Review Article

STATUS OF PRECISION FARMING TECHNOLOGIES IN INDIAN CONTEXT – A REVIEW

ABSTRACT

Precision farming is a farm management strategy that involves the application of technologies and principles to manage spatial and temporal variability associated with all aspects of crop production for improving crop performance and environmental quality .It is spreading rapidly in developed countries as a tool to fight the challenge of agricultural sustainability. With the progress and application of information technology in agriculture and horticulture sector, Precision farming has been increasingly gaining attention in Indian context. Though it is widely practiced in developed countries, it is still in nascent stage in most of the developing countries like India which needs integrated and sustainable efforts starting from preparatory tillage to post harvest handling in Agri - Horti crops. Knowledge on present developments with regard to precision farming technologies helps to foresee the forthcoming challenges. Hence this article provides an overview of development and current status of precision farming technologies in India.

Key words: Precision farming, Information technology, Crop production, Sustainability

Remove sustainability

INTRODUCTION

Precision farming is one of the most scientific and modern approaches to sustainable agriculture that has gained momentum towards the end of 20th century. According to International Society on Precision Agriculture (ISPA)- Precision farming is a management strategy that gathers, processes and analyzes temporal, spatial and individual data and combines it with other information to support management decisions according to estimated variability for improved resource use efficiency, productivity, quality, profitability and sustainability of agricultural production (Pavan Kumar *et al.* 2022)

Technological developments in agricultural sector yield better management practices resulting in more precision in agricultural operations from tillage to harvesting to reduce inputs, increase profits, and protects environment (Ess & Morgan, 2003; Rains & Thomas, 2009).knowledge poverty of the farmers is one of the problem in developing countries. In order to face environmental, technical, infrastructural & social constraints related to adoption of precision farming technologies which can manage and allocate efficiently all resources for sustainable development of agriculture and horticulture is necessary. Precision farming is not just the injection of new technologies but it is rather an information revolution, made possible by new technologies that result in a higher level, a more precise arm management system (Dutta *et al.*, 2011). Precision farming basically means application of the right amount of input at the right time and the right location within a field. It is a scientific approach to improve the crop management by application of information technology (IT) and satellite based technology to identify, analyze and manage the spatial and temporal variability of agronomic parameters (e.g. soil, pest or disease, fertigation etc.) within field by timely application of accurate amount of input to optimize profitability, sustainability, with a minimized impact on environment (Murali krishnan *et al.* 2019).

In this present scenario, the major challenges arising are shrinking land, depleting water and others related to resources in agriculture (Mondal *et al.*, 2011). There is need for promoting farmer-friendly, location-specific production system management technologies in a concerted manner to achieve vertical growth in agricultural and horticultural production duly ensuring quality of produce and better remuneration per unit of area with judicious use of natural resources. In this endeavour, precision farming aims to have efficient utilization of resources per unit of time and area for achieving targeted production of agricultural and horticultural produce. The precision farming technology assures the productivity enhancement with decreasing the production cost via efficient utilization of resources (Hemraj Meena *et al.* 2021). The accomplishment of the precision agriculture mostly depends on accurate evaluation of variability, management and evaluation in space & time continuum in crop. The key components of precision farming includes capturing the data at an appropriate scale and frequency, interpretation and analysis of the data and implementation of management response at an appropriate scale and time. The key differentiator between the conventional management system and precision farming is the application of modern information technologies towards providing, processing and analyzing the multi-source data of high spatial and temporal resolution for decision-making and operations in the management of crop production.

Table 1: Classification of Precision Farming (PF) Technologies

Data Collection Technologies	Data Process & Decision Making Technologies	Application Technologies
• Soil sampling and mapping • Yield monitoring and mapping • Remote sensing • Global satellite positioning • Geospatial Technology • Field/crop scouting	• GPS-GIS based farm management • Agricultural mapping software • Geoinformatics • Geostatistics • Crop modelling • Artificial Intelligence based Controlling systems	• Variable-rate technology • Yield monitors • Agricultural robots • Wireless data logger and Sensor catalogue • Global Navigation Satellite system (GNSS) based guidance • Hyperspectral sensor based applications • Automated control system through Greenhouse and Polyhouse cultivation • Precision Lazer Land leveller • Mulching • Low Tunnel Technology/Walking Tunnels • Microirrigation • Site-specific Nutrient Management (SSNM) • Drone Technology

The objective of this article was to review the studies on the precision farming technologies in Indian context and to compare the techniques applied in precision farming in terms of application, decision support systems as well as field data collection and analysis techniques.

