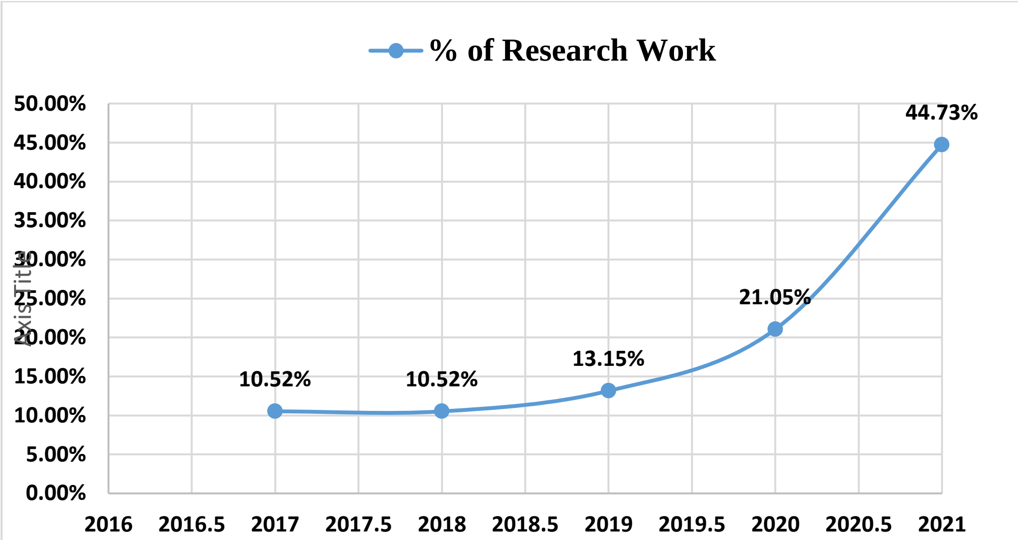


Fig. 2. Year Wise Analysis

Based on the year-wise analysis, one can observe a substantial growth in the Arecanut Research from 2019 to 2020. In the year 2021, an exponential increase can be seen with more publications than earlier indicating a growing trend in the Arecanut research area(Fig.2.). The graph in Fig.3. indicates the attribute-wise analysis classification considering the publications concerning Weather, Soil and Genotype attributes of an Areca crop. It is observed that the majority of the research work has been done on weather attributes compared to other parameters.

