International Journal of Advance Research in Science and Engineering
Volume No. 12, Issue No. 02, February 2023
www.ijarse.com
IJARSE
ISSN 2319 - 8354

A Comprehensive Review on Evolution of Learning Techniques for Early Identification of Severity and Infection Type in Tomato Crops

Harkesh Yadav[1], Sachin Kumar[2], Garima Srivastava[3], [4]Pragya

[1,2,3]Amity University Uttar Pradesh, Lucknow Campus (U.P.), India

[4]MVD College, Lucknow University, Lucknow, India

[1]harkeshyadav87@gmail.com, [2]skumar3@lko.amity.edu, [3]gsrivastava1@lko.amity.edu,

[4]dr.pragya2011@gmail.com

ABSTRACT

India is agricultural nation with 19.9% share of agriculture in GDP, India as a nation is geographically and demographically very wide and so is the variety and diversity ofcrops it cultivates, crops are generally cultivated in three main seasons, that are rabi, kharif and zaid, Food crops primarily cultivated include - Rice, Wheat, Millets, Maize, Pulses, Sugarcane, Oilseeds, Horticulture crops, Tea, Coffee, Rubber, Cotton, tomato, and Jute. Harvesting tomato is among the most profitable agriculture venture. Commercially crop is an excellent option as it can be harvested four times a year and for tomato yielding happens in short time almost 50 to 60 days after sowing. Tomatoes happen to be major dietary source of the antioxidant lycopene, that have abundant of health benefits, even reduced risk of heart disease and cancer. Tomatoes are also great source of vitamin C, potassium, folate, and vitamin K. Major state producers include Andhra Pradesh, Madhya Pradesh, and Karnataka. However even Tomatoes are prone to number of diseases like bacterial stem, early blight, wilt disease, fusarium wilt, leaf curl, damping off and Septoria leaf spot. Conventional techniques include inspection by human expert to identify anomalies in tomato plants caused by pests, diseases, climatic conditions, and nutritional deficiencies. Automated techniques included infection and disease identification employing artificial intelligence and image processing algorithms,but these algorithms had less accuracy later deep learning approaches embedded with hyper spectral imaging techniques were explored, which not only increased accuracy in early disease identification but also gave insight on various features such as stress level and optimum health. Paper presents a comprehensive survey on evolution on algorithms and techniques for determining and identifying severity of infection, disease type, stress level and optimum health of crops.

Keywords: deep learning, hyper spectral imaging, Tomato, severity of infection, disease type, stress level.

1. INTRODUCTION

India is agricultural nation with 19.9% share of agriculture in GDP, India as a nation is geographically and demographically very wide and so is the variety and diversity of crops it cultivates, crops are generally cultivated in three main seasons, that are rabi, kharif and zaid, Food crops primarily cultivated include - Rice, Wheat, Millets, Maize, Pulses, Sugarcane, Oilseeds, Horticulture crops, Tea, Coffee, Rubber, Cotton, tomato, and Jute. Harvesting tomato is among the most profitable agriculture venture. Commercially crop is an excellent option as it can be harvested four times a year and for tomato yielding happens in short time almost 50 to 60 days after sowing. Tomatoes happen to be major dietary source of the antioxidant lycopene, that have abundant of health benefits, even reduced risk of heart disease and cancer. Tomatoes are also great source of vitamin C, potassium, folate, and vitamin K. Major state producers include Andhra Pradesh, Madhya Pradesh, and Karnataka. However even Tomatoes are prone to number of diseases like bacterial stem, early blight, wilt disease, fusarium wilt, leaf curl, damping off and Septoria leaf spot.

The crop is quite easily affected by several types of diseases, and this very severely impacts on the quality and production of the tomato crop, even resulting in huge economic losses. Figure 1depicts the major producers of tomato crop world-wide. [1-5]

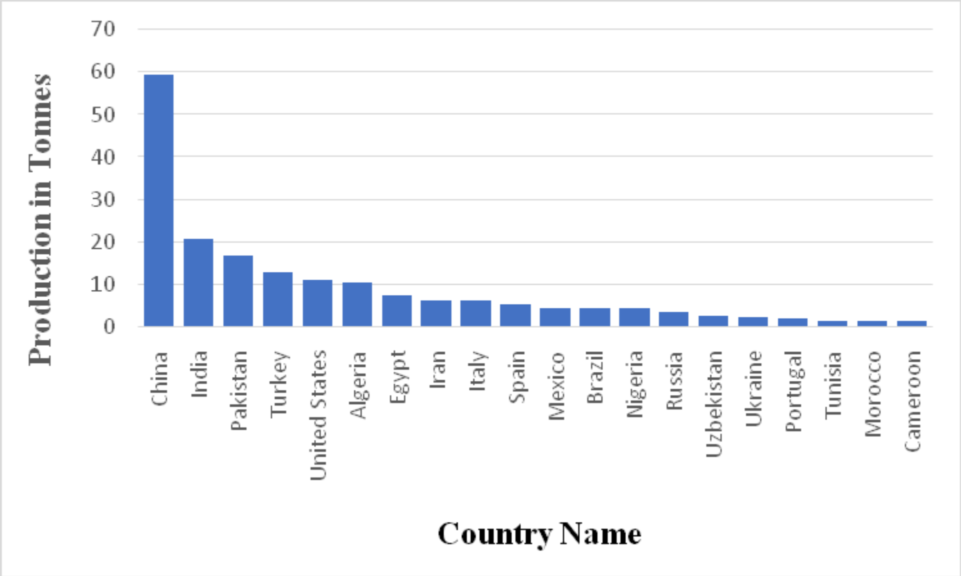

Figure 1: major tomato crop producing nations [1,2]

