Available online at http://www.journalcra.com

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

International Journal of Current Research
Vol.3, Issue, 4, pp.074-081, April, 2011

ISSN: 0975-833X

REVIEW ARTICLE

PRECISION FARMING AND ITS ROLE IN VEGETABLE PRODUCTION

Pradeep Kumar Singh, Feroz Ahmed Parry, Kouser Parveen, Sumati Narayan, Asima Amin and Ashis Vaidya

Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, India

ARTICLE INFO

Article History:
Received 7th October, 2010
Received in revised form
12th November, 2010
Accepted 30th December, 2010
Published online 17th April, 2011

Key words:
Precision farming, agriculture and vegetable production.

ABSTRACT

Precision farming is a farming system concept which involves the development and adoption of knowledge based technical management systems with the main goal of optimizing profit. This management system will enable micro-management concepts, that are the ability to appropriately manage if it is technically and economically advantageous to manage at that level. The system will likely include the ability to vary or tailor the rate of application of all inputs such as tillage, seeds, weed, insect and disease control, cultivation and irrigation.

INTRODUCTION

Agriculture is the backbone of our country and economy, which accounts for almost 30 per cent of Gross Demand Product (GDP) and employs 70 per cent of the population. Agricultural technology available in the 1940s could not have been able to meet the demand of food for today's population, in spite of the green revolution. Similarly, it is very difficult to assume that food requirement for the population of 2020 AD will be supplied by the technology of today. To meet the forthcoming demand and challenge we have to divert towards new technologies, for revolutionizing our agricultural productivity. Green revolution succeeded in India to increase the farmer's income, yield of major crops and made India self-reliant in food production, with the introduction of high-yielding varieties and use of synthetic fertilizers and pesticides (Ghosh *et al.*, 1999).

***Corresponding author:** pradeepsingh584@gmail.com

In the post-green revolution period agricultural production has become stagnant, and horizontal expansion of cultivable lands became limited due to burgeoning population and industrialization. In 1952, India had 0.33 ha of available land per capita, which is likely to be reduced to 0.15 ha by the end of year 2006 (Singh *et al.*, 2000). As the availability of land has decreased, application of fertilizers and pesticides became necessary to increase production. The major effect is that our agriculture became chemicalized. In this situation, it is essential to develop eco-friendly technologies for maintaining crop productivity. Since long, it has been recognized that crops and soils are not uniform within a given field (Cassman and Plant, 1992). The farmers have always responded to such variability to take actions, but such actions are inappropriate and less frequent. Over the last decade, technical methods have been developed to utilize modern electronics to respond to field variability. Such methods are known as spatially variable crop production, global positioning system based agriculture, site-specific and precision farming. Precision farming is a management philosophy or approach to the farm and is not a definable prescriptive system (Dawson, 1997). It identifies the critical factors where yield is limited by controllable factors, and determines intrinsic spatial variability. It is essentially more precise farm management made possible by modern technology. The variations occurring in crop or soil properties within a field are noted, mapped and then management actions are taken as a consequence of continued assessment of the spatial variability within that field. Development of geomatics technology in the later part of the 20th century has aided in the adoption of site specific management systems using remote sensing (RS), GPS and geographical information system (GIS). This approach is called precision farming or site specific management (Palmer, 1996). Precision farming is a farming system concept which involves the development and adoption of knowledge based technical management systems with the main goal of optimizing profit. This management system will enable micro-management concepts, which are the ability to appropriately manage if it is technically and economically advantageous to manage at that level. The system will likely include the ability to vary or tailor the rate of application of all inputs such as tillage, seeds, weed, insect and disease control, cultivation and irrigation.

What is precision farming?

The "precision farming" or "precision agriculture" offers the promise of increasing productivity, while decreasing production costs and minimizing the environmental impact of farming (NRC, 1997; SKY-Farm, 1999). Precision agriculture is broadly defined as monitoring and control applied to agriculture, including site specific application on inputs, timing of operations and monitoring of crops and employees (Lowenberg-DeDoer and Boehlje, 1996).

Goal of Precision Farming

The goal of precision farming is to gather and analyse information about the variability of soil and crop conditions in order to maximize the efficiency of crop inputs within small area of the farm field. To meet this efficiency goal the variability within the field must be controllable. Efficiency in the use of crop inputs means that fewer crop inputs such as fertilizer and chemicals will be used and placed where needed. The benefits from this efficiency will be both economical and environmental. Environmental costs are difficult to quantify in monetary terms. The reduction of soil and groundwater pollution from farming activities has a desirable benefit to the farmers and to society.

