# DEVELOPMENT OF GROUND BASED MULTI-SOURCE CROP INFORMATION COLLECTION SYSTEM

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## ABSTRACT

Precision agriculture requires reliable technology to acquire accurate information on crop conditions. A ground-based integrated sensor and instrumentation system was developed to measure real-time crop conditions. The integration system included multispectral camera and N-sensor for real time Nitrogen application. The system was interfaced with a DGPS receiver to provide spatial coordinates for sensor readings. Before mounting of the sensors on modified paddy transplanter, different mountings and frames were attached with the paddy vehicle to mount the sensors, camera and power source. Battery mounting plate was required to fit imported 12 V & 80 A battery on vehicle. New bracket had fabricated to suit the new battery and it can be adjusted vertically 25~30 mm as per the requirement. For overturning balancing of rice transplanter extra weights of 100 kg were added at the rear of the rice transplanter. Trails were done in puddle rice field. By adding additional weight, there was no problem of over turning in the field in normal operations. The results showed that the integration sensor and instrumentation system supports multi-source information acquisition and management in the farming field except high clearance of tractor.

**Keywords:** Ground Based Integration System, Paddy Transplanter**,** Multi-spectral Camera, N-sensor.

## INTRODUCTION

Precision agriculture has created a technology revolution in production agriculture. In developed countries, it is common to find combine harvesters with on-board data collection systems for mapping yield and moisture content of harvested crop. The agricultural equipment industry is moving towards controller area networks for agricultural equipment communication systems. These are basic factors that have led to increased opportunity for automation of agricultural guidance. With the advances of electronic and information technologies, various sensing systems have been developed for specialty crop production around the world.

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Accurate and reliable information technology is the basis of precision agriculture. Remote sensing has been widely used to obtain and map the temporal and spatial variability of crops in fields. Information on crop condition can be used to assess and monitor crop growth status, predict crop yield, or develop program for optimizing application of nitrogen fertilizer, fungicide, and growth regulator in precision agriculture. Successful information acquisition relies on the ability of sensors and instrumentation in detecting these crop canopy variables, which are indicative of crop growth (Goel et al. 2003).

Darvishzadeh et al. (2008) examined the utility of hyperspectral remote sensing in predicting canopy characteristics by using a spectral radiometer. Among the various investigated models, they found that canopy chlorophyll content was estimated with the highest accuracy. Some studies used multispectral image sensor system to measure crop canopy characteristics. Jones et al. (2007) estimated biomass based on multispectral images taken by a Duncan Tech® MS3100 multispectral camera (Auburn, CA).

Gerrish et al. (1984, 1985) investigated the potential of vision-based tractor guidance by studying the accuracy that could be achieved through automatic guidance, and by evaluating several images processing techniques to determine their applicability. Reid (1987) developed a vision-based guidance system for steering a tractor through row crops. Near infrared images were used to segment row crops into crop and soil. Segmented images were processed to produce sets of points representing crop row centres using run-length encoding and marking the centre pixel of each run. A simplified row crop guidance was developed later by Billingsley and Schoenfisch (1995, 1997) utilizing modern and low cost computer imaging hardware. In this system operator had to select the initial positions of row crops that were subsequently tracked and used to compute a vanishing point. Brandon and Searcy (1992) designed and built a vehicle control system using distributed control techniques to steer a tractor through row crops. Noguchi et al (1998a) developed a guidance system by the sensor fusion integration with a machine vision, an RTK-GPS and a geometric direction sensor (GDS). The developed navigation planner involved a priority scheme of the control strategies using a knowledge-based approach. Noguchi et al (1998b) developed an intelligent vision system for autonomous vehicle field operations. Field trials confirmed that the method developed was able to accurately classify crop and weeds through the entire growing period. After segmenting out the weed, an artificial neural network was used to estimate crop height and width. Finally, a geographic information system (GIS) was used to create a crop growth map.

A ground-based integrated sensor and instrumentation system was developed by Lan et. al. 2009, to measure real-time crop conditions including Normalized Difference Vegetation Index (NDVI), biomass, crop canopy structure, and crop height. Individual sensor components has been calibrated and tested under laboratory and field conditions prior to system integration. The integration system included crop height sensor, crop canopy analyzer for leaf area index, NDVI sensor, multispectral camera, and hyperspectroradiometer. The system was interfaced with a DGPS receiver to provide spatial coordinates for sensor readings. The results show that the integration sensor and instrumentation system supports multi-source information acquisition and management in the farming field.