MATERIAL & METHODS

In this study, literature was collected on the status of different precision farming (PF) technologies in Indian context. Scientific articles, reports, books and relevant web pages found after the review process were studied and information on the different Precision farming technologies in Indian context was compiled.

RESULTS & DISCUSSION

a) Status of Precision farming technologies in Indian context – Research Findings

The literature review shown in Table. 2 was published research focused on different crops, types of precision farming technology and methods of analysis in Indian context. There is a predominance of ex-post approach in these studies and Logit and Probit methods.

Table 2: Research Findings of Precision farming technologies in India

Author	**Publication year**	**Location & Crops**	**Studied PF Technology**	**Method of Analysis**	**Research Findings**
Koch *et al.*	2004	Bihar state in Paddy	Variable Rate Technology	Logit analysis	Results indicated that less N fertilizer was used with the Site-specific Management zones (SSMZ- Variable yield goal) N management strategy when compared with uniform N management. There is a reduction in N fertilizer application and an increase in N use efficiency due to identification of site-specific management zones
Persson *et al.*	2005	Shimla state in Potato crop	Differential Global Positioning system (DGPS) Digital Elevation Model (DEM)	Logistic regression analysis	From the DEM, topographical parameters were extracted and topographical indices were estimated. The relationship of yield and the topographical parameters and indices was investigated and up to 20% of the yield could be explained in the final model for one of the fields
Stamatiadis *et al.*	2005	Gujarat state in Cotton crop	Soil and crop sensors	Principal component analysis (PCA)	Ground-based sensors were used to simultaneously monitor soil and canopy reflectance in the visible and near-infrared (VNIR) in a cotton field. PCA technique was used to reveal spatial soil variation from near infrared reflectance (NIR) spectroscopy data of soil. Total carbon expressed a low spatial dependence whereas clay content and pH expressed spatial dependence at a range of 54 and 46 m, respectively.
Reyniers *et al.*	2006	Punjab & Haryana states in Winter Wheat crop	Airborne Data Acquisition and Registration (ADAR) remote sensing	Correlation & Regression analysis	To compare aerial image with optical data of an on-ground platform multi-spectral radiometer. The NDVI of the ground system was better related to yield variables at harvest compared to NDVI of the aerial

					system. Best correlation coefficient found for both systems was with nitrogen in grain: 0.84 and 0.91 for the aerial-based and the ground-based system, respectively
Mondal and Basu	2009	West Bengal state in Rice crop	Leaf color chart (LCC) based Nitrogen management	Split plot design	Adoption of Leaf Color Chart for Nitrogen Use Efficiency (NUE) in rice saved N by 25 Kg/ha (19.40%), with the highest saving of 314 Kg/ha (21.00%) in Boro season. It resulted in 50, 60, 90 Kg/ha additional yield in pre kharif, kharif and boro seasons. Reduced insecticide applications by 50%
Yang *et al.*	2011	Punjab state in Wheat crop	Remote sensing (Multispectral imagery)	Kappa analysis	Accuracy assessment showed that, the inclusion of the short-wave infrared band statistically significantly increased the overall accuracy from 82% to 91%. The increase in pixel size from 10 m to 20 m or 30 m did not significantly affect the classification accuracy for crop identification. These results indicate that SPOT 5 multispectral imagery in conjunction with maximum likelihood and SVM classification techniques can be used for identifying crop types and estimating crop areas.
Manjeet Singh *et al.*	2013	Punjab state in rice crop	Yield monitoring system & Mapping	Regression analysis	Three rice fields were harvested to evaluate the performance of the yield monitor for grain yield and moisture mapping of harvested grains. The actual yield maps were generated by using Arc GIS software. The minimum and maximum yields recorded within all the fields harvested were 577.08 and 7,661.48 kg ha-1with an average yield of 4,287.66 kg ha-1 having 37.26% coefficient of variation (CV) in all the three fields.
Pahuja *et al.*	2013	Punjab state in Horticultural crops	Automated Control System in Green House	Greenhouse advance microclimate monitoring	WSN monitored and controlled a greenhouse climate with high data and packet reliability (85 to