Strategies of precision farming

Precision farming provides a new solution using a systems approach for today's agricultural issues, namely the need to balance productivity with environmental concerns. Based on advanced information technology, it includes describing and modeling variation in soils and plant species and integrating agricultural practices to meet site specific requirements. The strategies of precision farming are described under few sentences:

- Reduction in fertilizer, chemical and seed costs
- Increase in yields
- Improvement in the quality of the crop
- Improved economic analysis – computerized capturing, storing and analyzing field records
- Reduce skip and overlap with input application
- Longer working hours and high labour productivity

Practical problems of implementation precision farming in Indian agriculture

Precision agriculture has been mostly confined to developed countries. Reasons of limitations of its implementation in developing countries like India are:

- Small land holdings
- Heterogeneity of cropping system and market imperfections
- Lack of technical expertise, knowledge and technology
- High cost of investment

In India, major problem is the small field size. More than 58 p er cent of operations holdings in the country have size less than 1 ha. Only in the states of Punjab, Rajasthan, Haryana and Gujarat more than 20 per cent of agricultural lands have operational holding size of more than 4 ha. There is a scope of implementing precision agriculture for crops like rice and wheat especially in the state of Punjab and Haryana. Commercial as well as horticultural crops show a wider scope for precision agriculture.

Steps to be taken for implementation precision farming in India

In the present existent situation, the potential of precision agriculture in India is limited by the lack of appropriate measurement and analysis techniques for agronomically important factors (National Research Council, 1997). High accuracy sensing and data management tools must be developed and valided to support both research and production. The limitation in data quality/availability has become a major obstacle in the demonstration and adoption of the precision technologies. The adoption of precision agriculture needs combined efforts on behalf of scientists, farmers and the government. The following methodology could be adopted in order to operationalise precision farming in the country.

- Creation of multidisciplinary teams involving agricultural scientists in various fields, engineers, manufacturers and economists to study the overall scope of precision agriculture.
- Formation of farmer's cooperatives since many of the precision agriculture tools are costly (GIS, GPS, RS, etc.).
- Government legislation restraining farmers using indiscriminate farm inputs and thereby causing ecological/environmental imbalance would induce the farmer to go for alternative approach.
- Pilot study should be conducted on farmers' field to show the results of precision agriculture implementation.
- Creating awareness amongst farmers about consequences of applying imbalanced doses of farm inputs like irrigation, fertilizers, insecticides and pesticides.

Tools of precision farming

Global positioning system	Geographical information system
Grid sampling	Variable rate technology
Yield monitors	Yield mapping
Remote sensors	Auto-guidance

1. Global positioning system

GPS is a set of satellites that identify the location of farm equipment within a meter of an actual site in the field. The value of knowing a precision location within inches is that:

- Location of soil samples and the laboratory results can be compared to a soil map.
- Fertilizer and pesticides can be prescribed to fit soil properties (clay and organic matter content) and soil conditions (relief and drainage)
- Tillage adjustments can be made as one finds various conditions across the field and
- One can monitor and record yield data as one goes across the field.

The GPS technology provides accurate positioning system necessary for field implementation of variable rate technology. The present internet makes possible the development of a mechanism for effective farm management using remote sensing.

2. Geographical information system (GIS)

A geographical information system (GIS) consists of a computer software data base system used to input, store, retrieve, analyse and display, in map like form, spatially referenced geographical information.

3. Grid sampling

Grid sampling is a method of breaking a field into blocks of about 0.5-5 ha. The sampling soils within those grids to determine appropriate application rates. Several samples are tkan from each grid, mixed and sent into the laboratory for analysis.

4. Variable rate technology

Variable rate technology (VRT) consists of farm field equipment with the ability to precisely control the rate of application of crop inputs that can be varied in their application commonly include tillage, fertilizer, weed control, insect control, plant population and irrigation.

5. Yield monitors

Yield monitors are crop yield measuring devices installed on harvesting equipment. The yield data from the monitor is recorded and stored at regular intervals alongwith positional data received from GPS unit. GIS software takes the yield data and produce yield maps.