Tomato crop requires at least twelve nutrients for normal growth and reproduction. These are nitrogen (N)

i. phosphorus (P)
ii. potassium (K)
iii. calcium (Ca)
iv. magnesium (Mg)
v. sulphur (S)
vi. boron (B)
vii. iron (Fe)
viii. manganese (Mn)
ix. copper (Cu)
x. zinc (Zn)

xi. molybdenum (Mo)

Functional operation of these major nutrients and their concentrations is depicted in figure 2.

. Nutrient Contents in Tomato Crops		
. Nutrient	*Contents (mg kg^{-1})*	*Function*
N	***48000***	***Constituent of proteins and amino acids***
P	***5000***	***Constituent of nucleic acids***
K	***55000***	***Activates enzymes (e.g. pyruvate kinase); regulates pH of tomato fruit.***
Mg	***5000***	***Constituent of chlorophyll***
Ca	***25000***	***Component of plant cell wall. Affects the permeability of cell membranes***
S	***16000***	***Constituent of proteins and amino acids (e.g. methionine)***
B	***35***	***Regulates the level of growth substances***
Fe	***90***	***Constituent of enzymes (e.g. peroxidase, catalase)***
Mn	***350***	***Activates enzymes (e.g. malic)***
Cu	***15***	***Constituent of oxidizing enzymes (e.g. phenolase)***
Zn	***80***	***Constituent of enzyme (Carbonic anhydrase)***
Mo	***0.5***	***Involved in the utilization of NO3 -N (nitrate reductase)***

Figure 2: Functional operation of major nutrients and their concentrations for Tomato

REQUIREMENT AND ROLE PLAYED BY NUTRIENTS CAN BE SUMMARIZED AS

Nitrogen: Nitrogen is the main component of enzyme, vitamin and green pigment and other cell organelles of plants. It is important for the development and growth of plant. Crops remove around 4.8 – 5.3lb of nitrogen for every ton of fruit produced. High rates of 223lb/ac or above are needed for average 44.6t/ac field crops. An adequate amount of Nitrogen is for maximum production of tomato. Its deficiency causes the growth of plant as well as yellowing of leaves at the lower part tomato, but it effects the mature leaves most as they die before time. Yellowing and dying of leaves affect the qualities like colour, texture and taste as well as quantity of fruit in plant. Excess of nitrogen will also decrease the production rate.

Phosphorus: Phosphorus is important for the initial stage of development as it fasten the root development by the fixation of plant in soil. A solution containing high concentration of P is normally used for tomato sapling in the beginning of early root development and fixation in the soil. The increased root growth stimulated by P helps in maximum absorption of water along with other nutrients from the soil and improve toughened growth of stem and healthy vegetative growth. Phosphorus is a component of nucleoprotein. It helps in the production of large number of blossoms in the early growth of tomatoes and early setting of fruits and seeds.

Potassium nutrition can affect the quality of tomato fruit. Potassium is required in stomatal movement for water regulation in the plant. It helps in activation of enzymes needed for carbohydrate metabolism and translocation, nitrogen metabolism and protein synthesis, and regulation of cell sap concentration. It also improved the durability of tomato fruit during storage. Potassium deficiency results in chlorosis and yellowing of tomato leaves and reduced the distance between internodes and affect the whole plant gradually.

Calcium: calcium is also needed by tomato in large amount because of its higher concentration in the plant components. Most soil has enough Calcium required for plant. Calcium deficiency occurs when soil pH decreases, and acidity increases in soils with poor structure or drainage

Magnesium: It is a component of leaf pigment chlorophyll, cell wall, and organic acids. Tomato fruit crop production is highly increased by using Mg fertilizer (Table 8). Magnesium deficiency causes interveinal chlorosis in leaves at the lower arial part of the plant and goes upwards.

Sulphur: Sulphur is a constituent of protein and amino acid. Deficiency of S in the field is rare because it is usually applied in combination with N, P, and K fertilizers. Acid rain and atmospheric pollution containing SO_2 also absorb S by the plants. SO_2 can causes spots on the middle and lower leaves, which become white, dry, and papery.

Boron: Boron plays a significant role in the breeding and reproductive growth of tomato. It can influence on the production of tomato flowers and fruits. Commercial production of tomato is mainly affected by the deficiency of boron. The deficiency found in compost and calcareous sandy soils.