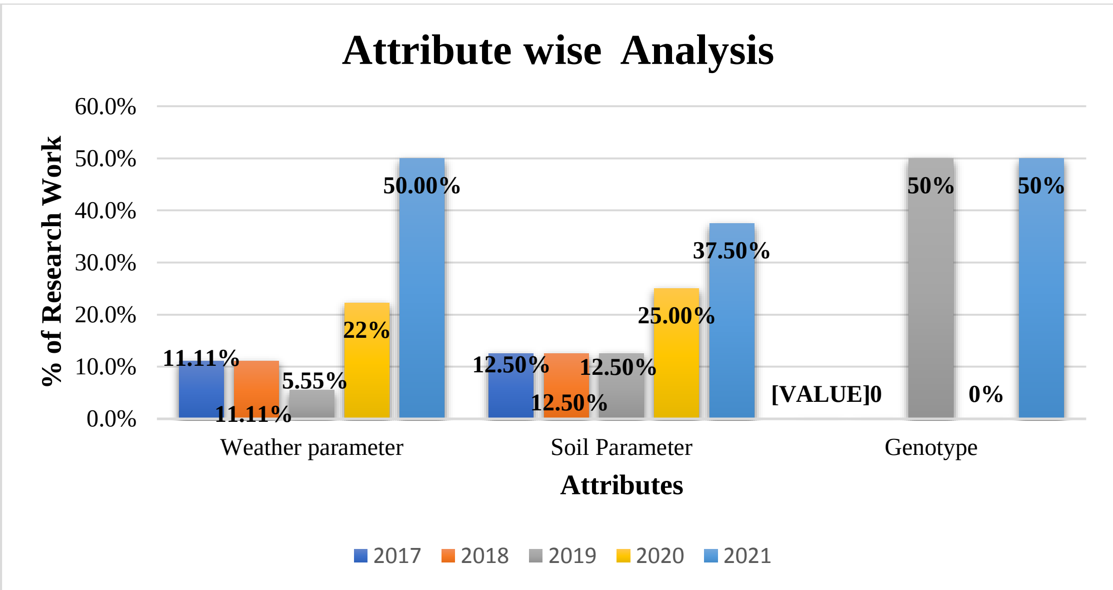


Fig. 3. Attribute Wise Analysis distribution

A detailed examination of the literature shows that relatively minimal research has been done on predicting arecanut crop productivity. To the best of the author's knowledge, no survey specifically mentions the yield prediction models of the Areca crop and its difficulties with the influencing parameters.

RQ-1: What is the impact of the 'Weather(agri-climatic conditions)' parameter on Arecanut yield forecasting models?

The first study issue concerns the impact of weather conditions on the production of areca crops. It can be observed that the irregular fluctuation of the weather concerning the magnitude and its distribution patterns has a significant influence on crop growth. The authors have retrieved six key climatic factors which influence the Arecanut crop yield from flowering to fruit set stage. In Fig. 4., the top key climatic factors which affect the yield production concerning the primary study are represented.

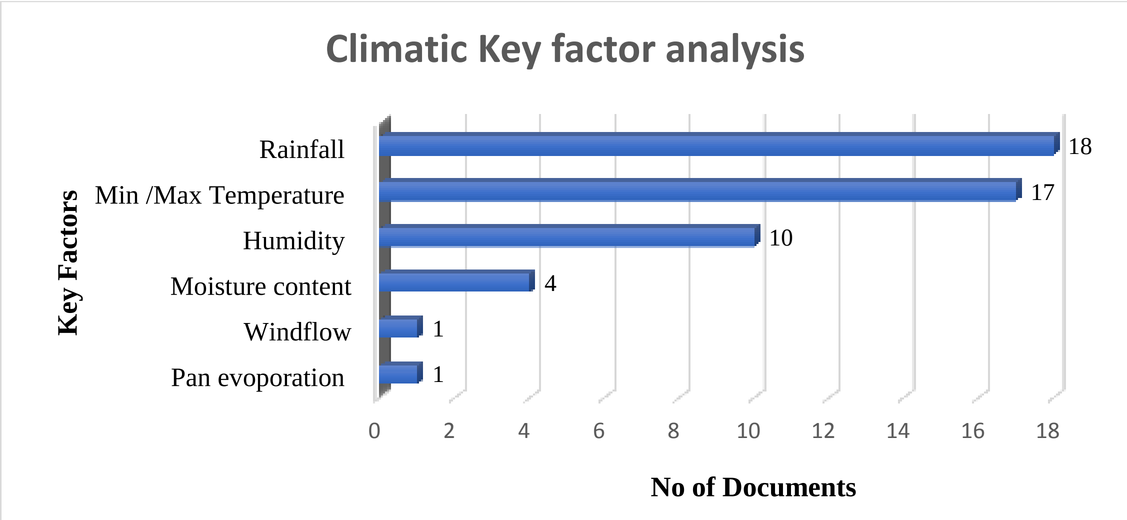


Fig. 4. The distribution of papers per Climatic Key factor

It is observed that Rainfall and Temperature have a major influence on Areca Crop production. The distribution of the primary study based on the Weather Parameter(considering the Key factors) is represented in below Table 1.

Table 1. Summary of the records included in the primary study based on Weather Parameter.

