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Cotton Exchange Building, 2nd Floor, Cotton Green, Mumbai - 400 033
Telephone: 8657442944/45/46/47/48 Email: cai@caionline.in
www.caionline.in

Artificial Intelligence in Augmenting Cotton Productivity

Dr. K. Rameash is a Principal Scientist at ICAR-Central Institute for Cotton Research, Regional Station, Coimbatore. He has 19 years of research experience in agricultural entomology. His areas of work include biorational pest management, insecticide resistance management, nanotechnology and geographic information system in pest modelling)

EXPERT's Column

Dr. K. Rameash
Principal Scientist (Agricultural Entomology)
ICAR - Central Institute for Cotton Research,
Regional Station, Coimbatore

Globally cotton is cultivated in 32.19 million hectares and India alone accounts for around 41 per cent share in the world's total area and about 26 per cent of the total world production. The deployment of improved cotton production, protection technologies and transgenic cotton has contributed to significant growth in the Indian cotton production during the past two decades. Though the annual production reached 371 lakh bales, the productivity has stagnated at around 500 kg lint/ ha for a few years, way behind the global average of 760 kg lint/ha.

The task of enhancing cotton productivity is challenged by multiple factors viz., increase in input cost; scarcity of farm workforce during critical operations like weeding and harvesting; excess rainfall or extended dry period due to vagaries of monsoon and deterioration of soil health.

Precision farming technologies in cotton cultivation could address these challenges by delivering the right input inthe right place at the right time. By employing innovative system approaches and tools like soil and plant sensors, IoT enabled devices, multispectral and hyperspectral-based remote sensing equipment, images processing, grid soil sampling and variable rate (VRT) fertilizer/ pesticide applicators, global positioning systems (GPS) and geographic information systems (GIS), etc., precision crop management could be accomplished in cotton. Precision tools replace the tedious and labour-intensive components of farming with more accurate and controlled techniques.

To organise and analyse the data received from these sensors and to arrive at decisions, the deployment of robust information processing technology is necessary. Artificial Intelligence

(AI) is a branch of computer science that can perceive its environment and react appropriately to the information that it recognises. Thus, AI becomes a prerequisite to process the data received from the elements of precision farming tools and arrive at a decision for action. AI is the analytic process one can associate with human thinking like speech recognition, image processing, natural language understanding and translation, knowledge management, decision making, learning, etc. which will make systems more comprehensive and pragmatic.

The application of artificial intelligence to agriculture would be imperative in providing potential answers to solve major issues such as smart irrigation and fertigation; targeted application of agrochemicals, weed management, early detection of pest and disease infestation, yield prediction and mechanical harvesting.

Smart Irrigation and Fertigation

A micro (drip/ sprinkler) irrigation system with soil moisture, temperature, and pressure sensors with solenoid valves and wireless control switch forms a basic smart irrigation system. The sensor networks in these irrigation systems help to monitor soil and ambient condition along with the operational parameter of the irrigation system that includes flow, pressure levels, etc. This information aids in the precise application of the required quantity of water to optimise the yield.

Fertigation is the process of precise delivery of chemical fertiliser through the water to fulfil the crop's nutrient requirements. Researchers at the Imperial College, London developed a machine learning algorithm for the nitrogenous fertiliser application based on a chemically functionalised paper-based electrical gas sensor (chemPEGS) that measures levels of ammonium in soil. With the supporting data on weather, soil conductivity, pH and time since fertilization, it predicts how much total nitrogen the soil has now and how much it will have up to 12 days in the future and the optimum time for fertilization. Integrating the smart irrigation system and fertiliser applications would be more promising for a crop like cotton whereby fertilizer and water losses can be significantly reduced besides higher N efficiency. The smart fertigation system would be of more practical use in the high-density planting system (HDPS) in cotton.

Precise Weed Management

An herbicide sprayer system coupled with computer vision technologies locates weed spots in real-time and manages to spray the desired chemical only on the targeted location. A precision spray technology can significantly reduce the quantity of herbicide required, compared with traditional broadcast sprayers that usually treat the entire field to control weed populations, which potentially results in redundant application to places that do not require any treatment. Targeted application of herbicide at specific places only where weeds occur could reduce the production cost, risk of crop injury and environmental impact.