Iron: Iron is a constituent of many enzymatic actions during in the metabolism reactions in tomato. Iron deficiency appears mainly highly alkaline soil and in calcareous soils. The deficiency appears as pale-yellow chlorosis on younger leaves at the lower arial part of plant.

Manganese: As with Fe, Mn deficiency is increased by high soil pH. Although less common in most field soils, Mn deficiency may visualise in a plant grown in sandy soils, organic soils, and peats due to over liming. The symptom appears as pale green or yellowish interveinal chlorosis in the middle and younger leaves, leading to brown spots in the centre of the pale area.

Zinc: Zinc is a constituent of carboxy anhydrase enzyme essential for metabolism of nutrients in tomato. The deficiency appears as brown patches spot on leaves along with slight chlorosis.

Copper: Cu deficiency may be seen in tomato cultivate in greenhouse soils or in soilless medium low in Cu content. Its main symptom visualises as curled leaves with tubular structure and curled petioles downwards.

Molybdenum: Molybdenum is needed for N metabolism in tomato. Molybdenum deficiency can occur in acid soils, peats, and soilless compost. The deficiency appears as pale green interveinal chlorosis in older leaves

Fertilizers and manures though help increase productivity but excessive use damages soil quality and environment. Apart from nutrient requirement, crop is also majorly affected by number of diseases. In this paper we are specifically focusing on identification of diseases through machine learning algorithms in Tomato crop. The paper is arranged as follows, section 2, presents diseases and symptoms that effect tomato crop. section 3 discusses evolution of learning techniques for early identification of infection in Tomato crops, section 4 presents technique for disease severity measurement and finally conclusion is presented in section 5.

2. Diseases and Symptoms: Tomato Crop

Yield of Tomato as crop suffers from number of factors that affect its production, factors range from diseases, insects, animals, adverse effect of pesticides and climatic conditions. Work conducted is an effort to summarize innovations in infection identification of Tomato crop through Machine learning algorithms. Figure 3 depicts different categories of infection in Tomato crop. Some of the most common diseases and infection that Tomato crop suffer from can be summarized as:

International Journal of Advance Research in Science and Engineering
Volume No. 12, Issue No. 02, February 2023
www.ijarse.com
IJARSE
ISSN 2319 - 8354

Bacterial	*Fungal*	*Viruses*	*Viroids*	*Oomycetes*
Canker Speck Spot Pith necrosis Stem rot Crown gall Bacterial wilt	**Alternaria stem canker Early blight Damping off Fusarium crown Fusarium wilt Gray leaf spot Gray mold Leaf mold Septoria leaf spot Southern blight**	**Alfalfa mosaic Cucumber mosaic Curly top Potato leafroll Potato virus Y Pseudo curly top Tobacco etch Tobacco (tomato) mosaic**	**Tomato bunchy top Tomato apical stunt Tomato planta macho**	**Damping off Buckeye rot Late blight**

Figure 3: Categories of infection in Tomato crop

Damping Off: Among one of the worst infections that crop suffer from occurring at nascent stage. Infection appears in two layers, pre-emergence, and the post-emergence phase. In the pre-emergence layerthe seeds die even before they reach the soil surface whereas in post-emergence layer infection happens in young crop, tissues of the collar of young crop gets infected. Infection can be controlled viaseed treatment for fungal culture Trichoderma viride (4 g/kg of seed) or Thiram (3 g/kg of seed).

Figure 4: Early Blight infection – Tomato crop Leaf

Early Blight: Is a very common infection type for the Tomato crop, the infection appears at foliage and can appear at any stage of the growth. fungalinfection attacks the foliage causing characteristic leaf spots and blight. The infection appears as small, black lesions mostly on the older foliage. Remedy will involve removal and destruction infected area. Infection is depicted in figure 4.

Buck Eye Rot: Buckeye rot is a very severe infection for all Tomato harvesting regions. Infection causes the crop to rot affects the crop near to the ground. Infection occurs as greyish green or brown water-soakedpatches generally occurs where the crop touches the soil. Remedy would require optimum drainage resources to be ensured in the sowing area.

Late Blight: infection appears when humid environment coincides with low temperatures for extended intervals. Lesions that appear are first irregular in shape and are large greenish-black and water absorbed. These regions enlarge rapidly, becoming dark brown, and under moist environment, develop a white fungal growth on the lower surface of stems. Remedy comprises of rotation of crops being sown and harvesting diseasefree seeds and transplants.

Fusarium Wilt: One of the worst infections that crop can face, first symptoms of the infection are dying of veins and chlorosis. In young plants, symptom may also comprise of dropping of petioles. Remedy comprises of regular inspection of wilt infected plants once infected crops should be removed and destroyed.

Figure 5: Septoria leaf spot for Tomato plant

Septoria Leaf Spot: Crop may get infected from this disease at any stage of its life, infection is characterized by number of small greyish circular patches with dark border, remedy involves removal of affected parts. The infection is depicted in figure 5.

Bacterial Wilt:This infection makes one of the most severe impacts on crop reasons include high moisture content of soil and temperature. The infection is characterized by rapid and full wilting of normal grown-upcrops, remedy include crop rotations.

