Sustainability and Precision Agriculture

Prof. Shishira Kanta Behera[1], Prof. Bijoy Kumar Sahu[2]
[1,2]Department of Agriculture, Siksha 'O' Anusandhan (Deemed to be University),
Bhubaneswar, Odisha
Email - [2]bijoykumarsahu@soa.ac.in

Abstract

Precision agriculture (PA) can aid in the environmentally friendly control of crop production inputs. PA can assess fertilizer, seed and chemicals levels for soil and other conditions by means of site-specific knowledge. PA combines tangible sources with information and knowledge. A review of the literature shows that PA will lead to the long-term sustainability of production farming in many respects, and reinforces the intuitive notion that PA can minimize environmental pressure by using fertilizers and pesticides only where necessary. Environmentally friendly agriculture has a more concentrated use of inputs, reduced losses caused by excesses and reduced losses due to fertilizer imbalances, yoked exhaustion, insect damage, etc. Other advantages are reducing the development of pesticide resistance. One drawback of the articles analyzed is that few specifically measured environmental indices, such as soil sensor leaching. Mainly the environmental benefits were indirectly estimated by measuring lower chemical load. Results of an on-farm experiment in Argentina provide an example of how site details and the use of variable rates could be used to sustain productivity while reducing N applications. Results of sensitivity analyses show that for a wide range of restrictions on N applications PA is a modestly more profitable alternative to field administration. Such limitations could include government regulations to recognize the landowner's environmental management. For example, the variable rate of N retains the agricultural productivity even when nitrogen is limited to less than half the standard amount prescribed.

Key words: Environment, GPS, Precision agriculture (PA), Sustainability, VRT

Introduction

Precision agriculture (PA) and sustainable development concepts are inextricably linked. The opportunity for environmental benefits has been debated since the first time a global positioning system has been used on agricultural equipment[1], [2]. The use of fertilizer and pesticides would intuitively minimize the environmental burden only where and when they are needed. This paper will examine the realities of PA and sustainability, PA assist sustainability and measure environmental advantages. The paper starts with concepts of precision agriculture and sustainable agriculture[3], [4]. In the next segment the PA environmental impacts study will be discussed. The last section provides an example of how site-specific information and the introduction of variable rates could be used to maintain profits and that application of N.

1. Sustainable Agriculture*:*

The importance of' sustainability' has been discussed for a long time. The concept was used in the first instance to refer to agricultural and manufacturing innovations that minimized or prevented sometimes related economic destruction of the environment[5], [6]. Economically, researchers described it as the ability to maintain constant demand or productivity by substitution of natural resources and manmade production property. The" manmade capital" in this sense encompasses anything that is created through human effort, whether physical capital (e.g. machinery, structures) or intellectual capital (e.g. intelligence, information). The researcher described this economically by suggesting that in the cycle of development natural resources and produced human capital have to balance each other and that natural resources are the limiting factor in growth[7], [8]. In the United Nations, sustainable development is described more broadly as "to meet the needs of the present without undermining future generation’s ability to satisfy their own needs.” More specifically, environmental, the holistic analysis of the economic and sociological implications of any growth has included sustainability[9], [10]. Achieving the notion of agriculture, the American Society of Agriculture describes "Sustainable agriculture to increase environmental quality and the base of capital on which farming relies, to meet basic human and fibrous food needs, to be economically viable and to improve the quality of life of farmers and society as a whole."

2. Precision Agriculture:

The American Society of Agronomy defines sustainable agriculture as "a concept that improves the environmental quality and resource base on which agriculture depends, provides basic needs for human food, fiber, economically viable, and improves farmers and society as a whole in terms of the quality of their lives." PA includes all those farming practices using information technology, to either adapt inputs to achieve and monitor desired outcomes (e.g., application of variable rates; output monitoring; remote sensing). SSM is defined by the researcher as the Electronic monitoring and inspection used to collect process and decide the temporal and spatial allocation of crop production input. They emphasize that agricultural crops are the priority but claims are relevant to horticultural and electronic cattle marking. Input control based on information on life cycles of crops, livestock or pesticides is important for temporary SSMs. Such temporal information is often referred to as information about the developmental stage. Integral pesticide management, for example, involves several DS practices, such as the use of pesticide surveys to determine the need and timing of pesticide control. For livestock management DS monitoring is also used: bar-coding and other sensors are used as a way of tracking growth, food consumption and health of individual dairy cow milk.

3. Ethical Debate:

Agriculture cannot be viable if farmers adopt socially unacceptable or unprofitable activities. There are also good practical reasons that address climate degradation, global change, water pollution, excessive erosion and increased resistance of biocidal pests. For many, the aim of sustainability is to take these utilitarian interests on board. Nevertheless, they are the main driving force behind the research done by the ARS national program on water quality and management which aims at PA performance. There are however philosophical and religious questions that deserve attention, apart from the practical and physical aspects. One of them is stewardship. Land management is sometimes seen as a liability to future generations. It is often viewed as an obligation in a religious context to protect and improve the existence of God. In any event, land and nature in general are regarded as something for which people have a temporary responsibility. This goes against the view that natural resources are used as assets for the personal profit of the existing owner of the property. The farm is seen by a similar line of thinking as a living organism, an organism, and charges farmers to lead the organism in growing crops and animals in accordance with the climate. In some examples, this perspective focuses on agriculture as an organization that is self-contained and minimally dependent on procured supplies and commodity markets. The farmer's goal in this regard is to boost the biological equilibrium in which the fertility of the soil makes the cultivation possible.