H-Sensor® (Agricon GmbH, Germany) and See and Spray® (Blue River Technology, USA) are recent commercial spraying technologies that utilise artificial intelligence and can distinguish between crop plants and various weeds. The University of California, Davis, USA, developed a real-time robotic weed control system that distinguishes grass–like weeds from cotton plants and applies a chemical spray only to targeted weeds. The system consisted of a real-time imaging sensor, a controlled illumination chamber, and a precision herbicide applicator. The system correctly sprayed 89% of the weeds in commercial cotton fields while travelling at a continuous speed of 0.45 m/s.

Early Detection of Pests and Diseases

The average global yield loss due to cotton pests and diseases was estimated to be 28.8 % (insect pests-12.3%, weeds-8.6% and pathogens-7.9%). Monitoring, early detection and timely intervention are the key elements in a successful pest management programme in cotton. For a long time, pest identification was done mainly by trained crop protection personnel and experienced farmers. However, manual identification is subjective, inefficient, and delayed. Therefore, it is necessary to find an objective, efficient and rapid method for detecting pests and diseases without expert intervention. Advances in computer vision by deep learning have paved the way for AI-based pest and disease diagnosis.

Several machine learning algorithms and methods are being used for the classification and detection of diseases through computer vision. The colour, texture, and edges are extracted from the images of the diseased leaf or insect pest samples. The segmented images fed into the machine learning classification algorithms such as Support Vector Machine (SVM), Artificial Neural Network (ANN), Convolutional Neural Network (CNN), Naïve Bayes (NB), K-Nearest Neighbours (KNN), Recurrent Neural Network (RNN), single-shot multibox detector (SSD), Stochastic Gradient Descent (SGD), Logistic Regression (LR), etc.

Machine learning algorithms were successfully developed in detecting pests and diseases viz.,Cercosporaleaf spot (SVM); bacterial leaf spot (KNN); grey mildew (KNN); fusarium wilt (SVM); Ascochyta blight (CNN); cotton aphid (CNN); American bollworm, pink bollworm, boll weevil, whitefly, thrips, mealy bug, spider mite (RNN) with 80-96% detection accuracy.

Yield Prediction

Estimation of yield before harvest offers numerous benefits to government agencies, industry, researchers and various other stakeholders of the cotton value chain. The traditional yield measurement method through sampling surveys requires a large area of destructive sampling of cotton fields and consumes considerable time and labour costs. Yield predictions of cotton fields from aerial imagery using machine learning techniques were successfully attempted by researchers at The University of Georgia, USA. By using a single plot image extracted from an orthomosaic map, a Support Vector Machine (SVM) classifier was trained to predict the cotton yield with an accuracy of 89%.

By combining the multispectral images and high-resolution RGB spectra of open bolls taken from an Unmanned Aerial Vehicle (UAV), Chinese researchers developed a cotton yield prediction model using a Bayesian regularisation BP (back propagation) neural network. AI with remote sensing enables quick, efficient and consistent estimation of cotton yields, as opposed to traditional field measurements and surveys.

Automated Harvesting

Hand-picking is considered the most labour-intensive operation in cotton cultivation that accounts for around 30% of the total cost of production. The scarcity of labourers during the peak season further adds to the cotton

growers' problems. Small-sized land holdings, unsynchronised boll bursting, and bushy plant architecture makes mechanical harvesting less amenable under Indian conditions. AI based multi-armed small pickers may be a suitable solution for the present scenario.

The University of Georgia, USA, developed an ensemble method of deep learning, colour segmentation and image transformation to track and count cotton bolls from an inexpensive 3-D camera on a mobile harvester in real-time, to classify and locate cotton bolls. In each image taken by a camera, a trained deep learning method, the YOLO (You Only Look Once) model is used to detect open cotton bolls and then colour segmentation is applied to detect bolls missed by the YOLO model with an accuracy of 93%. The AI based cotton picker improves the harvested lint quality as the contamination is reduced.