				and control software (GH-ACMCs) Collaborative data processing and statistical analysis like histogram, cumulative distribution frequency	100 percent) and low battery drop (0.03 V). The climate controller tracked the initially high inside VPD and lowered the value to meet optimal conditions by operating the devices as needed. Furthermore, the real-time display of greenhouse climate-control statistics helped the grower make better decisions in executing greenhouse operations, eventually leading to healthy crop growth and better yields.
Karimi *et al.*	2014	Rajasthan state in Corn	Artificial Intelligence based control system	Remote hyperspectral image analysis	Support Vector Machines (SVM) and ANN as instruments for detecting and classifying weeds on a corn field with the aim of intelligently controlling the amount of nitrogen application for weed management. In the research, the SVM technique achieved low misclassification rates and high generalization ability in comparison to the ANN. Conclusion is arrived that SVM is best suited for the effective detection and control of weeds.
Halimi and Moussa	2015	Uttar Pradesh state in Potato crop	Robotic Greenhouse system for crop scouting	Radial Basis Function Networking analysis	The Guelph Intelligent Greenhouse Automation System (GIGAS) is an intuitive robotics system with outstanding functional capacity for greenhouse applications. The research indicated that 92.3% production efficiency is achieved using GIGAS whereby a 63.2% increase in yields was achieved
Durga *et al.*	2018	Telangana state in Rabi maize crop	Precise irrigation system using nano soil moisture sensors	Split plot design	The research results indicated that the plant height of maize was significantly influenced by irrigation methods and irrigation scheduling. Higher plant height was recorded at 60, 90 days after sowing and at harvest in drip irrigated plots over surface irrigation method. There is decrease in the dry matter production in tensiometer based irrigation

					scheduling due to less frequent irrigation associated with tensiometer irrigation.
Kanannavar *et al.*	2020	Karnataka state in Paddy	Precision Laser Land leveller technology	Uniformity coefficient analysis	The research results indicated that there is a considerable reduction in drudgery of land levelling, higher levelling index, higher uniformity in soil-moisture distribution. It was observed that 25 to 35 % increase in paddy yield and water saving (25-30%), 30- 40 % labour saving and 30 to 40 % saving in energy requirement in paddy cultivation.
Arti Verma	2021	Punjab state in Capsicum crop	Low Tunnel Technology	Randomized Block Design (RBD)	The research findings indicate that the yield of PSM-1 variety cultivated in low tunnels is a profitable method with yield of 82 quintals/acre.
Padmaja *et al.*	2021	Telangana state in Cucumber crop	Drip & Fertigation	Split plot design	Yield attributes were significantly higher at 150% recommended dose of NK than 75%recommended dose of NK. Fruit yield was significantly higher at 150 % recommended dose of NK (76.70 t ha-1) than 75% recommended dose of NK (60.30 t ha-1) and onpar with both 125% and100% recommended dose of NK. Water use efficiency was higher in drip irrigation scheduled at 0.8 Epan (28.6 kg m-3) followed by 1.2 Epan (27.2 kg m-3) and 1.0 Epan (26.6 kg m-3). 150 % recommended dose of NK registered significantly higher water use efficiency (30.1 kg m^{-3}) than75% recommended dose of NK (23.5 kg m^{-3}).
Subramanian *et al.*	2021	Tamil Nadu state in rice crop	Drone technology	Coefficient of variation	The research study indicated the efficacy of pesticide spray (fungicide copper oxychloride 53.8% @ 35 g 16 L^{-1} against bacterial and fungal diseases) in rice fields using drones during the cropping season of September 2020. Preliminary studies have shown the optimal flying height (3 m), speed (5 m

					s^{-1}), swath (4 m), and the area coverage (4 min $acre^{-1}$). It clearly demonstrate that drone-enabled pesticide spray is an emerging potential technology to overcome labor shortages and to carry out plant protection measures without loss of time.

The research papers analyzed so far in this comparative literature review demonstrate the constructive and effectual utilization of Wireless Sensor Networks in precision farming. Therefore, it is necessary to undertake the design, analysis and implementation of a system that takes into account the specific requirements of a particular crop. The accuracy in precision farming technology can be monitored through sensors and its related interface system. The review related to the existing control & monitoring systems and its modules for sensing micro climate parameters was given in table 3.