6. Yield maps

Yield maps are produced by processing data from adopted combine harvester that is equipped with a GPS that is integrated with a yield recording system. Yield mapping involves the recording of the grain flow through the combine harvester, while recording the actual in the field at the same time.

7. Remote sensors

Remote sensors are generally categorized as aerial or satellite sensors. They can indicate variations in field colour that corresponds to changes in soil type, crop development, field boundaries, roads, water etc. Remote science in agricultural terms means viewing crop from overhead (from a satellite or low flying aircraft) without coming into contact, recording what is viewed and displaying the image and provide the map to pinpoint the field problems more earlier and more effectively. In remote sensing, information transfer is accomplished by use of electromagnetic radiation (EMR). EMR is a form of energy that reveals its presence by the observable effects it produces when it strikes the matter. Due to remote sensing we have been able to observe large regions suitable for agriculture, making use of sensors to measure energy at wavelengths which are beyond the range of human vision (ultraviolet infrared, etc.) and globally monitoring earth possible from nearly any site. Remote sensing technology can be used to provide valuable information on various agricultural resources which influences production (Roa, 1999). Some of the broad agricultural application areas are:

i. **Crop production forecasting:** It includes the identification of crops, acreage estimation and yield forecasting. Reliable and timely estimates of crop acreage and production are important for the formation of marketing strategies and price fixation. Identification of crop is based on the fact that each crop has a unique spectral signature, which is influenced by the leaf area index, per cent ground cover, growth stage, difference in cultural practices, stress conditions and canopy architecture, yield of crop is influenced by large number of factors such as crop genotype, management practices, weather conditions of soil characteristics. Remote sensing data related to yield parameters are used in yield modeling for yield forescasting.
ii. **Soil mapping:** Soil maps afford the information on the suitability and limitation of the soil for agricultural production, which are helpful in selection of proper cropping system and optimal land use planning.
iii. **Wasteland mapping:** Information on degraded and wasteland e.g. salt affected areas, acidic soils, eroded soils, water logged area, dryland etc. Landuse/land cover information is important for spatial planning management and utilization of land for various purposes like agriculture, forestry, environmental studies and to find out the additional land resources that could be tilled. The information generated on landuse pattern also help identify suitable cropping patterns to convert single cropped area to double cropped and allows cultivation of land for increasing the food production.
iv. **Water stress:** The use of remote sensors to directly measure soil moisture has had very limited success. Synthetic Aperture Radar (SAR) sensors are sensitive to soil moisture. SAR data requires extensive use of processing to remove surface induced noise such as soil surface roughness, vegetation and topography. A crop evapotranspiration rate decrease is an indicator of crop water stress or other crop problems such as plant disease or insect infestation. Remote sensing images have been combined with a crop water stress index model to measure field variations (Moran *et al.*, 1997).

v. **Insect detection:** Aerial or satellite remote sensing has not been successfully used to identify and locate insects directly. Indirect detection of insects through the detection of plant stress has generally been used in annual crops. Te economic injury level for treatment is usually exceeded by the time plant stress is detected by remote sensing entomologists prefer to do direct in field scouting in order to detect insects in time for chemical treatments to be effective and economics.

vi. **Nutrient stress:** Plant nitrogen stress areas can be located in the field using high-resolution colour infrared aerial images. The reflectance of near infrared, visible red and visible green wavelengths have a high correlation to the amount of applied nitrogen in the field (Biswas and Subba Rao, 2000).

8. Auto-guidance systems

Auto-guidance system allows farmers to maintain straight rows during farm operations and to come back to the same rows the next season. They allow more precise input application with these systems.

9. Proximate sensors

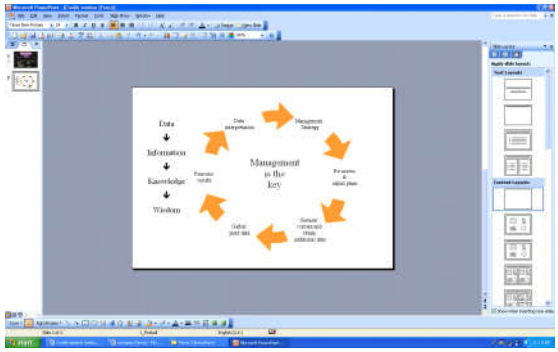
Proximate sensors can be used to measure soil (N and pH) and crop properties as the tractor passes over the field. The soil sample is scooped, pressed against an electrode, stabilization period of about 10-15 seconds allowed, and the reading taken.