Figure 6: Bacterial leaf spot – Tomato crop

Bacterial Leaf Spot: increased moisture in form of environmental conditions or rain favour growth of leaf spot infection. General outbreaks of the infection can be linked with heavy rain. leaves once infected show smallbrownish circular patches with yellowhalo. Infection is difficult to control once it appears inthe field. Infection free seed and seedlings should always be employed, and crop should be harvested on rotation.

Bacterial Canker: Infection causes permanent wilting of leaves, light coloured streaks occur at the juncture of petiole and stem, remedy includes hot water treatment of seeds at 50°C for 25 minutes, seed treatment and crop rotation.

Tomato Mosaic Virus: infection can be identified by light and day green mottling on the leaves. Leaves once infected gets distorted and compress in shape. Remedy comprises Seeds from disease free healthy plants and treatment in a solution of Trisodium Phosphate (90 g/litre of water) a day before sowing.

Tomato Spotted Wilt Virus: Spotted wilt virus spreads through thrips, the infection results in streaking of the leaves, stems, and fruits. Remedy involves removal of infected plant.

Tomato Bunch Top Virus: Disease displays enhanced extra growth with apical proliferation. Leaflet margins curls towards the tips and the outward look displays puckered conditions. Remedy involves infected plants should be removed and destroyed.

Tomato Big Bud (TBB): This infection effects crop parts, infection spreads through leaf hopper. Primary symptoms include spots that appear at the tips of the actively growing shoots. Remedy involves removal and destruction of the affected plant parts.

Anthracnose: First sign of infection displays small sunkenwater filled patches, patches over time become large and dark in colour.Fungal infection is easily distinguishable as lesions on surface. Remedy involves having well irrigated soil, rotation of crop and anti-fungal treatment.

Monitoring the health of the crops is important step towards the growth in productivity. There are certain factors which should be kept in mind while monitoring crop's growth like light, water, temperature, nutrients, diseases and many more. Early detection of whatever issues associated with any one of the above factors can help us to monitor the growth in an efficient way and without wasting our resources in later stage. [13-15]

3. EVOLUTION OF LEARNING TECHNIQUES FOR EARLYIDENTIFICATION OF INFECTION IN TOMATO CROPS

Innovations in technology more precisely now termed as disruptive technologies have accelerated the pace at which expert solutions for precision agriculture are being proposed and implemented, results are better production and yield. Evolution of learning algorithms as depicted infigure7outlines various algorithms already into development and implementation stage. These Machine Learning algorithms is outcome of diversified advancement of many related domains, innovations and out of the box ideas.

In earlier stages of precision agriculture and automated techniques, digital image processing was used for identification of crop diseases, the algorithms were usually implemented MATLAB or similar other platforms. With advent of innovations in techniques learning algorithms and deep learning with Neural Network started pitching in, these algorithms providedimproved classification and with enhanced accuracy owing to its multiple feature segmentation stages automatically [22]. Later several diversified approaches were designed having enhanced accuracy, Convolutional Neural Network (CNN) was one among them, the algorithm depicts a higher performance percentage when compared to at par existing traditional classification techniques.[25]. Currently with Deep CNN techniques like VGGNet, LeNet, ResNet, etc. performance has further significantly improved, reference [40] suggest technique that were trained for the prediction of tomato leaf disease that gave the most accurate classification performance. Number of frequently employed object detection and segmentation algorithms namely R-CNN, Mask R-CNN, FCN, SSD, etc., were designed for improved identification but took lot of time to provide improved result [36]. Later some hybrid techniques were also proposed to further improve the accuracy and performance of CNN algorithms.