Table 3. Classification of existing control and monitoring systems and its modules for sensing Microclimate

References	Sensors interfaced	Technology	Monitoring system	Module interfaced
Irmak *et al.* (2006)	Light, moisture and temperature, soil moisture, Humidity, CO2, illumination	ZigBee, Internet	PC, Laptop	ZigBee module 3160
Tan and Panda (2010)	Humidity, illumination, Temperature	ZigBee, internet	Laptop	CC2420, MSP430
Sabri *et al.* (2012)	Temperature, humidity	ZigBee, SunplusSPCE061A	TFT-LCD	Chip (SoC)
Kim *et al.* (2014)	Temperature and soil moisture	ZigBee, GPRS	Mobile phone	JN5121, ARM9
Rani and Kamalesh (2014)	Temperature, soil temperature and moisture, Humidity, Anemometer, illumination, rain gauge	ZigBee, Internet	Laptop, PDA	MSENS SoC
Navaro *et al.* (2015)	Temperature, humidity, PH	Sensor node(mono-chip sensors)	-	RF CC3271 PSOC kit
Sai *et al.* (2016)	Temperature, humidity	ZigBee	PC, Matlab 7.0	PECRP

CONCLUSION

In precision farming, to obtain high-quality products in agricultural and horticultural crops, the soil, crop, environmental parameters should be effectively monitored and controlled to provide optimal values related to productivity, profitability, input use efficiency, environmental sustainability etc. Hence A review on status of precision farming technologies in Indian context based on remote monitoring and control approaches have been presented. A detailed comparison of various decision-making platforms employed for precision farming such as ANN, DGPS, LCC, ADAR, Bayes, SVM, Remote sensing, mapping technologies and modules used for monitoring sensor data such as ZigBee, internet, GSM and RFID have also been looked at in terms of water and soil requirements. Areas of application of soft computing includes efficient irrigation, nutrient and fertilizer planning and management for optimization of yields, early identification and eradication of crop weeds, diseases and pests and analysis of crop yield prediction. The research review conducted illustrated that some of the challenges incurred in precision farming can be tamed with the implementation of Wireless Sensor Network with the aid of a discrete, intelligent, intuitive decision making and control protocol for effective yield production & irrigation management. Therefore future strategy for adoption of precision farming in India should consider the problem of land fragmentation, lack of highly sophisticated technical centres for precision farming, specific software for precision farming, poor economic condition of general Indian farmer etc. Integrating farmer knowledge, precision farming tools, and crop simulation modelling to evaluate management options for poor-performing patches in cropping fields can be an excellent option for country like India.

REFERENCES

Arti Verma. Raising Capsicum in low tunnel is a profitable method. *ICAR- Indian Horticulture.* Edition: Nov-Dec 2021; 13-14.

Bhadoria PBS. Allelopathy: A Natural Way towards Weed Management. *American Journal of Experimental Agriculture*. 2011; 1(1): 7-20.

Durga C, Ramulu V, Umadevi M, Suresh K.evalaution of soil moisture sensors and irrigation scheduling in Rabi maize. *International Journal of chemicals studies.*2018;6(5):1789-1792.

Dutta R, Stein A, Bhagat RM. Integrating satellite images and spectroscopy to measuring green and black tea quality. *Food Chemistry*.2011; 127 (2): 866-874.

Ess, D. & Morgan, M. (2003).The Precision-Farming Guide for Agriculturists. *Deere & Company, Moline,* Illinois. 138.

Halimi K, Moussa T. A Guelph Intelligent Greenhouse Automation System (GIGAS) for greenhouse based precision agriculture. *In IEEE Transactions on Neural Systems and Rehabilitation Engineering*. 2015; 25(6): 686-693.

Hemraj Meena, Dharmendra Kumar, Keshav Prasad. Precision Agriculture: Present Status & Scope: A Review. *Just Agriculture – Multidisciplinary Newsletter*. 2021; 1(5): 213-219.

Irmak A, Jones J, Batchelor W, Irmak S, Boote K. Artificial neural network model as a data analysis tool in precision farming.*International Journal of Precision Agriculture*. 2006; 9 (6): 227–237.

Kanannavar PS, Premanand BD, Subhas B, Anuraja B, Basavaraj Bhogi P. Laser Land Levelling- An Engineering Approach for Scientific Irrigation Water Management in Irrigation Command Areas of Karnataka, India. *International Journal of Current Microbiology and Applied Sciences*. 2020; 9(5): 2393-2398.

Karimi Y, Prasher O, Patel M, Kim H. Application of support vector machine technology for weed and nitrogen stress detection in Precision Agriculture. *Journal of Computers and Electronics in Agriculture*. 2014; 51 (1–2): 99–109.

