INVESTIGATIONS ON TRACTOR MOUNTED N-SENSOR FOR WHEAT CROP IN INDIA

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ABSTRACT

Sensor technology, which benefits from high temporal measuring resolution, real-time data transfer and high spatial resolution of sensor data that shows in-field variations, has the potential to provide added value for crop production. The tractor-mounted N-sensor is a remote sensing system which processes the real-time measurements using an onboard computer to produce sensor biomass data. The N-sensor installed on the tractor at 2.74 m height, based upon its geometry, it scanned the cropped area of 46.72 m^2. It consists of two diode spectrometers, fiber optics and microprocessor in a hard shell, built on the roof of the tractor. The viewing angles of two spectrometers of N-sensor are 58 and 70° on each side. The N-sensor was operated in the five wheat crop plot having different nitrogen levels (0, 40, 80, 120 and 160 kgN/ha) and it was observed that the N-sensor data gave good correlations with nitrogen uptake at 35 growth stage (approximately 90 DS) on wheat crop.

Keywords: *N-sensor, Wheat, Biomass, N-uptake.*

1. INTRODUCTION

Precision agriculture is such a new emerging, highly promising technology, spreading rapidly in the developed countries. Precision agriculture is a scientific endeavor to improve the agricultural management by application of sensor technology, satellite based technology (*e.g.* global positioning system, remote sensing, etc.) and Information Technology (IT) to identify, analyze and manage the spatial and temporal variability of agronomic parameters within field by timely application of only required amount of input to optimize profitability, sustainability with a minimized impact on environment. Sensor technology has the potential to provide added value for agriculture *e.g.*, for improving yield quality or for decreasing costs or risks in production. Today, low-cost powerful computers, real-time controllers, variable rate application hardware, accurate location systems, and advances in sensor technology have combined to provide the technology to make precision farming a reality. Currently sensor technology has been most commonly applied in real-time weather monitoring for support of management practices, and in precision agriculture (Pierce and Elliott 2008; Wang *et al.,* 2006). Agriculture benefits from high temporal measuring resolution, real-time data transfer and high spatial resolution of sensor data that shows in-field variations (Hart and Martinez 2006; Butler 2006). Advancement in sensor technology changed Indian environment as well as created new scopes for farm sectors. So under this changed condition it is necessary to grasp over the new cutting edge technologies in agriculture invented in the developed world and subsequent modification according to the domestic conditions for proper digestion of Indian farm sectors.

The tractor mounted N-sensors available in the world is one of the sensor technologies which measures the level of light reflectance by crop canopies using spectrometers (Link *et al.,* 2002; Wiltshire *et al.*, 2002). It is a remote sensing system which processes real-time scanner measurements using an onboard computer to produce sensor biomass readings which are combined with GPS technology to produce biomass maps. But in developing countries like India, the uses of such type of sensor technology are in very nascent stage. Investigation of such type of technology in Indian agriculture concern is a dire need of present time. So the objectives of this paper are to investigate the tractor mounted N-sensor.

2. MATERIALS AND METHODS

2.1 Description of N-sensor

N-sensor (make Yara) consists of two diode spectrometers, fiber optics and microprocessor in a hard shell, built on the roof of the 55 hp tractor (make New Holland model 5500). A spectrometer collects reflectivity at wavelengths from 620 to 1000 nm with four points, which are around the tractor. Correction radiation occurs through the second spectrometer recognizing area sky at the same wavelength. Crop is scanned by the N-sensor with viewing angle of two spectrometers 58 and 70° on each side. A fifth sensor positioned skywards measures the intensity of light allowing the sensor system to compensate for different light conditions while operating. The N-sensor having 2 m width of rig, installed on the tractor at 2.74 m height, based upon its geometry, it scanned the cropped area of 46.72 m^2. The whole process of determining the crop's Nitrogen requirement and application of the correct fertilizer rate happens instantaneously, with no time delay. This enables real time agronomy to be possible. The N-sensor system was connected to a Differential Global Positioning System (DGPS) signal to allow Location, sensor and application information to be plotted enabling the production of 'biomass' and Nitrogen application maps for the field. The N-sensor was also connected to the computer screen which is installed on the tractor cabin in front of driver seat. All the sensing operations command was given through the computer screen. The N-sensor can also be further connected to the variable rate controller for variable rate application of the fertilizer. A system view of N-sensor and technical setup shown in Figures 1 and 2 showed the view of N-sensor viewing angle, DGPS and computer screen.