10. Computer hardware and software

In order to analyses the data collected by other precision agriculture technology components and to make it available in usable formats such as maps, graphs, charts or reports, computer support is needed.

Elements of precision farming or how precision farming works

Precision farming relies on three main elements – information, technology and decision support (management). Timely and accurate information is the modern farmers' most valuable resources. This information should include data on crop characteristics, hybrids responses, soil properties,



fertility requirements, weather predictions, weed and pest populations, plant growth responses, harvest, yield, post harvest processing and marketing projections. Precision farmers must find, analyse and use the available information at each step in the crop system. An enormous database is available on the internet. The data is both accessible and Precision farmers must assess how new technologies can be adopted to their operations. For example, the personal computer (PC) can be used to effectively organize analyses and manage data. Record keeping is easy on a pie and information from past years can be easily accessed. GIS and other types of application software are readily available and most are easy to use. Another technology that precision farmers use is the GPS. GPS allows producers and agricultural consultants to locate specific field positions within a few feet of accuracy. As a result, numerous observations and measurements can be taken at a specific position. GIS can be used to create field maps based on GPS data to record and assess the impact of farm management decision. Data sensors used to monitor soil properties, crop stress, growth conditions, yield or post harvesting processing are neither available or under development. These sensors provide the precision farmer with instant (real-time) information that can be used to adjust or control operational inputs. Decision support combines traditional management skills with precision farming tools to help precision farmers make the best management choices or prescriptions for their crop production system.

Role of precision faming technology in improving productivity of vegetable crops

Economics of tomato production were estimated for precision and non-precision methods of

Table 1. Economics of tomato production under precision and non-precision farming

(Rs./ha)

S. No.	Particulars	Precision Farming	Non-precision farming	Difference (%)
1.	Human labour	25,693 (25.04)	18,382 (215.47)	39.77
2.	Machine power	6,000 (5.84)	5250 (7.27)	14.28
3.	Seedlings	5,100 (4.97)	5,700 (7.90)	-10.52
4.	Manures	7,292 (7.10)	4,000 (5.54)	82.30
5.	Plant protection chemicals	9,410 (9.17)	22,420 (31.06)	-58.02
6.	Fertilizers	27,858 (27.15)	7,004 (9.70)	297.73
7.	Stacking	6,666 (5.55)	4,700 (6.51)	20.56
8.	Drip system	8,850 (8.62)	0 (0.00)	100.00
9.	Interest on working capital @ 7%	6,710 (6.54)	4,721 (6.54)	42.15
10.	Total variable cost	10,258 (100.00)	72,178 (100.00)	42.15
11.	Main product (kg/ha)	78,663	43,662	80.16
12.	Gross returns	4,32,649	1,96,480	120.20
13.	Gross margin	330,068 Nos.	124,302	165.54

[Maheswari *et al.*, 2008]

Figures in parentheses indicate percentage to total variable cost

Table 2. Economics of brinjal production under precision and non-precision farming

S. No.	Particulars	Precision Farming	Non-precision farming	Difference (%)
1.	Human labour	38668 (34.86)	25853 (29.25)	49.57
2.	Machine power	6000 (5.41)	5340 (6.04)	12.00
3.	Seedlings	4800 (4.32)	5100 (5.77)	-6.25
4.	Manures	6031 (5.43)	5975 (6.76)	0.93
5.	Plant protection chemicals	13441 (12.12)	30061 (34.01)	-123.64
6.	Fertilizers	25853 (23.31)	10273 (11.62)	151.66
7.	Drip system	8850 (7.98)	0 (0.00)	100.00
8.	Interest on working capital @ 7%	7685 (6.54)	5782 (6.54)	32.92
9.	Total variable cost	110900 (100.00)	88386 (100.00)	25.47)
10.	Main product (kg/ha)	77626	57928	34.00
11.	Gross returns	350633	231714	51.32
12.	Gross margin	239732	143327	67.26

[Maheswari *et al.*, 2008]

Figures in parentheses indicate percentage to total variable cost

Table 3. Economics of tomato and brinjal production under precision and non-precision farming