Study	Key Factor	Focus	Short description
(Krishna, R., et al., 2022)	Temperature Humidity rainfall	Fruit rot disease prediction model using Machine Learning techniques	Weather based Arecanut fruit rot disease prediction model using Machine Learning techniques
(Patil, B., et al., 2022)	Annual rainfall Min/Max Temperature Humidity	Multiple Linear Regression Model using climatic variables	Regression model analyse the influence of climatic factors on fruit rot occurrence in arecanut plantations
(Sagar, M., et al., 2022)	Rainfall Temperature	Time series model using Markov chain analysis	Analyse the Effect of increased climate variability and rainfall on Areca crop growth
(Praveen, K. M.,	Rainfall	Rainfall prediction model using	Rainfall prediction model to

et al, 2022)		Time series Analysis	analyse crop harvesting, fertiliser giving, ordo spaying
(Kanan, L., et al., 2021)	Min/max temperature Humidty Rainfall Windflow	Areca Forecast model using ML and IoT	Disease prediction model for Arecanut yield using climatic parameters
(Thube, Shivaji Hausrao et al, 2021)	Temperature	Fungus prediction model using Colonization study Molecular characterisation	Model to predict the occurrence of whitefly colonies fungus on arecanut plant
(Anilkumar, M. G., et al., 2021)	Rainfall	Disease detection model using CNN, Deep learning, Image processing	Model to detect the disease like Mahali Disease (Koleroga), Bud Rot Disease, Stem Bleeding, Yellow Leaf spot, Yellow Disease in arecanut leaves, trunk
(Chandol, Mr Mohan Kumar, et al., 2021)	Temperature Rainfall	Yield Prediction model using K-nearest neighbour, Random Forest Bayesian based Network classification technique	Yield prediction model for crops targeting Arecanut, coconut, black pepper, ginger
(Hebbar, K. B., et al., 2021)	Temperature Moisture Content	ANOVA based model to analyse moisture content of Areca Crop	Analyse the moisture/low temperature effect with respect to Aspergillus flavus disease in arecanut
(Tamang, P. D., et al., 2020)	Rainfall Moisture Content	Crop Model using Data Analytics	To identify the challenges and issues of Arecanut farmers & To assess the socio-economic benefit of areca nut
(SharathKumar , K. R., et al., 2020)	Temperature Humidity Rainfall	Disease prediction model using IoT and Machine Learning	Model to predict the disease in Areca crop at the early stage considering climatic factors
(Chavan, I., et al., 2020)	Temperature Humidity rainfall	Multiple regression crop model to detect Pest Activity in Arecanut	To study the seasonal effect of Raoiella indica Hirst pest on Arecanut crop
(Khedekar, R. G., et al,.2020)	Temperature rainfall	Analysis of Arecanut and Coconut cropping system	To study the adverse climatic effect on coconut and arecanut yield with respect nutrition management, disease management, Yield and nut characteristics
(Jose, C. T., et al., 2019)	Temperature Humidity rainfall	Crop model using Corelation Analysis & Spline smoothing technique	To study the effect of weather on Arecanut yield
(Sujatha, S., et al., 2018)	Rainfall Min/max Temperature Pan evaporation Humidity	Crop model based on Descriptive statistics	To study the influence of weather variability on Arecanut and coca yields
(Jadhav, P. B., et al., 2018)	Humidity	Aquacrop model using Stewart formula	To develop a Aquacrop model to study the crop performance under water requirability and humidity conditions for

			plantation crops.
(Sujatha, S., et al., 2017)	Rainfall Humidity temperature	Crop model using Descriptive Statistics And Corelation analysis	To study the suitable climate conditions for the plantation crops Arecanut and Coca
(Sujatha, S., et al., 2017)	Rainfall temperature	Model to analyse areca and coca soil properties	To study the effect of climate on soil nutrients.

Although many studies have been done considering the climatic variable with respect to its key factors, it is found that the majority of the research work has been done considering Rainfall, Min/Max temperature and humidity(Table 2). It seemed that the three key factors Temperature, Rainfall and Humidity have a major influence on the Arecanut Cropping system.

Table 2. The distribution of papers per weather parameter (key factors).

Key Factor	Occurrence	Percentage of occurrence
Rainfall	18	47.3%
Min /Max Temperature	17	44.7%
Humidity	10	26.3%
Moisture content	4	10.5%
Windflow	1	2.63%
Pan evaporation	1	2.63%

RQ-2: How does the external parameter 'Soil Sustainability' influence Arecanut yield production?