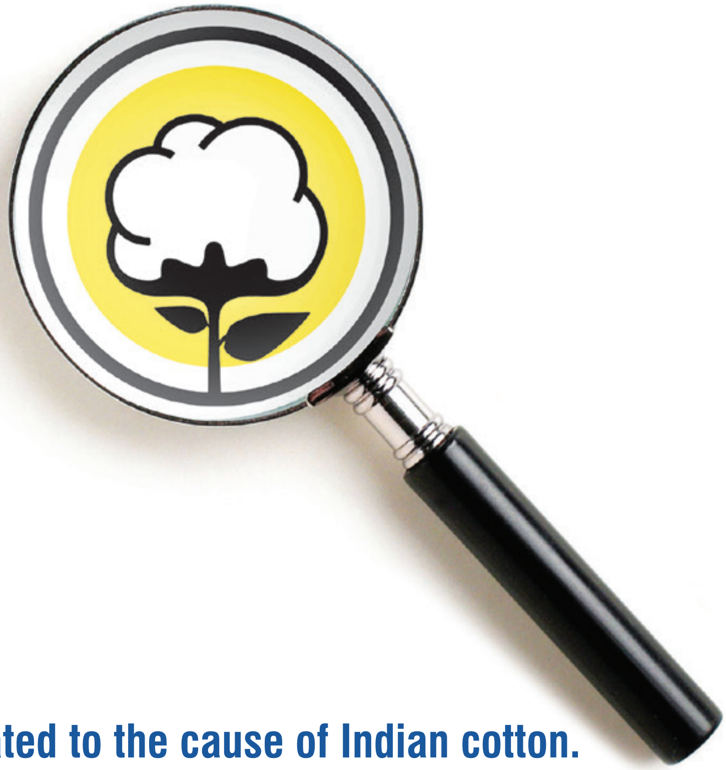
Conclusion

Artificial intelligence in cotton cultivation has the potential to address the crucial issues faced by farmers today viz., judicious use of agro-inputs (seed, water, fertilizers, and pesticides), reduce the dependence on manpower in intercultural operations and increase the crop productivity while sustaining the environment and soil health. Nevertheless, the implementation of AI in cotton farming has a few challenges. AI systems require a great deal of data, both spatial and temporal to train machines and to make precise predictions. Building a location-specific machine learning algorithm requires a huge initial investment, skilled manpower, concentrated research and development plans and a considerable cost on operation and maintenance.

The poor internet connectivity and bandwidth limitations in remote locations may limit the implementation and adaptability of AI.

However, the technology is making quick progress as several agricultural enterprises are expected to implement AI solutions within the next few years, to help farmers get more income from the available cropland while using resources sustainably.

(The views expressed in this column are of the author and not that of Cotton Association of India)



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we are dedicated to the cause of Indian cotton.

Just one of the reasons, you should use our Laboratory Testing Services.

The Cotton Association of India (CAI) is respected as the chief trade body in the hierarchy of the Indian cotton economy. Since its origin in 1921, CAI's contribution has been unparalleled in the development of cotton across India.

The CAI is setting benchmarks across a wide spectrum of services targeting the entire cotton value chain. These range from research and development at the grass root level to education, providing an arbitration mechanism, maintaining Indian cotton grade standards, issuing Certificates of Origin to collecting and disseminating statistics and information. Moreover, CAI is an autonomous organization portraying professionalism and reliability in cotton testing.

The CAI's network of independent cotton testing & research laboratories are strategically spread across major cotton centres in India and are equipped with:

- State-of-the-art technology & world-class Premier and MAG cotton testing machines
- HVI test mode with trash% tested gravimetrically

LABORATORY LOCATIONS

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COTTON ASSOCIATION OF INDIA
Established 1921
ISO 9001:2015

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Cotton Exchange Building, 2nd Floor, Opposite Cotton Green Railway Station, Cotton Green (East), Mumbai - 400 033, Maharashtra, INDIA
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Glimpses of Sneh Sammelan
held at CAI on 31st October 2022

UPCOUNTRY SPOT RATES

(Rs./Qtl)