These sensor-intensive technologies include some benefits like sensing is non contact, large amount of information is collected quickly and the potential exists to be both cheap and powerful. But there are some difficulties also such as moving of ground vehicle within the submerged crop like rice, storing and processing the data, extracting usable information from images, dealing with natural objects and operating under natural lighting conditions.

Combinations of sensors provide data for crop management in addition to guidance functions. The combination of various sensors with Global Positioning System (GPS) provides opportunities for mapping crop responses as the vehicle performs field tasks. Rice crop being submerged, it is difficult to move a tractor or platform within the crop. In relation to above view a ground-based integrated sensor and instrumentation system was developed to measure real-time wheat and rice crop conditions.

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## DEVELOPMENT OF VEHICLE

Paddy transplanter used for the transplanting of mat type rice seedlings is available in the Japan, Korea and other Asian Countries. It can be used as a vehicle for other operations, if transplanting mechanism mounted at the rear of the transplanter is removed. It may become unstable after removing the transplanting mechanism but extra weight can be added to make it stable. Before mounting of the sensors, different mountings and frames were attached with the paddy vehicle to mount the sensors, camera and power source. Battery mounting plate was required to fit imported 12 V & 80 A battery on vehicle. New bracket had fabricated to suit the new battery and it can be adjusted vertically 25~30 mm as per the requirement. Battery positive cable had been replaced to suit the new battery .Separate MS sheet had been welded to support the foam of the operator' seat. Hinges had been welded to the MS sheet. For balancing of rice transplanter extra 100 kg weights were added at the rear of the rice transplanter. By adding additional weight, there was no problem of over turning in the field in normal operations. It was observed that while entering into the field from main road (big bunds between field and road), rice transplanter has tendency to little lift from rear. A DC (12 V) to AC (230 V) converter was required for the frame grabber used to store the multi-spectral images acquired by the multi spectral camera.