Soil fertility and Soil type play a vital role in sustainable crop production. A better Soil Health management system always improves crop quality by increasing crop production rate. During the primary study, the authors realised that soil health and fertility are dependent on many key factors, mainly soil pH level and organic carbon content as shown below (Fig. 5.) and the overall summary of the detailed study considering these basic soil key factors is represented in Table 3.

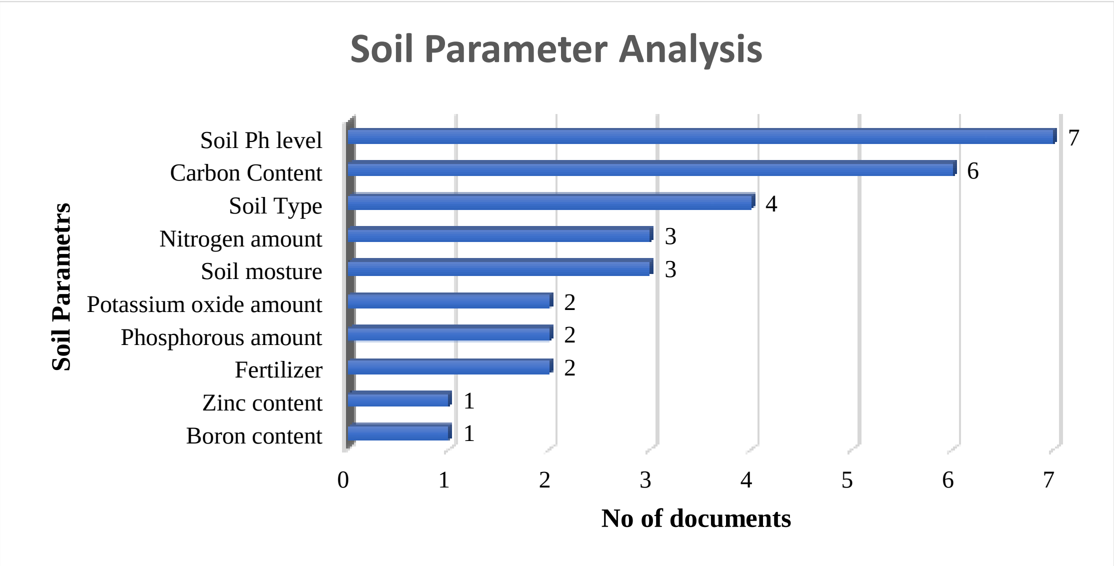


Fig. 5. The distribution of papers per Soil parameters

Table 3. Summary of the records included in the primary study based on Soil Parameter.

Study	Key Factor	Focus	Short description
(Vasundhara, R., et al., 2021)	Soil fertility Nitrogen amount Soil Ph level Phosphorous amount Potassium oxide amount	Soil fertility for crop growth	• To study the soil fertility with respect to Nitrogen amount, Soil Ph level, Phosphorous amount, Potassium oxide amount in Arecanut and coconut growing soils under agri-climatic conditions
(Raghavendra, Bachu, et al., 2021)	Soil Type(red, sandy)	Stem root disease	• Analyse the effect of basal stem root disease in red, sandy soil • To analyse the influence of soil type on crop production
(Hota, Surabhi, et al., 2021)	Organic carbon Soil moisture content Soil pH	Soil health and properties	• To investigate the soil physicochemical properties and soil microbial population and its effects on Arecanut, paddy and banana cultivation
(Lei, Shuhan, et al., 2021)	Soil fertiliser	Yellow leaf disease	• Model to detect the yellow leaf disease in Arecanut plants • Excessive use of fertilizers can damage the soil components and increase the disease
(GA, Kade Sutariati, et al., 2021)	Soil fertilizer Fix nitrogen	Suitable Areca growing medium composition	• To study the suitable growing medium composition to increase the areca growth • The growing media using the composition of 25% soil, 25% rice husk charcoal and 50% organic plus fertilizer is the best growing medium composition that can increase the growth of areca nut seedling.
(Kanan, L., et al, 2021)	Soil moisture	'Koleroga', Yellow Leaf Disease	• To predict the 'Koleroga', Yellow Leaf Disease in Arecanut yield at earlier stage.
(Ramakrishnappa, et al., 2020)	Soil Type (Six Soil types were	Areca-based Soil cropping system	• To study and test the six major types of Arecanut