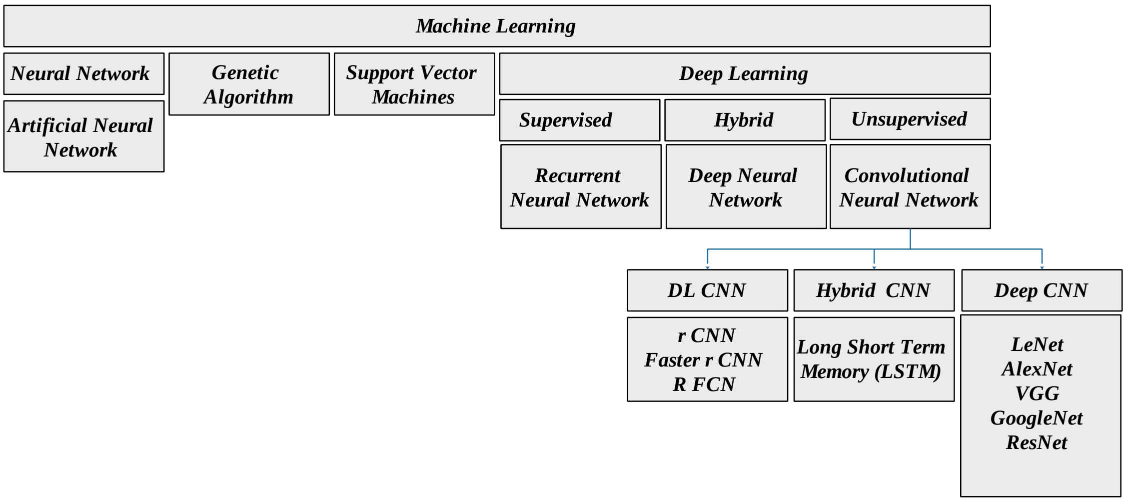

Figure 7:Evolution of learning algorithms for Precision Agriculture

Primary objective of CNN algorithm is object detection, identification, segregation, classification, etc., that gives excellent performance with sufficient labelled data. Innovations in CNN further resulted in hybrid CNN termed as Long Short-Term Memory (LSTM) [31] that very well had some of the diversified advantages of basic algorithm like automated feature extraction, hierarchical learning process, multitasking.H.Al-Hiary et al, gave a crop disease identification technique, employing k-means cluster technique embedded Neural Network. The algorithm performed both identification and classification of the type of crop diseases with pre trained model. The model provided a precise accuracy ranging between 83% and 94%. [16] Dheeb Al Bashish et al, proposed combined K-means cluster technique for segmentation and ANN algorithm for infection identification throughpattern infecting the leaf. Technique proposed worked with almost 93% accuracy. Advantages included efficient recognition of parameters. Disadvantages include, minor level segregation and extraction of feature is required.[17] Anand.H.kulkarni et al, gave an ANN algorithm for classification and identification of infected leaves. Gabor mask was employed for segmenting of sample images.Model designed obtained 91% accuracy. Advantages include,excellent classification and identification.Disadvantages incorporation of hybrid classifiers can further improve identification rates.[18] S.Arivazhagan et al, gave a Support Vector Machine(SVM) based identification technique. Model designed gave 94% accuracy. Advantages included automated leaf disease identification andclassification. Disadvantages NN classifiers can be employed for better and improved performance. [19]Usama Mokhtar et al, gave SVM technique with other kernel functions to identify tomato leaves infection with an improved accuracy of 99.5%. advantages were efficient and effective results. Disadvantages includeddiversified inputs that affects and degrades performance. [20] Sharada.P.Mohanty et al, designed a deep learning algorithm using AlexNet and GoogleNetframeworkthat secures aimproveddisease recognition percentage. Proposed trained model (GoogleNet) achieved 99.35% accuracy. Advantages included that classification process is very fast in algorithm proposed. Disadvantage included, numerous hours of training is needed.[21] Srdjan Sladojevic et al, gave a deep CNN model. After training model provided 96.3% of accuracy. Advantages included, designed methodology is better and achieves more precise classification. Disadvantages include improvement in accuracy. [22] H.Sabrolgave a classification model based on tree, primary features were extracted from cleaned and segmented sample dataset are fed as input to classification tree model, which labels tomato crop infection with 97.3% accuracy. Advantage includesexcellent classification efficiency. [23] Mohammed Brahimi et al, gave a CNN model for enhanced labelling. Importance of CNN is primarily automated extraction of features from raw sample dataset.Trained model achieves 99.18% accuracy. The system performs with high efficiency. [24] Alvaro Fuentes et al, gave an object identification model with faster r-CNN, R-FCN, and SSD techniques merged with the feature extractor techniques of deep CNN. Model proposed displayed improved identification in output. Disadvantages include slag in working.[25] HalilDurmas et al, gave a DL network assisted architecture titled sqeezeNet and AlexNet for tomato crop infection identification. AlexNetgave improved classification accuracy of 95.65%. Advantage included, squeezeNet is light in weight and has very low computational support. [26] Jia Shijie et al, gave a CNN network assisted VGG16 model. VGG has excellent image classification efficiency and localization features. Model achieves 89% overall classification accuracy. [27]

Santosh Adhikari et al, gave aML assisted model supported with CNN architecture, and data augmentation minimizes overfitting while training the model. The model achieves overall 89% accuracy. Disadvantages includethat transfer learning is needed to classify all kinds of infection.[28]Konstantinos P. Ferentinosdesigned DL CNN assisted framework. This framework achieved aaccuracy of 99.53% after the model was tuned and trained. Advantage are that the model is more robust than previous versions. [29] EndangSuryawati et al, designed a VGG Net model, model proposed achieved 95.24% accuracy, the model is very effective in disease identification. Modelis less robust as compared to similar existing solutions. [30]Aravind Krishnaswamy Rangarajan et al, designed a pretrained DL assisted architecture for tomato infection identification. AlexNet achieved 97.49% of classification accuracy with very less execution time. [31]BelalA.M.Ashqargave a DCNN model with grayscale and fullcolour technique. Model designed achieved 99.84% accuracy for full-colour model.[32] KekeZhang et al, designed an optimization technique for DNN, optimal SGD with the ResNet technique gave an accuracy of about 97.28%. The model was fine-tuned which saved computation resources and time. [33] Prajwala TM et al, designed a CNN assisted LeNet model. Model achieved an accuracy between 94-95%. The model gives almost accurate and correct identification with minimum computational effort. [34]Robert G.de Luna et al, designed a CNN &F-RCNN assisted model. Model designed achieved a 91.67% performance accuracy. Advantages are that the transfer learning identifying model gains enhanced accuracy. [35]MelikeSardogan et al, designeda CNN assisted model supported by LVQ algorithm. Model achieves 86% accuracy. Technique is gives excellent performance in early and the efficient recognition of crop leaf infection identification. [36]Peng Jiang et al, gave aDL assisted CNN supported by INAR-SSD model. Model achieves a detection rate of 78.80%mAP. Model performs with enhanced accuracy in real-time. [37]