**Fig. 1. Multispectral camera and N Sensor holding frame**

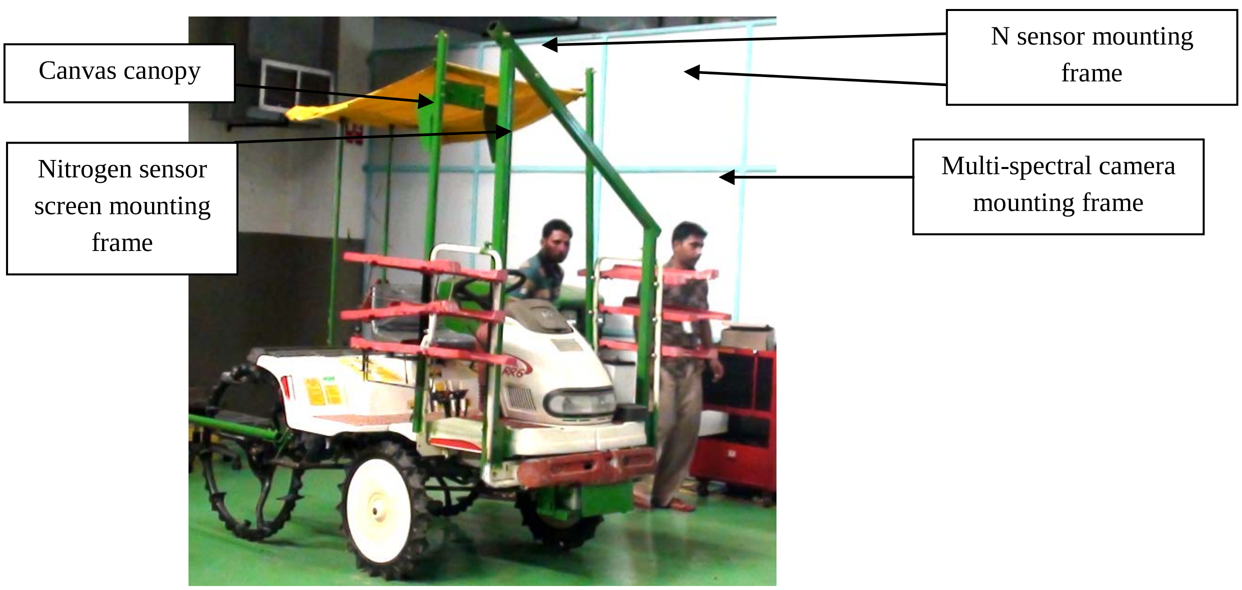



**Fig. 2. Different frames mounted to the developed vehicle**

## DEVELOPMENT OF GROUND BASED INTEGRATION SYSTEM

The developed ground-based multi-source information system to measure real time crop conditions consisted of N-sensor and Multi-spectral camera. The system is interfaced with a DGPS (Differential Global Positioning System) receiver to provide spatial coordinates for sensor readings. Individual sensor components has been calibrated and tested under laboratory and field conditions prior to system integration. The integrated system collected multi-sensor data and store the spatial information and crop property information in database. The different components and how they were unified are described in the following sections.

## N-sensor

A frame was developed to mount N-sensor with the vehicle (Fig.1 and Fig.2). The N sensor was installed on the vehicle at 2.74 m height (h) (Fig. 3) which made the scanning area 46.56 $m^2$. N-sensor consists of two diode spectrometers, fiber optics and microprocessor in a hard shell, built on the roof of the vehicle. A spectrometer collects reflectivity at wavelengths from 620 to 1000 nm with four points, which are around the vehicle. A fifth sensor positioned skywards measures the intensity of light allowing the sensor system to compensate for different light conditions while operating.

## Multi-spectral Camera

A frame to mount the Multi-spectral Camera was developed and attached with the vehicle (Fig.1 and Fig. 2). The height of Multi-spectral camera was kept equal as the N-sensor. But its mounting height can increased or decreased by moving the frame upward or downward. The information available can be maximized by combining information found in multiple spectral bands. The photonic spectrum includes energy at wavelengths ranging from the ultraviolet through the visible, near infrared, far infrared, and finally, x-rays. The color image from a Charge Coupled Device (CCD) array is acquired by sensing the wavelengths corresponding to red, green, and blue light. CCD sensors are capable of detecting light beyond the visible wavelengths out to 1100 nm.

## Differential Global Positioning System (DGPS)

The N-Sensor and Multi-spectral camera system was connected to a Differential Global Positioning System (DGPS) signal to allow Location, sensor and application information to be plotted enabling the production real time crop information. The DGPS was mounted at the height of 2.5 m on the frame of Multi-spectral camera and its serial console was connected to the N-sensor display.


**Fig. 3 View of developed vehicle with installed sensor working in the field**

## FIELD OPERATION OF GROUND VEHICLE

The N sensor gives the data in the form of log file which can be converted into the CSV file format with the help of log converter software or with N sensor card writer software. This CSV file can be opened in excel format which contain the real time information of the crop. Vehilce was opeared in the Five wheat crop plot having inceasing nitrogen level rate (0, 40, 80, 120 and 150 kgN/ha) with N-sensor and Multi-spectral installed on it to measure real-time crop conditions. The data was taken after 60 days after sowing (DAS). The N-sensor Nitrogen recommendation map prepared after the operation of N-sensor (Fig.4). The recommendation map was also located on the Google Earth. The map showed that the minimum and maximum nitrogen recommendation rate were 16 and 105 kgN/ha.

Multispectral camera was also operated during the operation. Images (Fig. 5) taken at 0 and 80 kgN/ha level plot showed that, there is textural difference between the images. Darker the red color of the canopy more is the nitrogen uptake. Brown color in the images depicts shadow of plant and white color showed reflectance of the bare soil. There is difference in terms of density of the canopy at different level of nitrogen.