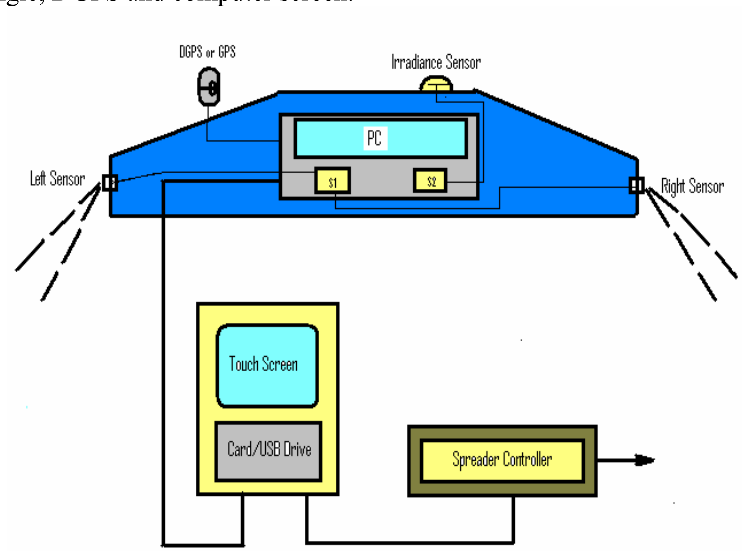

Fig. 1: N-sensor System View and Technical Setup

Fig. 2: View of N-sensor Viewing Angle, DGPS and Computer Screen

2.2 Calculation of Area Sensed by N-Sensor

From Figure 3, equations (i) and (ii) ((Source: YARA (Hydro Agri), tec5Hellma) can be obtained through which area sensed by the N-sensor can be calculated as follows:

$$X1 = d/2 + h \tan 58°/(2)^{1/2} = 0.5d + 1.13\ h \quad \ldots (i)$$

$$X2 = d/2 + h \tan 70°/(2)^{1/2} = 0.5d + 1.94\ h \quad \ldots (ii)$$

Where: d width of the sensor rig, h: height of sensor rig, X1: inner point of sensor area, X2 = outer point of sensor area, y: width of sensed area, m and n = major and minor axis of ellipse,

H = 2.74 m, from equation (i) and (ii), X1 = 4.22 m and X2 = 6.44 m

y = X2–X1 = 2.2 m, a = X2–d/2–y = 3.12, b = a+y = 5.32, p = b × tan 45°, q = p × 2 = 10.64 m, L = b/cos45° = 10.13

L1 = a/cos45° = 5.9, m = L–L1 = 4.23, Area of Ellipse = πmn, Area of one ellipse = $\pi mn \times 1/4 = 11.68$ m^2, Total area scanned by the 4 sensors = $4 \times 11.68 = 46.72$ m^2

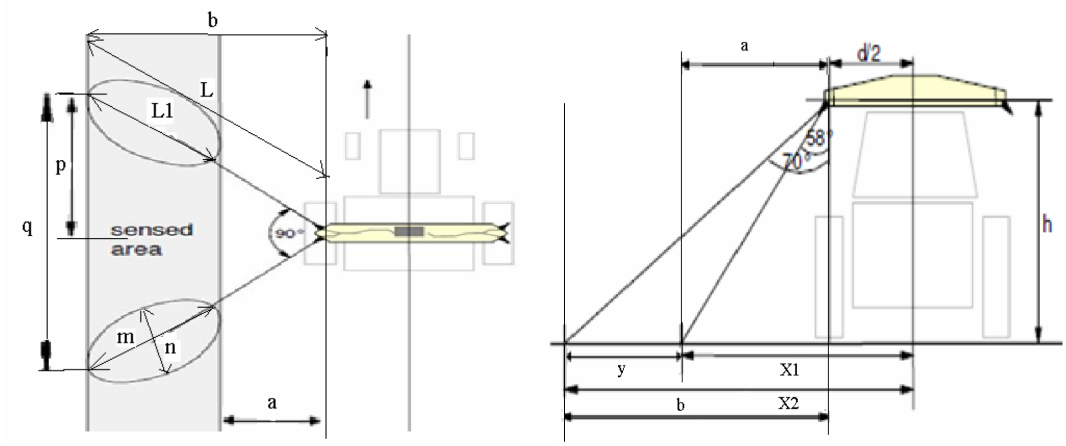

Fig. 3: Top and Front View of Geometry of N-Sensor (all dimensions are in meter)