	considered)		growing soil • To analyse the variance in morphological, chemical and physical properties of soil to improve crop cultivation
(Paul, et al., 2020)	Fertilizer Soil pH Nitrogen Carbon content	Soil nutrition factor for Crop growth	• To study the impact of soil sustainability in arecanut cropping system
(Amruthesh, P., et al., 2020)	Organic carbon Soil pH	Soil Properties(acidic, alkaline)	• A soil survey was made to study the physico-chemical properties of arecanut gardens
(Karthika, K. S., et al., 2020)	Organic carbon	Soil fertility	• To study the influence of Organic carbon(SOC) towards soil fertility, nutrition management in plantation crops
(SharathKumar , K. R., et al., 2020)	Soil Moisture	Areca crop disease prediction model	• Model to predict the disease in Areca crop at the early stage considering climatic factors and soil moisture content
(Mahesh Mohan, et al., 2019)	Soil pH	Soil Health	• To study the bacterial diversity in arecanut cropping system for better soil health management
(S. Basavaraj, et al., 2018)	Soil type	Ganodema foot rot disease	• To analyse the influence of Ganodema foot rot in arecanut with respect to soil patterns.
(Nagaveni, H. C., et al., 2018)	Zinc Boron	Soil fertility	• To determine the fertility status of the soil in Arecanut growing areas
(Sujatha, S., et al., 2017)	Soil pH Organic carbon Phosphorus pentoxide (P2O5) potassium oxide	Soil health	• To study the soil health indicators with respect to soil nutrition requirement, diffiency. • To analyse the impact of Soils with sticky clay, sandy, alluvial, brackish and calcareous nature with respect to Arecanut cultivation
(Kumar, M. D., et al., 2017)	Soil pH Organic carbon	Soil fertility	• To analyse the distribution of organic carbon in arecanut growing soils • To study its influence on

			soil fertility, water holding capacity and areca crop growth management.

Figure 5. above shows that the productivity of arecanut crops has a higher impact on the type of soil, the pH of the soil, and the amount of carbon in the soil. Hence from the primary study, it is very clear that Soil characteristics are crucial for producing high crop yields for the Areca crop. Table 4. Represents the distribution of papers per soil parameters (key factors).

Table 4. The distribution of papers per weather parameter (key factors).

Key Factor	Occurrence	Percentage of occurrence
Soil pH	7	18.4%
Carbon content	6	15.78%
Soil type	4	10.52%
Nitrogen amount	3	7.89%
Soil moisture	3	7.89%
Potassium oxide amount	2	5.26%
Phosphorus pentoxide amount	2	5.26%
Fertilizer	2	5.26%
Zinc content	1	2.63%
Boron content	1	2.63%

RQ-3: What effect does 'Crop-genotype' have on Arecanut yield performance?

During the data extraction, the authors found that very limited studies have been done on the genetic diversity of the Arecanut crop. To improve the crop yield quality, it is necessary to determine the impact of genotype, environment, crop management and their interactions on the yield. Below Table 5 highlights the result of the primary study concerning Genetic diversity of the Areca crop.

Table 5. Summary of the records included in the primary study based on Crop genotype parameter.

Study	Key Factors	Focus	Short Description
(Kumar, D. K., et al., 2021)	palm height, husk thickness, kernel breadth and dry weight of kernel	Genetic variability	• A study was made on genetic variability for various morphological characteristics and the association of different yield components in arecanut germplasm.
(Cao, X., Zhao, R., et al., 2021)	Leaf samples	Yellow leaf disease (APV1)in Areca genome	• A study was made on areca palm using RNA extraction to find out the impact of Areca palm velarivirus 1(APV1) on different genotypes • It's found that Phylogroup A is the most prevalent APV1 genotype in areca palm plantations

(Chavan, I., et al., 2019)	Plant leaf tissues	Mite Raoiella indica Hirst	• To study the various biochemical content of different arecanut genotypes • To test and assess the biochemical basis of resistance in response to the infestation by arecanut mite Raoiella indica Hirst
(Rajesh, B., et al., 2019)	Areca fruit husk thickness (cm), stem girth (cm) last exposed node (cm)	Genetic diversity	• To study the various arecanut genotypes using principal component method considering vegetative, reproductive, nut and yield characters.