Qimei Wang et al, designed object identification technique [24] Model employs R-CNN with ResNet-101 which shows a higher identification rate and accuracy of 99.64%mAP. [38]Akshay Kumar et al, designed a CNN-assisted framework, in the model proposed, VGGNet outperformed well and achieved 99.25% accuracy. [39] Mehmet Metin Qzguven et al, designed a faster R-CNN framework, designed proposed is timeconsuming in infection identification rates. Framework achieved anclassification accuracy of 99.25% [40]Karthik R.et al, designed a CNN assisted model that gave 98% of classification accuracy, the model had achieved higher detection rate as compared to othersimilar existing solutions. [41] Surampalli Ashok et al, designed a CNN supported model that achieved 98% accuracy. Model gave performance at par with existing algorithms. [42]Nithish Kannan E et al, designed combination of Deep CNN with ResNet-50 model that achieved 97% accuracy. Model was pretrained that employed data augmentation for enhanced performance. [43]ThairA.Salih et al, gave a DL CNN assisted model that secured 96.43% of classification accuracy. Model required short computation time as compared with other existing solutions. [44] Yang Zhang et al, designed a faster RCNN combined res101 technique. Combination achieved an accuracy of 98.54% mAP, proposed crop infection identification technique displayed quick detection speed compared to original faster RCNN. [30], Figure 8 depicts model accuracy of learning algorithm for precision agriculture from different research articles cited.

Model Accuracy Comparision		
Methodology Used	***Reference Number***	***Performance Metrics***
Neural Network	***[1]***	***94%***
SVM Classifier	***[5]***	***99.55%***
CNN (Full Colour)	***[18]***	***99.84%***
DCNN (VGG)	***[15]***	***99.53%***
RCNN (RESNET 101)	***[24]***	***99.64%***

Figure 8: Depicts model accuracy of learning algorithm

4. INFECTION SEVERITY MEASUREMENT

Severity measurement of infection in crops is estimated through evaluating the ratio of area of infected region to complete area of the assessment, the regions in digital image processing is usually evaluated in terms of number of pixels. Number of tools are available with specialized features and functions to do the task. Programming languages like MATLAB and Python have rich library and lot of open support to assist in the task. Percentage area of infected region is estimated employing following relation:

$$PercentageAreaInfected = float \frac{(Areaofdetectedregion)}{(Areaofcompleteleaf)} \text{x } 100 \ldots\ldots\ldots\ldots \text{i}$$

The process of estimation of severity involves conversion to grey scale, estimation of infected region and complete area in terms of number of pixels. Segmentation and severity measurement is generally performed for most severe tomato infected samples so as to assess the complete damage to the crop. [47-49], several hybrid techniques are now also being worked upon to increase efficacy and efficiency.

5. CONCLUSION

Tomatoes happen to be major dietary source of the antioxidant lycopene, that have abundant of health benefits, even reduced risk of heart disease and cancer. Tomatoes are also great source of vitamin C, potassium, folate, and vitamin K. Major state producers include Andhra Pradesh, Madhya Pradesh, and Karnataka. However even Tomatoes are prone to number of diseases like bacterial stem, early blight, wilt disease, fusarium wilt, leaf curl, damping off and Septoria leaf spot. Conventional techniques include inspection by human expert to identify anomalies in tomato plants caused by pests, diseases, climatic conditions, and nutritional deficiencies. Automated techniques included infection and disease identification employing artificial intelligence and image processing algorithms, but these algorithms had less accuracy later deep learning approaches embedded with hyper spectral imaging techniques were explored, which not only increased accuracy in early disease identification but also gave insight on various features such as stress level and optimum health. Paper presents a comprehensive survey on evolution on algorithms and techniques for determining and identifying severity of infection, disease type, stress level and optimum health of crops.From the in-depth survey of recent articles for precision agriculture it can be summarized that Machine learning algorithms are finding lot of potential in smart farming, learning algorithms like Neural Network(94% accuracy), Support Vector Machines (99.55% accuracy), Convolutional Neural Network for full colour identification (99.84% accuracy), Deep Convolutional NeuralNetwork (99.53% accuracy) and RCNN-ResNet 101 (99.64 accuracy) are giving excellent identification results. Researchers are now also working with hybrid algorithms for further enhancing the accuracy for identification.