Kim Y, Yang Y, Kang W, Kim D. Design of beacon based wireless sensor network for precision agricultural monitoring systems. *Journal of Agricultural Engineering Research*.2014; 12 (6): 134–138.

Koch B, Khosla R, Frasier WM, Westfall DG, Inman D. Economic feasibility of Variable rate Nitrogen application utilizing site-specific management zones. *Agronomy Journal*. 2004; 96: 1572-1580.

Manjeet Singh, Kumar R, Ankit Sharma, Singh B, Pramod Kumar Mishra, Sharma K. Evaluation of yield monitoring system installed on indigenous grain combine harvester for rice crop. *Agricultural Engineering International: CIGR Journal*. 2013; 15(3): 148-153.

Mondal P, Basu M, Bhadoria PBS. Critical review of precision agriculture technologies and its scope of adoption in India. *American Journal of Experimental Agriculture*. 2011; 1(3): 49-68.

Mondal P, Basu M. Adoption of precision agriculture technologies in India and in some developing countries: Scope, present status and strategies. *Progress in Natural Science*.2009; 19: 659–666.

Murali Krishnan, Ram Bahal, Padaria RN, RajeshNallaiah. Analyze the Constraints, Training Needs and Extension Strategies Related to Precision Farming. *Advances in Life Sciences*. 2019; 5(19): 8783-8785.

Navarro H, Torres-Sánchez R, Soto-Valles F, Albaladejo C, Riquelme J, Domingo R. Wireless sensors architecture for efficient irrigation water management. *In Proceedings of the Fourth International Conference on Precision Agriculture*. 2015; 1089–1100.

Padmaja S, Latheef Pasha MD, Umadevi M, Hussain SA, Nirmala A. Influence of Drip Irrigation and Fertigation on Fruit Yield and Water Productivity of Cucumber under Naturally Ventilated Poly House. *International Journal of Environment and Climate Change*.2021; 11(6): 162-168,

Pahuja R, Verma H, Uddin A. A wireless sensor network for greenhouse climate control. *Journal of Agricultural Engineering Research*.2013; 4(2): 49-58.

Pavan Kumar, Pandey AK, Susheel Kumar Singh, Singh SS, Singh VK. A Text Book on Sustainable Agriculture Systems and Technologies. *Wiley Publishers*. 2022.

Persson A, Pilesjo P, Eklundh L. Spatial Influence of Topographical Factors on Yield of Potato (Solanum tuberosum L.) .*Precision Agriculture*.2005; 6(4): 341- 357.

Rains CR, Thomas DL. Precision farming: An introduction. *The University of Georgia. Bulletin.* 2009. 12.

Rani M, Kamalesh S.Energy efficient fault tolerant topology scheme for precision agriculture using wireless sensor network. *In Proceedings of the International Conference on Advanced Communication Control and Computing Technologies (ICACCCT)*.2014; 1208– 1211.

Reyniers M, Vrindts E, Baerdemaeker JD. Comparison of an aerial-based system and an on the ground continuous measuring device to predict yield of winter wheat. *European Journal of Agronomy*.2006; 24: 87–94.

Sabri N, Aljunid S, Ahmad R, Kamaruddin R, Salim M. Smart prolong fuzzy wireless sensor-actor network for smart agricultural application. *International Journal of Science, Engineering and Technology Research (IJSETR)*.2012; 6 (1): 172-175.

Sai Z, Fan Y, Yuliang T, Lei X, Yifong Z. Optimized algorithm of sensor node deployment for intelligent agricultural monitoring. *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering*. 2016; 3(2): 76–86.

Stamatiadis S, Christofides C, Tsadilas C, Samaras V, Schepers JS, Francis D. Ground-Sensor Soil Reflectance as Related to Soil Properties and Crop Response in a Cotton Field. *Precision Agriculture*.2005; 6(4): 399-411.

Subramanian KS, Pazhanivelan S, Srinvasan G, Santhi R, Sathiah N. Drones in Insect Pest management. *Frontiers in Agronomy*. 2021; 3: 1-12.

Tan Y, Panda K. Review of energy harvesting technologies for sustainable wireless sensor network for precision agriculture. *International Journal of Advanced Computer Technology (IJACT).*2010; 8 (9): 51 – 55.

Yang C, Everitt JH, Murden D. Evaluating high resolution SPOT 5 satellite imagery for crop identification.*Comput.Electron.Agriculture.*2011;75(2): 347-354.