Standard Descriptions with Basic Grade & Staple in Millimetres based on Upper Half Mean Length [By law 66 (A) (a) (4)]								Spot Rate (Upcountry) 2021-22 Crop November 2022					
Sr. No.	Growth	Grade Standard	Grade	Staple	Micronaire	Gravimetric Trash	Strength /GPT	14th	15th	16th	17th	18th	19th
1	P/H/R	ICS-101	Fine	Below 22mm	5.0 – 7.0	4%	15	- -	- -	- -	- -	- -	- -
2	P/H/R (SG)	ICS-201	Fine	Below 22mm	5.0 – 7.0	4.5%	15	- -	- -	- -	- -	- -	- -
3	GUJ	ICS-102	Fine	22mm	4.0 – 6.0	13%	20	15185 (54000)	15185 (54000)	15382 (54700)	15382 (54700)	15382 (54700)	15382 (54700)
4	KAR	ICS-103	Fine	23mm	4.0 – 5.5	4.5%	21	16731 (59500)	16731 (59500)	16872 (60000)	16872 (60000)	16872 (60000)	16872 (60000)
5	M/M (P)	ICS-104	Fine	23mm	4.5 – 7.0	4%	22	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)
6	P/H/R (U) (SG)	ICS-202	Fine	27mm	3.5 – 4.9	4.5%	26	- -	- -	- -	- -	- -	- -
7	M/M(P)/ SA/TL	ICS-105	Fine	26mm	3.0 – 3.4	4%	25	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)
8	P/H/R(U)	ICS-105	Fine	27mm	3.5 – 4.9	4%	26	- -	- -	- -	- -	- -	- -
9	M/M(P)/ SA/TL/G	ICS-105	Fine	27mm	3.0 – 3.4	4%	25	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)
10	M/M(P)/ SA/TL	ICS-105	Fine	27mm	3.5 – 4.9	3.5%	26	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)
11	P/H/R(U)	ICS-105	Fine	28mm	3.5 – 4.9	4%	27	- -	- -	- -	- -	- -	- -
12	M/M(P)	ICS-105	Fine	28mm	3.7 – 4.5	3.5%	27	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)
13	SA/TL/K	ICS-105	Fine	28mm	3.7 – 4.5	3.5%	27	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)
14	GUJ	ICS-105	Fine	28mm	3.7 – 4.5	3%	27	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)
15	R(L)	ICS-105	Fine	29mm	3.7 – 4.5	3.5%	28	- -	- -	- -	- -	- -	- -
16	M/M(P)	ICS-105	Fine	29mm	3.7 – 4.5	3.5%	28	- -	- -	- -	- -	- -	- -
17	SA/TL/K	ICS-105	Fine	29mm	3.7 – 4.5	3%	28	- -	- -	- -	- -	- -	- -
18	GUJ	ICS-105	Fine	29mm	3.7 – 4.5	3%	28	- -	- -	- -	- -	- -	- -
19	M/M(P)	ICS-105	Fine	30mm	3.7 – 4.5	3.5%	29	- -	- -	- -	- -	- -	- -
20	SA/TL/K/O	ICS-105	Fine	30mm	3.7 – 4.5	3%	29	- -	- -	- -	- -	- -	- -
21	M/M(P)	ICS-105	Fine	31mm	3.7 – 4.5	3%	30	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	- -	- -
22	SA/TL/ K / TN/O	ICS-105	Fine	31mm	3.7 – 4.5	3%	30	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	- -	- -
23	SA/TL/K/ TN/O	ICS-106	Fine	32mm	3.5 – 4.2	3%	31	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)
24	M/M(P)	ICS-107	Fine	34mm	2.8 - 3.7	4%	33	20668 (73500)	20668 (73500)	20668 (73500)	20528 (73000)	20528 (73000)	20528 (73000)
25	K/TN	ICS-107	Fine	34mm	2.8 - 3.7	3.5%	34	- -	- -	- -	- -	- -	- -
26	M/M(P)	ICS-107	Fine	35mm	2.8 - 3.7	4%	35	21652 (77000)	21652 (77000)	21652 (77000)	21512 (76500)	21371 (76000)	21371 (76000)
27	K/TN	ICS-107	Fine	35mm	2.8 - 3.7	3.5%	35	- -	- -	- -	- -	- -	- -

(Note: Figures in bracket indicate prices in Rs./Candy)

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(Rs./Qtl)