RQ-4: How does Arecanut diseases and Pest are related to Weather, Soil and Genotype external parameters?

Many results from the primary study have shown that Pest and Disease management is the biggest challenge in Arecanut cultivation. A detailed literature study by Puneeth, B. R., et al., 2021 demonstrated the various types of diseases which affect the Areca cropping system. The diseases like a yellow leaf, Fruit root, Koleroga, Basal stem root, Bud root etc., may cause a potential decrease in Areca production. The authors observed the effective relation of Arecanut diseases with external parameters like Weather, Soil and crop Genotype. The study clearly demonstrates that these parameters can exacerbate the disease by reducing crop yield. Table 6. summarises the various types of Arecanut diseases and pests, as well as their relationships to the external parameters considered in RQ1, RQ2, and RQ3.

Table 6. Summary of the records included in the primary study based on Areca Diseases.

Study	**Parameter**	**Disease Identified**	**Short description**
(Krishna, R., et al., 2022)	Temperature Humidity rainfall	Fruit rot disease	• Fruit rot disease has strong relation with temperature, relative humidity and rainfall
(Patil, B., et al., 2022)	Annual rainfall Min/Max Temperature Humidity	Fruit rot disease	• The fruit rot disease in Arecanut has a strong relation with temperature, relative humidity and rainfall
(Anilkumar, M. G., et al., 2021)	Rainfall	Mahali Disease (Koleroga), Bud Rot Disease, Stem Bleeding, Yellow Leaf spot, Yellow Disease	• Continues Rainfall has an adverse effect in causing major diseases in Arecanut.

(Kanan, L., et al, 2021)	Min/max temperature Humidty Rainfall Windflow Soil moisture	Koleroga, Yellow Leaf Disease Fruit rot	• Variations in the Climatic parameters has a greater influence on increasing diseases. • Decrease in Water content(Soil moisture) may cause different diseases.
(Thube, Shivaji Hausrao et al, 2021)	Temperature	Whitefly colonies fungus	• Adverse climate conditions and temperature has a major effect on whitefly complex.
(Hebbar, K. B., et al., 2021)	Temperature Moisture Content	Aspergillus flavus	• Moisture and low temperature conditions has a greater influence on Aspergillus flavus disease in arecanut
(Raghavendra, Bachu, et al., 2021)	Soil Type(red, sandy)	Basal stem root disease	• Even though disease is common in all the soil types but the Red and Sandy soil type has major influence of the root disease.
(Lei, Shuhan, et al., 2021)	Soil fertiliser	Yellow leaf disease	• Excessive use of fertilizers can damage the soil components and increase the disease
(Cao, X., Zhao, R., et al., 2021)	Leaf samples	Yellow leaf disease (APV1)in Areca genome	• Phylogroup A is the most prevalent APV1 genotype in areca palm plantations
(Chavan, I., et al., 2020)	Temperature	Raoiella indica Hirst pest	• Pest activity has a higher influence on min/max temperature
(SharathKumar, K. R., et al., 2020)	Temperature Humidity Rainfall Soil moisture	Disease prediction	• Climatic factors have a strong corelation on Areca diseases • Soil moisture also plays a vital role in disease detection.
(Chavan, I., et al., 2019)	Plant leaf tissues	Mite Raoiella indica Hirst	• Mite population rate is related to the biochemical contents in the Areca genotypes • Sumangala genotype has a higher resistance towards Mite Raoiella indica Hirst
(S. Basavaraj, et al., 2018)	Soil type	Ganodema foot rot disease	• The disease was less observed in sand and red soil types

RQ5: What strategies are employed for the Arecanut yield prediction models in various domain applications?