Source of productivity difference	Contribution (%) Tomato	Brinjal
Total difference in output	63.86	28.14
Source of contribution		
Output difference due to technology	33.71	20.48
Input use		
Seed rate (kg)	-6.12	0.47
Manures (tones)	-27.42	15.39
Labour (man days)	-27.42	15.39
Plant protection		
Chemicals (g)	0.16	18.32
Irrigation (ha-cm)	-2.67	-0.02
Nitrogen (kg)	12.54	-2.07
Phosphorus (kg)	54.47	-11.52
Potassium (kg)	22.79	-13.07
Output difference due to input use	30.15	7.68

[Maheswari *et al.*, 2008]

cultivation by Maheswari *et al.* (2008) and the results are presented in Table-1. The share in total variable cost in the case of precision farming was highest for fertilizer (27.15%) followed by human labour (25.04%). Within the cost of human labour, 72.21 per cent was paid out to hired labour and the rest was imputed value of family labour. In non-precision farming, plant protection chemical was found to be major input, accounting for 31.06 per cent of the total cost, followed by human labour (25.47%), fertilizer (9.70%) and seedlings (7.90%). The gross margin calculated as difference between the gross return and variable cost, was 166 per cent higher in precision than non-precision farming in tomato cultivation. The economics of brinjal production under precision and non-precision methods have been presented in Table 2. Labour cost accounted for the highest share in total

Table4. Reasons for adoption and constraints to adoption of precision farming

Reasons	Mean Garrett's score	Rank
Lack of finance and credit facilities	73	1
Drip installation and water soluble fertilizers are expensive	65	2
Lack of knowledge about precision farming technologies	54	3
Labour scarcity	53	4
Farmers perception on yield impact of low quantity of inputs	51	5
Lack of water availability and pumping efficiency	44	6
Lack of technical skill to follow precision farming recommendations	42	7
Market tie ups lead to low price fixation for the produce/unprofitable negotiations	41	8
Inadequate training and demonstrations and weak research-extension-farmer relationship	41	9
Inadequate size of land holdings for adoption of precision farming	27	10

[Maheswari *et al.*, 2008]

variable cost in precision farming and it was 49.57 per cent more than that of non-precision farming. The cost of fertilizer was the second highest, with 151.66 per cent more in precision farming, mainly due to the high cost of water-soluble fertilizers. Non-precision farmers spent 123.64 per cent higher cost on plant protection chemicals because of high use of these chemicals. The spending on seedlings, machine power and manures were more or less the same in both the cases. The precision farmer incurred a total cost of Rs. 1,10,900/ha which was 25.47 per cent higher than by non-precision farmers. The gross return and variable cost, was 67 per cent higher in precision than non-precision farming in brinjal cultivation.

Decomposition of the productivity difference in precision and non-precision farming

The productivity difference between the precision and non-precision productions was decomposed into its constituted sources and the results are presented in Table 3. The Table 3 reveals that the total productivity difference between precision and non-precision farming of tomato was 63.86 per cent. Among various sources responsible for total productivity variation, the contribution of technology was higher at 33.71 per cent. The contribution due to differences in input-use level was 30.15 per cent. Among various inputs contributing to the productivity differences in precision farming, labour (1.47%), plant protection chemicals (0.16%), phosphorus (54.47%) and potassium (22.79%) contributed positively whereas seed (-6.12%) and manure (-27.42%), irrigation (-2.67%) and nitrogen (-12.54%) contributed negatively. The productivity difference between the precision and non-precision farming of brinjal was estimated at 28.14 per cent. Among the various sources responsible for total productivity variation, the contribution of technology was highest at 20.48 per cent. The contribution due to input-use levels was 7.68 per cent. Among various inputs contributing to the productivity difference between precision and non-precision brinjal production, seed (0.47%), manures (15.39%), labour (0.19%) and plant protection chemicals (18.32%) contributed positively, whereas irrigation (-0.02%), nitrogen (-2.07%), phosphorus (-11.52%) and potassium (-13.07%) contributed negatively.