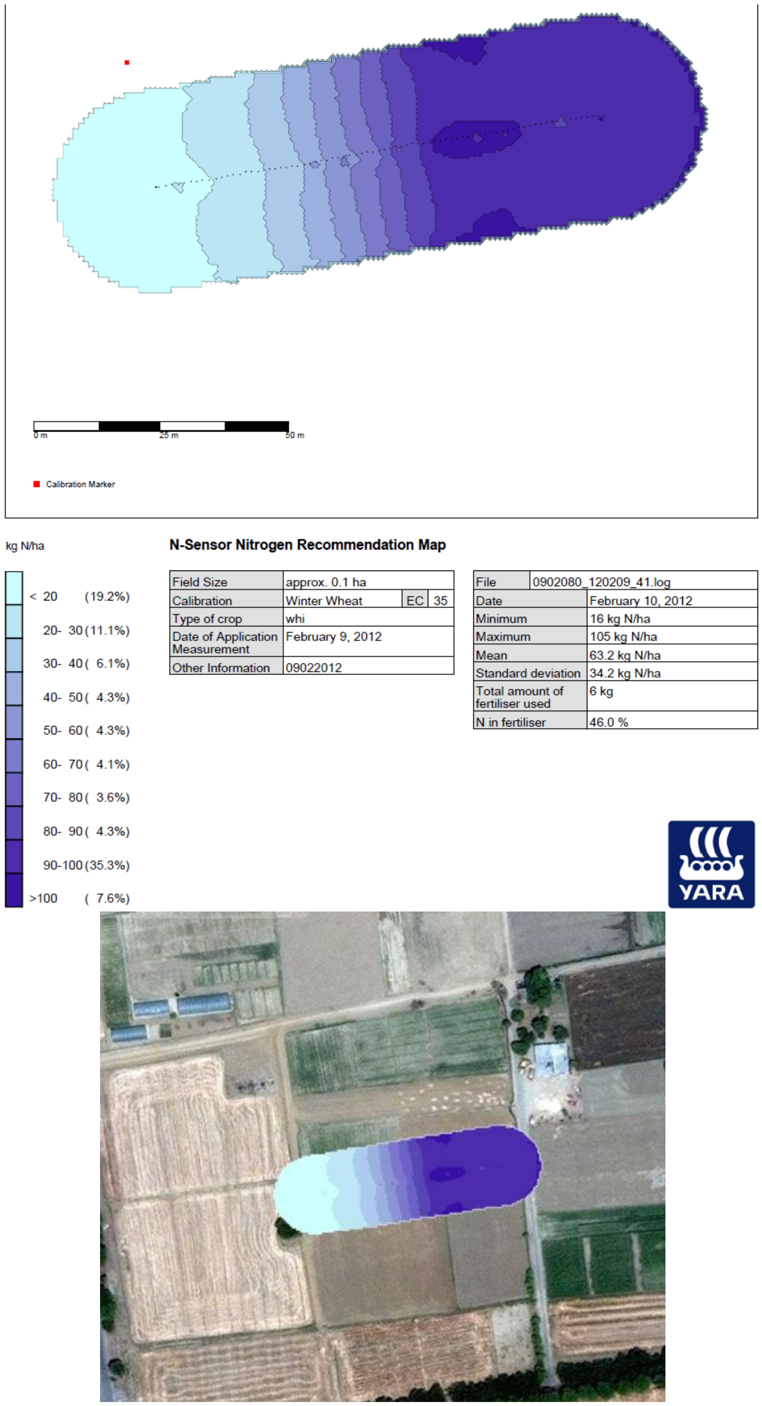
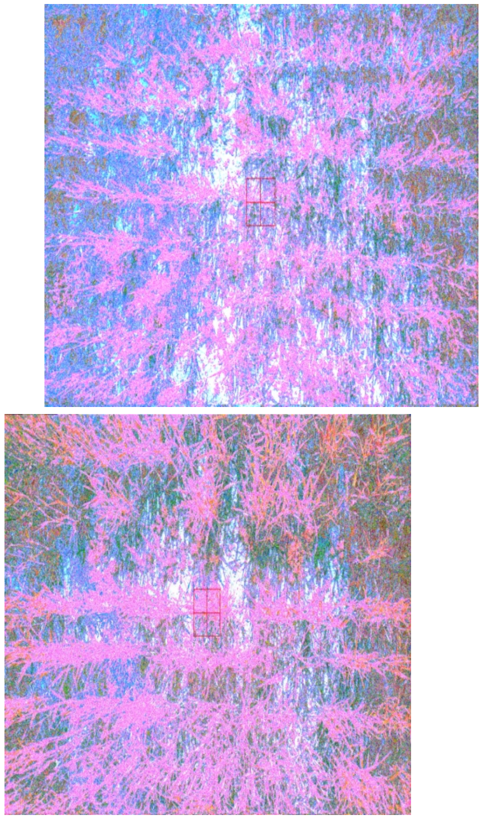