Although Arecanut crop yield prediction is one of the challenging tasks in agriculture, it is possible to increase the crop yield with the help of revolutionary technologies like data analytics, deep learning etc. The primary study showed that many forecasting models are implemented using technologies like time series, multiple regression, descriptive statistics, image processing and many more. Many machine learning and data mining algorithms are also used in the implementation phases. Figure 6, represents the summary of the major technologies which are used in the present Areca prediction models.

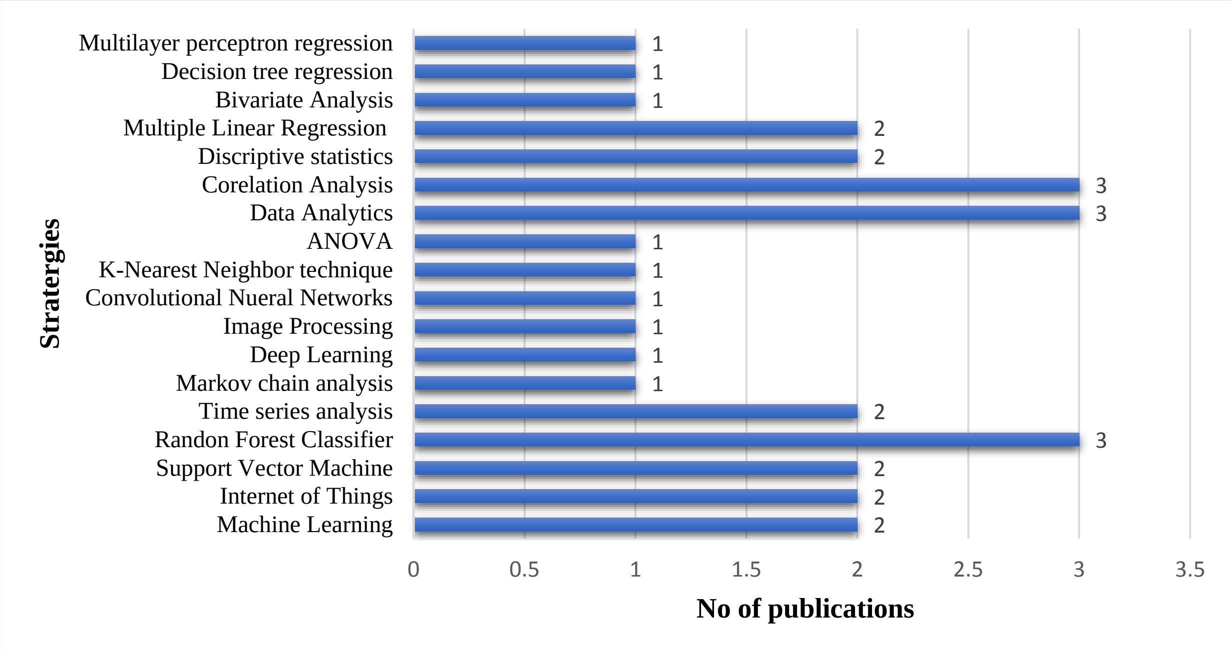


Fig. 6. The distribution of papers per Strategies employed in Arecanut research

4. DISCUSSION

In this section, we present the discussion related to each research question(Section 2) as follows.

General discussion

It has become undeniably obvious that research on the Arecanut crop has been rapidly increased since 2020, with a two-fold increase as shown in Figure 2. The primary study mainly focused on the datasets aimed at the key influencing external parameters. Considering the objective of the study the authors have reviewed 38 journal articles focusing mainly on the three effecting independent variables weather, soil and crop genotype(Figure 3). The preceding result demonstrates a clear association between these three attributes and the yield of the areca crop.

RQ1 -related: As stated in the primary study (Table 1), several important weather-related key factors were applied to the models of arecanut crop production. This indicates the impact of an external component, weather, on areca yield. It is evident from the results in Table 2 that rainfall, temperature (min/max) and humidity have a significant impact on the development of areca yields. The study makes it even more clear that abrupt climate changes, such as high rainfall rates, excessive temperature inversions, or a loss of air moisture due to humidity, can have a detrimental effect on yield growth by reducing crop production. Figure 4, depicts the study findings for all the climatic factors and reveals that the external parameter Weather has a substantial impact on the production of the arecanut crop.