2.3 Operation of N-sensor in the Field

The N-sensor installed on the tractor was operated in the five plots of wheat crop (variety PBW 621) of size 20 m × 20 m each (Figure 4) having inceasing nitrogen level rate (0, 40, 80, 120 and 160 kgN/ha (Figure 5). Before N-sensor is used in selected plots, a simple agronomic calibration procedure is required for each field. This process involves scanning a small area of crop to measure the average sensor reading. A plot of 40 m × 20 m size was selected for the agronomic calibration of N-sensor. An optimum nitrogen rate is then calculated, for that area, using either farm practice, N-tester or N-plan. This optimum Nitrogen rate is then keyed into the computer in the tractor cab and assigned to the average sensor reading. As the tractor passes over the field where it is to be operated, the N-sensor will vary the rate around this average optimum, according to the crop's requirements. If required, the range of application rates can be restricted by setting maximum and minimum levels.

Fig. 4: View of Installed N-sensor on the Tractor Roof in the Field

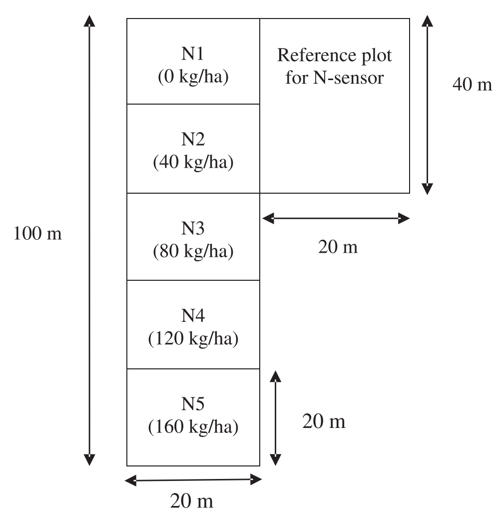

Fig. 5: Experimental Layout of Operation of N-Sensor in the Field

3. RESULTS AND DISCUSSION

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 contains the real time information of the crop. The N-sensor installed on the tractor roof was operated in the five wheat crop plot having increasing nitrogen level rate (0, 40, 80, 120 and 160 kgN/ha). The data was taken at 35 growth stage (approximately 90 days after sowing (DS)). The relation between N-sensor data and crop N-uptake was studied (Figure 6) and it was observed that Crop N-uptake was increased as sensor data increased (equation was also added with trend line). The coefficient of correlation was found to be 0.907.

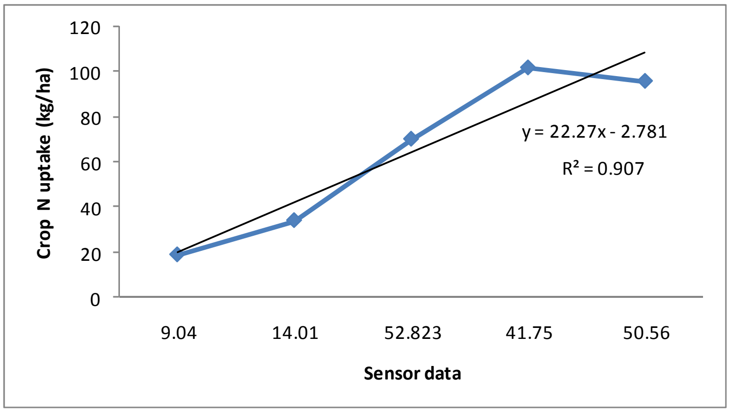

Fig. 6: Relation between Crop N-uptake and Sensor Biomass Data

The N-sensor Biomass map was also prepared from the log file after the operation of N-sensor (Figure 7). The log file was processed through the sensor office software available on the YARA company website (www.sensoroffice.com). The map can be downloaded online from the website. The map showed that the minimum and maximum biomass were 0.8 and 5.4 with average value 2.89 having standard deviation 1.71. Also the relation between N-input and Normalized Difference Vegetation Index (NDVI) (Figure 8) was obtained from the study which indicate that as the N-input rate increase the NDVI also increases because with increase in N-input the biomass of crop also get increased.