REFERENCE

[1] Hanssen, Inge M., Moshe Lapidot, and Bart PHJ Thomma. "Emerging viral diseases of tomato crops." Molecular plant-microbe interactions 23.5 (2010): 539-548.

[2] Moriones, E., and J. Navas-Castillo. "Tomato yellow leaf curl virus, an emerging virus complex causing epidemics worldwide." Virus research 71.1-2 (2000): 123-134.

[3] Abdel-Samad, S., Ismail, E.A.M., El-Beltagy, A.S., and Abou-Hadid, A.F., 1996a. Tomato growth in calcareous soils in relation to forms and levels of some macro- and micronutrients. Acta Hort. 434: 85-94.

[4] Abdel-Samad, S., Ismail, E.A.M., El-Beltagy, A.S., and Abou-Hadid, A.F.1996b. Iron, zinc and phosphorus relationships in the nutritional statusof tomato seedlings grown on sandy soils. Acta Hort. 434: 77-84.

[5] Adb-Alla, A.M., Adam, S.M., Abou-Hadid, A.F., and Iman, S.S.B. 1996.Temperature and fertilizer effects on tomato productivity. Acta Hort.434: 113-119.

[6] Errebhi, M., Rosen, C.J., Gupta, S.C., and Birong, D.E. 1998. Potato yieldresponse and nitrogen leaching as influenced by nitrogen management.Agron. J. 90: 10-15.

[7] Sainju, Upendra M., RamdaneDris, and Bharat Singh. "Mineral nutrition of tomato." Food, Agriculture & Environment 1.2 (2003): 176-183.

[8] Gould, W.A. 1983. Tomato Production, Processing, and Quality Evaluation. AVI Publishing Co., Westport, CT.

[9] Hayslip, N.C., and Iley, J.R. 1967. Influence of potassium fertilizer onseverity of tomato graywall. Florida Agricultural Experiment StationJournal Series No. 2840. p. 183-186.

[10] Kaniszewki, S., and Elkner, K. 1990. Effect of nitrogen fertilization andirrigation on yield and fruit quality of two stated tomato cultivars. Hort.Abstract, p. 406.

[11] Kocevsky, G.J.V., Jakimov, N.D., Kekic, M.M., and Koleva, R.L. 1996.The effect of nitrogen, phosphorus, potassium, magnesium, and boronon the yield, morphological, and quality characteristics of

industrial tomatoes. Acta Hort. 462: 183-186.

[12] Maynard, D.N., Barker, A.V., and Lachman, W.H. 1966.Ammonium-induced stem and leaf lesions of tomato plants. Proc. Amer.Soc. Hort. Sci. 88: 516.

[13] Meisinger, J.J., Hargrove, W.L., Mikkelsen, Jr., R.L., Williams, J.R., andBenson, V.W. 1991. Effects of cover crops on groundwater quality. In:W.L. Hargrove (ed.). Cover Crops for Clean Water. Soil and WaterConservation Society, Ankeny, IA. p. 57-68.

[14] http://vegetablemdonline.ppath.cornell.edu/DiagnosticKeys/TomWlt/TomWiltKey.html

[15] http://nhb.gov.in/pdf/vegetable/tomato/tom002.pdf

[16] Al-Hiary, Heba, et al. "Fast and accurate detection and classification ofplant diseases." International Journal of Computer Applications 17.1(2011): 31-38.

[17] Al Bashish, Dheeb, Malik Braik, and Sulieman Bani-Ahmad. "Detectionand classification of leaf diseases using K-means-based segmentationand." Information technology journal 10.2 (2011): 267-275.

[18] Kulkarni, Anand H., and Ashwin Patil. "Applying image processingtechnique to detect plant diseases." International Journal of ModernEngineering Research 2.5 (2012): 3661-3664.

[19] Arivazhagan, Sai, et al. "Detection of unhealthy region of plant leavesand classification of plant leaf diseases using texture features."Agricultural Engineering International: CIGR Journal 15.1 (2013): 211-

[20] 217.

[21] Mokhtar, Usama, et al. "Tomato leaves diseases detection approachbased on support vector machines." 2015 11th International ComputerEngineering Conference (ICENCO). IEEE, 2015.

[22] Mohanty, Sharada P., David P. Hughes, and Marcel Salathe. "Usingdeep learning for image-based plant disease detection." Frontiers in plantscience 7 (2016): 1419.

[23] Sladojevic, Srdjan, et al. "Deep neural networks based recognition ofplant diseases by leaf image classification." Computational intelligenceand neuroscience 2016 (2016).

[24] Sabrol, H., and K. Satish. "Tomato plant disease classification in digitalimages using classification tree." 2016 International Conference onCommunication and Signal Processing (ICCSP). IEEE, 2016.

[25] Brahimi, Mohammed, Kamel Boukhalfa, and AbdelouahabMoussaoui."Deep learning for tomato diseases: classification and symptomsvisualization." Applied Artificial Intelligence 31.4 (2017): 299-315.

[26] Fuentes, Alvaro, et al. "A robust deep-learning-based detector for realtimetomato plant diseases and pests recognition." Sensors 17.9 (2017):2022.