RQ2 -related: Several soil characteristics were used as inputs in the Areca-developed research models, with soil pH level and carbon content (Table 4) highlighting the major dependency on yield production. Each soil type, yet if red, clay, or sandy, will have a soil health indicator for proper soil nutrition management (Sujatha, S., et al., 2017). Apart from that, bacterial diversity (Mahesh Mohan et al., 2019) plays a crucial role in soil sustainability. The original study's findings make it abundantly evident that soil pH and carbon content are essential for soil fertility and crop growth(Table 3). Thus, it is noticeable that the external parameter Soil plays a significant role in the Areca cropping system.

RQ3 -related: The genetic makeup of the plant always plays an important role in plant breeding. Even though there has been relatively limited research on this parameter, the study examined the genetic diversity of arecanut using several methodologies, including molecular analysis, RNA extractions, and the principal component method (Rajesh, B., et al., 2019). The major parameters of the genetic study, which include palm height, husk thickness, and leaf tissue samples (Table 3), are used in Areca disease management models to analyse the major threats that could reduce yield productivity. A very strong resilience to significant Areca diseases was observed in some Areca plant genotypes(Cao, X., Zhao, R., et al., 2021). Therefore, it highlights the significance of crop genotype as an external variable in yield output.

RQ4 -related: As illustrated in Table 6, the weather, soil, and genotype factors have a considerable influence on the various types of Arecanut diseases and fungus effects. According to the findings, major diseases such as fruit root, yellow leaf, Mite Raoiella indica Hirst, and many others that can reduce yield productivity have a strong relationship with key factors including temperature, humidity, soil moisture, and rainfall rate. As a whole, it again demonstrates the significance of the external factors stated in relation to RQ1, RQ2, and RQ3 on Areca crop yield.

RQ5 -related: Many different technologies and algorithms were used in the primary studies, as shown in (Figure 6) for the extraction of various types of Arecanut attributes. Many Areca crop models, such as disease prediction models, were discovered to heavily rely on data analytics, particularly regression analysis. . On the other hand, the primary study related to soil parameters doesn't rely much on these technologies. However, the outcomes of the primary analyses demonstrated that regression analysis is the most popular method for estimating crop yield.

5. CONCLUSION

In our study, earlier research on Arecanut crop predictions has been reviewed by employing a detailed attribute analysis where the three basic external independent parameters were examined to determine their effect on the production of the arecanut crop. The literature review emphasized figuring out how weather, soil, and genotype characteristics interact with the Areca cropping system. Several Areca predictive models have shown a substantial reliance on the three main climate variables of rainfall, temperature, and humidity. An increase in crop diseases including yellow leaf, fruit rot, and other problems have been linked to abrupt weather fluctuations indicating the crop reliance on Weather parameter.

The prominent publications of Arecanut concerning Soil parameter revelled its dependency on the robust cropping systems. Both soil pH level and the amount of carbon content in the soil have shown a remarkable impact on plant health. Studies on soil types to its bacterial diversity, nutrition management, water holding capacity have impacted the crop growth by indicating its extreme dependence on Areca cropping system. However, due to the lack of available public data on crop genotypes and the scant amount of available research, data extraction for the analysis of Areca genotypes became time-consuming. Several studies on leaf tissue extraction, fruit husk thickness, and so on have demonstrated the genetic diversity of the Arecanut plant. By showing the highest resistance to plant diseases, the crop genotypes have determined their impact on the healthy cropping system.

A notable remark in the review was, the influence of these external parameters on the Areca disease management systems. Major diseases like yellow leaf, Raoiella indica Hirst pest, and Ganodema foot rot disease have shown a strong correlation with temperature variations, soil moisture, rainfall and on many other parameters. Therefore, it is undoubtedly clear from the findings that the three external factors taken into account in the aforementioned study have a considerable impact on the crop production of arecanut. Despite the fact that many strategies were employed, many of the studies relied on regression techniques. In the present study, the authors have limited their analysis to three parameters, in future the study could be extended considering the effect of other variables on the same.

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