Standard Descriptions with Basic Grade & Staple in Millimetres based on Upper Half Mean Length [By law 66 (A) (a) (4)]								Spot Rate (Upcountry) 2022-23 Crop November 2022					
Sr. No.	Growth	Grade Standard	Grade	Staple	Micronaire	Gravimetric Trash	Strength /GPT	14th	15th	16th	17th	18th	19th
1	P/H/R	ICS-101	Fine	Below 22mm	5.0 – 7.0	4%	15	16956 (60300)	18081 (64300)	18081 (64300)	18222 (64800)	18025 (64100)	18025 (64100)
2	P/H/R (SG)	ICS-201	Fine	Below 22mm	5.0 – 7.0	4.5%	15	17153 (61000)	18278 (65000)	18278 (65000)	18419 (65500)	18222 (64800)	18222 (64800)
3	GUJ	ICS-102	Fine	22mm	4.0 – 6.0	13%	20	- -	- -	- -	- -	- -	- -
4	KAR	ICS-103	Fine	23mm	4.0 – 5.5	4.5%	21	- -	- -	- -	- -	- -	- -
5	M/M (P)	ICS-104	Fine	23mm	4.5 – 7.0	4%	22	- -	- -	- -	- -	- -	- -
6	P/H/R (U) (SG)	ICS-202	Fine	27mm	3.5 – 4.9	4.5%	26	17772 (63200)	17772 (63200)	18053 (64200)	18053 (64200)	17856 (63500)	17631 (62700)
7	M/M(P)/ SA/TL	ICS-105	Fine	26mm	3.0 – 3.4	4%	25	- -	- -	- -	- -	- -	- -
8	P/H/R(U)	ICS-105	Fine	27mm	3.5 – 4.9	4%	26	17940 (63800)	17940 (63800)	18222 (64800)	18222 (64800)	18025 (64100)	17800 (63300)
9	M/M(P)/ SA/TL/G	ICS-105	Fine	27mm	3.0 – 3.4	4%	25	- -	- -	- -	- -	- -	- -
10	M/M(P)/ SA/TL	ICS-105	Fine	27mm	3.5 – 4.9	3.5%	26	- -	- -	- -	- -	- -	- -
11	P/H/R(U)	ICS-105	Fine	28mm	3.5 – 4.9	4%	27	18475 (65700)	18475 (65700)	18756 (66700)	18756 (66700)	18559 (66000)	18334 (65200)
12	M/M(P)	ICS-105	Fine	28mm	3.7 – 4.5	3.5%	27	- -	- -	- -	- -	- -	- -
13	SA/TL/K	ICS-105	Fine	28mm	3.7 – 4.5	3.5%	27	- -	- -	- -	- -	- -	- -
14	GUJ	ICS-105	Fine	28mm	3.7 – 4.5	3%	27	- -	- -	- -	- -	- -	- -
15	R(L)	ICS-105	Fine	29mm	3.7 – 4.5	3.5%	28	18700 (66500)	18700 (66500)	18981 (67500)	18981 (67500)	18840 (67000)	18615 (66200)
16	M/M(P)	ICS-105	Fine	29mm	3.7 – 4.5	3.5%	28	19656 (69900)	19543 (69500)	19684 (70000)	19543 (69500)	19431 (69100)	19431 (69100)
17	SA/TL/K	ICS-105	Fine	29mm	3.7 – 4.5	3%	28	19712 (70100)	19600 (69700)	19740 (70200)	19600 (69700)	19487 (69300)	19487 (69300)
18	GUJ	ICS-105	Fine	29mm	3.7 – 4.5	3%	28	19403 (69000)	19290 (68600)	19543 (69500)	19403 (69000)	19290 (68600)	19290 (68600)
19	M/M(P)	ICS-105	Fine	30mm	3.7 – 4.5	3.5%	29	19740 (70200)	19684 (70000)	19825 (70500)	19684 (70000)	19571 (69600)	19571 (69600)
20	SA/TL/K/O	ICS-105	Fine	30mm	3.7 – 4.5	3%	29	19825 (70500)	19768 (70300)	19909 (70800)	19768 (70300)	19656 (69900)	19656 (69900)
21	M/M(P)	ICS-105	Fine	31mm	3.7 – 4.5	3%	30	- -	- -	- -	- -	19825 (70500)	19825 (70500)
22	SA/TL/ K / TN/O	ICS-105	Fine	31mm	3.7 – 4.5	3%	30	- -	- -	- -	- -	19909 (70800)	19909 (70800)
23	SA/TL/K/ TN/O	ICS-106	Fine	32mm	3.5 – 4.2	3%	31	- -	- -	- -	- -	- -	- -
24	M/M(P)	ICS-107	Fine	34mm	2.8 - 3.7	4%	33	- -	- -	- -	- -	- -	- -
25	K/TN	ICS-107	Fine	34mm	2.8 - 3.7	3.5%	34	21793 (77500)	21793 (77500)	21793 (77500)	21793 (77500)	21652 (77000)	21652 (77000)
26	M/M(P)	ICS-107	Fine	35mm	2.8 - 3.7	4%	35	- -	- -	- -	- -	- -	- -
27	K/TN	ICS-107	Fine	35mm	2.8 - 3.7	3.5%	35	22496 (80000)	22496 (80000)	22496 (80000)	22496 (80000)	22355 (79500)	22355 (79500)

(Note: Figures in bracket indicate prices in Rs./Candy)