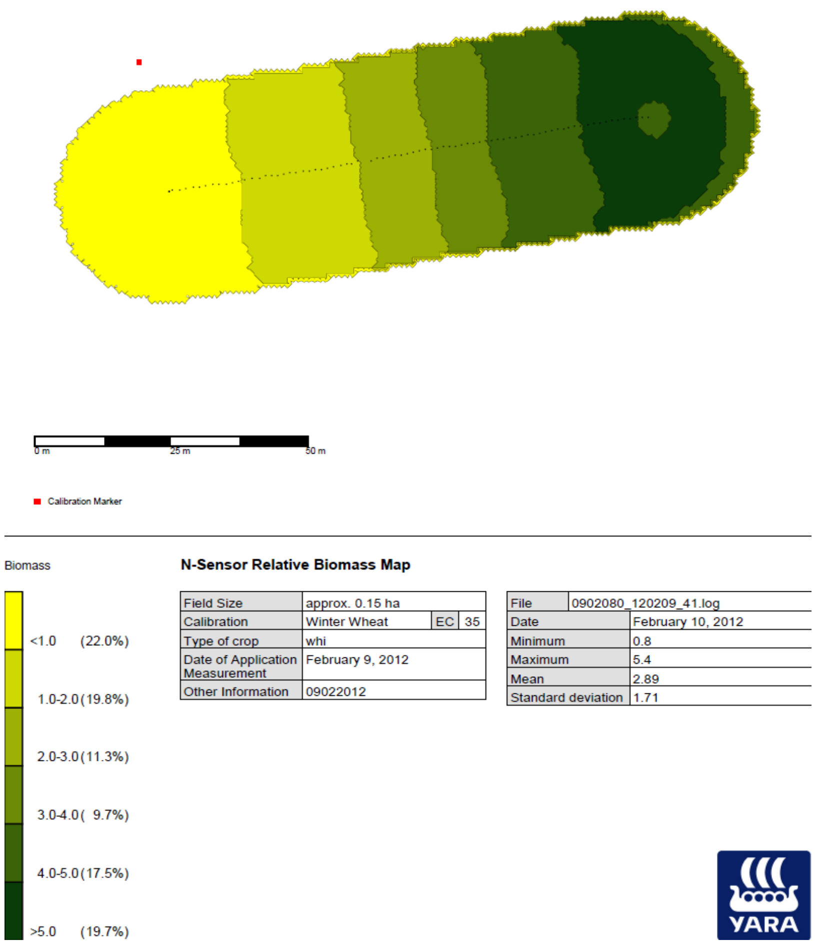

Fig. 7: View N-sensor Biomass Map

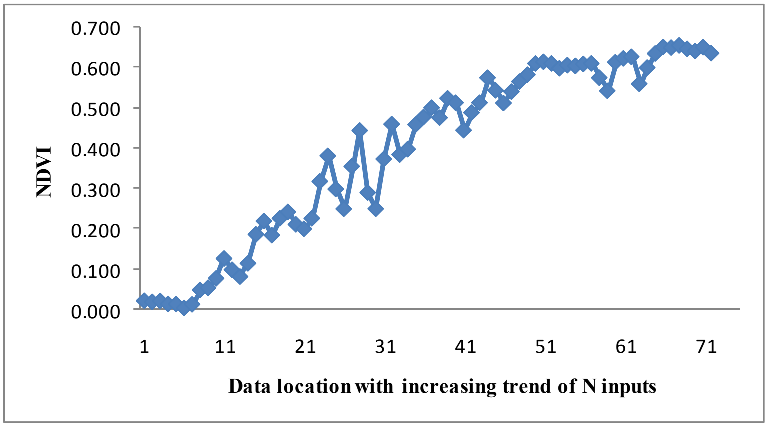

Fig. 8: Relation between N-inputs and NDVI Derived from N-sensor

4. CONCLUSIONS

This study has shown the N-sensor to be a useful sensor technology which can estimate cereal crop biomass and N-status at different crop growth stages. The N-sensor readings gave good correlations with crop N-uptake (kg/ha), it also indicates the biomass reading at key growth stage. The N-sensor installed on the tractor at 2.74 m height, based upon its geometry, it scanned the cropped area of 46.72 m^2. It consists of two diode spectrometers, fiber optics and microprocessor in a hard shell, built on the roof of the tractor. The viewing angles of two spectrometers of N-sensor are 58 and 70° on each side. The N-sensor was operated in the five wheat crop plot having different nitrogen levels (0, 40, 80, 120 and 160 kgN/ha) and it was observed that the N-sensor data gave good correlations with nitrogen uptake at 35 growth stage (approximately 90 DS) on wheat crop. The biomass map prepared showed that the NDVI increased as the N-input increases due to increase in biomass having average value of 2.89 and standard deviation of 1.71.

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