[27] Durmu§, Halil, EceOlcayGune§, and MurvetKirci. "Disease detectionon the leaves of the tomato plants by using deep learning." 2017 6thInternational Conference on Agro-Geoinformatics. IEEE, 2017.

[28] Shijie, Jia, Jia Peiyi, and Hu Siping. "Automatic detection of tomatodiseases and pests based on leaf images." 2017 Chinese AutomationCongress (CAC). IEEE, 2017.

[29] Adhikari, Santosh, et al. "Tomato plant diseases detection system usingimage processing." 1st KEC Conference on Engineering andTechnology, Lalitpur. Vol. 1. 2018.

[30] Ferentinos, Konstantinos P. "Deep learning models for plant diseasedetection and diagnosis." Computers and Electronics in Agriculture 145(2018): 311-318.

[31] Suryawati, Endang, et al. "Deep structured convolutional neural networkfor tomato diseases detection."

2018 International Conference onAdvanced Computer Science and Information Systems (ICACSIS).

[32] IEEE, 2018.

[33] Rangarajan, Aravind Krishnaswamy, Raja Purushothaman, and AniirudhRamesh. "Tomato crop disease classification using pre-trained deeplearning algorithm." Procedia computer science 133 (2018): 1040-1047.

[34] Ashqar, Belal AM, and Samy S. Abu-Naser. "Image-Based TomatoLeaves Diseases Detection Using Deep Learning." (2018).

[35] Zhang, Keke, et al. "Can deep learning identify tomato leaf disease?."Advances in Multimedia 2018 (2018).

[36] Tm, Prajwala, et al. "Tomato leaf disease detection using convolutionalneural networks." 2018 Eleventh International Conference onContemporary Computing (IC3). IEEE, 2018.

[37] de Luna, R.G., Dadios, E.P. and Bandala, A.A., 2018, October.Automated image capturing system for deep learning-based tomato plantleaf disease detection and recognition. In TENCON 2018-2018 IEEE

[38] Region 10 Conference (pp. 1414-1419). IEEE.

[39] Sardogan, Melike, AdemTuncer, and YunusOzen. "Plant leaf diseasedetection and classification based on CNN with LVQ algorithm." 20183rd International Conference on Computer Science and Engineering

[40] (UBMK). IEEE, 2018.

[41] Jiang, Peng, et al. "Real-time detection of apple leaf diseases using deeplearning approach based on improved convolutional neural networks."IEEE Access 7 (2019): 59069-59080.

[42] Wang, Qimei, et al. "Identification of Tomato Disease Types andDetection of Infected Areas Based on Deep Convolutional Neuraletworks and Object Detection Techniques." Computational

[43] Intelligence and Neuroscience 2019 (2019).

[44] Kumar, Akshay, and M. Vani. "Image Based Tomato Leaf DiseaseDetection." 2019 10th International Conference on Computing,Communication and Networking Technologies (ICCCNT). IEEE, 2019.

[45] Ozguven, Mehmet Metin, and Kemal Adem. "Automatic detection andclassificationo f leaf spot disease in sugar beet using deep learningalgorithms." Physica A: Statistical Mechanics and its Applications 535

[46] (2019) : 122537.

[47] Karthik, R., et al. "Attention embedded residual CNN for diseasedetection in tomato leaves." Applied Soft Computing 86 (2020): 105933.

[48] Ashok, Surampalli, et al. "Tomato Leaf Disease Detection Using DeepLearning Techniques." 2020 5th International Conference onCommunication and Electronics Systems (ICCES). IEEE, 2020.

[49] Kaushik, M., et al. "Tomato Leaf Disease Detection using Convolutional

[50] Neural Network with Data Augmentation." 2020 5th InternationalConference on Communication and Electronics Systems (ICCES). IEEE,2020

[51] Salih, Thair A. "Deep Learning Convolution Neural Network to Detectand Classify Tomato Plant Leaf Diseases." Open Access Library Journal7.05 (2020): 1.

[52] Zhang, Yang, Chenglong Song, and Dongwen Zhang. "Deep learningbasedobject detection improvement for tomato disease." IEEE Access 8(2020) : 56607-56614.

[53] Khan, Asifullah, et al. "A survey of the recent architectures of deeponvolutional neural networks." Artificial Intelligence Review 53.8(2020): 5455-5516.

[54] H. D. Gadade and D. K. Kirange, "Tomato Leaf Disease Diagnosis and Severity Measurement," 2020 Fourth World Conference on Smart Trends in Systems, Security and Sustainability (WorldS4), 2020, pp. 318-323, doi: 10.1109/WorldS450073.2020.9210294.

[55] Liang, Qiaokang, et al. "PD2SE-Net: Computer-assisted plant disease diagnosis and severity estimation network." Computers and electronics in agriculture 157 (2019): 518-529.

[56] Prabhakar, Maheswari, Raja Purushothaman, and Durga Prasad Awasthi. "Deep learning based assessment of disease severity for early blight in tomato crop." Multimedia Tools and Applications 79.39 (2020): 28773-28784.