**Fig. 4. N-sensor Nitrogen Recommendation map and its location on Google Earth.**



**(a) (b)**

**Fig.5. Images of multispectral camera at 0 and 80 kgN/ha level plot**

Nitrogen can be co-related with NDVI:

NDVI= (NIR –R)/(NIR+R)

Change in NDVI can be referred through change in scatter diagrams of NIR and R level. Multispectral images need to be first pre-processed by using various image enhancement techniques. Later, specific band information need to be extracted from the processed image and plotted in the form of graph

## CONCLUSIONS

Sensors are needed in site specific crop production for the controls of those properties of soil and plants, which are spatially variable, essential for economy and environment and which cannot be recognized by the farmer during field work immediately. Experimental work to determine the best use of sensors in crop production is still in its infancy. Machine vision gives promising results, but is sensitive in field work still. The integration system included Multi-spectral camera and N-sensor for real time crop information. Before mounting of the sensors on modified paddy transplanter, different mountings and frames were attached with the paddy vehicle to mount the sensors, camera and power source. Battery mounting plate was required to fit imported 12 V & 80 A battery on vehicle. New bracket had fabricated to suit the new battery and it can be adjusted vertically 25~30 mm as per the requirement. For overturning balancing of rice transplanter extra weights of 100 kg were added at the rear of the rice transplanter. By adding additional weight, there was no problem of over turning in the field in normal operations. This preliminary study indicates that the potential of the integration sensor and instrument system to realize multi-source information acquisition and management in the field.

## REFERNCES


Billingsley, J. and M. Shoenfish. 1995. Vision guidance of agricultural vehicles. Autonomous Robots 2:65-76.

Billingsley, J. and M. Shoenfish. 1997. The successful development of a vision guidance system for agriculture. Computers and Electronics in Agriculture 16: 147-163.

Brandon, J. R. and S. W. Searcy. 1992. Vision assisted tractor guidance for agricultural vehicles. SAE Technical Paper Series No. 921650. Warrendale, PA:SAE

Darvishzadeh, R**.,** A. Skidmore, M. Schlerf, C. Atzberger, F. Corsi and M. Cho**.** 2008**.** LAI and chlorophyll estimation for a heterogeneous grassland using hyperspectral measurements. *ISPRS Journal of Photogrammetry & Remote Sensing* 63(4): 409- 426.

Gerrish, J. B. and T. C. Surbrook. 1984. Mobile robots in agriculture. In *Proc. of First International Conf. on Robotics and Intelligent Machines in Agriculture*, 30-41, St. Joseph, MI:ASAE.

Gerrish, J.B. and G.C. Stockman. 1985. Image processing for path-finding in agricultural field operations. Summer Meeting. Michigan State University, East Lansing, MI: ASAE. Paper No.: 85-3037.

Goel, P.K., S.O. Prasher, J.A. Landry, R.M. Patel and A.A. Viau. 2003. Estimation of crop biophysical parameters through airborne and field hyperspectral remote sensing. *Transactions of the ASAE* 46(4): 1235–1246.

Jones, C.L., N. O. Maness, M.L. Stone, R. Jayasekara, M.L. Stone and D. Chrz. 2007. Chlorophyll estimation using multispectral reflectance and height sensing. *Transactions of ASABE* 50(5): 1867-1872.

Lan Y., H. Zhang, R. Lacey, W.C. Hoffmann and W. Wu. “Development of an Integrated Sensor and Instrumentation System for Measuring Crop Conditions”. Agricultural Engineering International: the CIGR Ejournal. Manuscript IT 08 1115. Vol. XI. April, 2009.

Noguchi, N., J.F. Reid, E.Benson, J. Will, amd T. Stombaugh. 1998a. Vehicle automation system based on multisensory integration. ASAE Paper 983111. St. Joseph, MI.

Noguchi, N, J. F. Reid, Q. Zhang, and L.F. Tian. 1998b. Vision intelligence for precision farming using fuzzy logic optimized genetic algorithm and artificial neural network. ASAE Paper 983034. St. Joseph, MI.

Reid, J.F. 1987. The development of computer vision algorithms for agricultural vehicle guidance. Unpublished Ph.D Thesis. Texas A&M University College Station, TX 77843.