Constraints in adoption of precision farming

Reason for non-adoption of precision farming as ranked by the farmers, were analysed through Garrett's ranking technique and results are presented in Table 4. The results showed that the lack of finance and credit facilities were the most important reasons for non-adoption of precision farming. Obtaining credit was a difficult process, because farmers could not produce collateral security. Drip installation and use of water soluble fertilizers were very expensive and required credit. Besides of output price fluctuations, farmers were not ready to make investments. Lack of knowledge about precision farming technologies was another important constraint, because a majority of small farmers were illiterate and were not able to follow and adopt latest technologies. Labour scarcity was also a problem in adopting precision farming. Due to urbanization and migration, there was a scarcity of labour for agricultural operations. Since precision farming was highly labour-intensive technology and operations were time bound, farmers faced the dearth of labour, especially during stacking and harvesting. The traditional farmers had a wrong perception about the higher yield from the précised quantity of inputs. It was a major constraint to the adoption of precision farming for the entire crop duration and pumping efficiency of motor should also be about 12000 litres of water per hour, lack of water availability and pump efficiency, lack of technical skill, inadequate size of land-holdings, mindset and traditional beliefs were constraints to adoption of precision farming. The local market was not big enough to market the huge quantity of output produced through precision farming, so farmers had to negotiate with supermarkets etc. but sometimes it lead to low price and less profit.

Conclusion

- Precision farming is a part of professional farming system
- Precision farming aids management decisions
- Inputs can be managed better
- Crop traceability can be managed more effectively
- Avoid environmental degradation
- Enhance sustainability
- Overall farm profitability can be improved.

REFERENCES

Biswas, C. and Subba Rao, A.V.M. *Jojana*, 2000. (Committee on Assesing Crop Yield. Site Specific Farming, Information System and Research Opportunities). National Academy Press, Washington, DC, USA, 149 p.

Cassman, K.G. and Plant R.E. 1992. Site specific nutrient management. *Fertilizer Research,* 31 : 151-163.

Dawson, C.J. 1997. In : Precision Agriculture (Ed. J.V. Stafford). Bios Scientifc Publishers Ltd. Vol. 1, pp 45-58.

Ghosh, S.K., Murthy, K.M.D., Ramesh, G. and Palaniappan, S.P. 1999. Green Revolution. *Employment News* 222 : 1-2.

Hanson, L.D., Robert, P.C. and Bauer, M. 1995. Mapping wild oats infestation using digital imagery for site-specific management. In : *Proceedings of Site Specific Management for Agricultural System* 227-230, March 1994, Minneapolis, MN, ASA-CSA-SSSA, Madison, WI, pp 495-503.

Ladha, J.K., Fischer, A.K., Hossain, M., Hobbs, P.R., Hardy, B. 2000. Improving the productivity and sustainability of rice-wheat system of the Indo-gangetic plains: a systematic synthesis of NARS-IRRI Partnership Research. IPRI Discussion Paper Rice Research Institute, 31 p.

Maheswari, R., Ashok, K.R. and Prahadeeswaran, M. 2008. Precision farming technology, Adoption, Decision and Productivity of Vegetables in Resource-poor environments. *Agricultural Economics Research Review* 21 : 415-424.

Moran, M.S., Inovey, Y. and Barnes, E.M. 1997. Opportunities and limitations of image based remote sensing in precision crop management. Remote Sensing Environment *Isozymes – their Application in Fruit Crops* 61 : 319-346.

Mulla, D.J. 1997. Geostatistics, remote sensing and precision farming. In : *Precision Agriculture : Spatial and Temporal Variability of Environmental Quality* (Ed. J.V. Lake, G.R. Bock and J.A. Goode). John Wiley and Son, New York, pp 100-119.

Palmer, R.J. 1996. Site Specific Management for Agriculture System. Minneapolis, MN, ASA-CSSA-SSA, Madison, Wl, 27-30 March, 1996, pp 613-618.

Pierce and Nowak, 1999. Precision Farming : Basic Concepts. Department of Agronomy, Purdu University.

Rao, D.P. 1999. Remote sensing valuable information aid. *The Hindu Survey of Indian Agriculture*, pp 197-200.

Singh, K.K., Khan, M. And Shekhawat, M.S. 2000. Agriculture as affected by population and industrialization. *Yojana*, June 2000, pp 26-28.

Sky-farm, 1999. Opportunities for precision farming in Europe. Updated report 1999, 126 p.

Talor, J.C., Thomas, G. and Wood, G.A. 1997. Diagnosing sources of within field variation with remote sensing. In : *Precision Agriculture*'97, vol. II. Technology, IT and Management (Ed. J.V. Stafford). Bios Scientific Publishers Ltd. Lxford, UK pp 705-712.

****