4. Challenges:

The researchers say that there are many elements in the environment, but there are three variations that can be summarized within a given area: (1) natural such as topography and soil; (2) spontaneous, such as rainfall; (3) managed fertilizer or seed application. The relationship between these three variance factors results in offsite impacts. Natural variation comprises (a) variation in the soil, (b) biological variation (c) variation in the soil process. Soil varies in nature by topography and by a number of competing elements in water loss capacities, organic matter and other physical and chemical properties. The task is to calculate the variability of the surface. The diversity in biodiversity in the region, including plant species microbial, insect populations, disease incidences, crop growth and yield, is just as important as soil patterns, enabling farmers to consider all the biological variations. Region variation is as great as that of the soil. Variations in the soil process are best understood by the dynamics of nitrogen. The answer by varying levels of response in soil types and topography is a challenge. Although the nature of the relationships between the physical and the biological response creates a situation in which the reaction to different practices is difficult to quantify, analyze of spatial regression of soil characteristics from data on the yield monitor have promising results. The researchers showed the issue of spatial scaling and the importance of taking spatial field heterogeneity into account. As the relationships of yield reaction, soil testing and the fertilizer applied are non-linear, their results suggest that there cannot be a standard soil test configuration in fields with varying spatial variation. Another challenge consists of demonstrating that PA has a positive environmental impact. However, very few studies directly address this aim, and most of them come to this conclusion as a by-product of other research. Such experiments can be classified as (1) the management of nutrients, (2) the management of pests and (3) the condition of soil and water.

5. Pest Management:

Weed control is the main source of pesticides used in agriculture. Pesticide agriculture's environmental problems are primarily related to soil and surface water quality. Researchers indicated that, as a result of organic matter, soil texture, landscape position and the interaction between these factors with plant management and cultivar crops, weeds are spatially variable across fields. PA offers a range of solutions for minimizing the potential environmental problems resulting from the management of pests. This spatial and temporal field tools map weed spread, VRT to use herbicides in weed-infestation zones, and return maps for weeds analysis on crop yields. Insects and viruses may be regarded with the same standards as weeds. The private benefits of lower herbicide production and social benefits of decreased herbicide use have to be offset by the models of pesticide control with the costs of introducing VRT, before PA can become one of the chosen pesticide management strategies.

5.1. Herbicides:

A four-year experiment was conducted in five fields of sugar beet, wheat, barley and maize in the Bonn region. Weeds have been sampled in grids and maps have then been created using UNPROG software. Three strategies were followed by the application of herbicides: field spray, band spray and site-specific treatment. They found that herbicidal savings differed by crop and year, but overall savings in herbicides averaged 54 per cent (or € 33 ha-1 in a monetary value). The environmental damages incurred by less herbicide-contaminated surface water and water was also reduced. The authors also recorded that a similar site-specific weed control study permitted herbicides to be saved 47-80% in cereals and 42% in maize for two years in the soil-rotation in the Blue Earth County, MN, with a soil impact on fate and transport of herbicides and weed density through the soil-landscape. Herbicide lipid was measured using car samplers and surface velocity sensors, which measured rush and sediment content in various watersheds. They found that there were spatial variations in soil properties, such as organic matter, pH, texture and adsorption factor of herbicides and weed density. The herbicide imazethapyr adsorption coefficient (Kd) was strongly correlated with the soil pH, while the herbicide alachlor's Kd was strongly correlated with organic matter (OM). The spread of broad leaf weeds was related to the characteristics of the soil-landscape. Results indicated a reduction in the use of herbicide based on site-specific application based on soil and weed density.

The spatial weed variation in the soya field in Southern Dakota and used it to generate pre-plus post-emergence, pre-emergence and post-emergence herbicide strategies at three field sites as input data for a bio-economic weed control model. In contrast with each site of a manufacturer's blanket herbicide, weed control performance, crop production and productivity is calculated. Therapies included untreated monitoring, the normal use of herbicides by farmers and three computer-generated pre-emergency, post-emergency and post-emergency guidelines. Each replicate was determined by soil sampling. The herbicide efficacy was measured and the ANOVA results analyzed. They observed that $82 ha-1 was cheaper than the manufacturer's product and the guidelines from the bioeconomic model resulted in similar or better weed control, soybean yields and net returns. The researchers have concluded that there was optimum economic benefits and protection for the consumer and community in terms of application and location of herbicides at the site. The study showed the ability for weed control at the site for better environmental outcomes using a conceptual framework, because of reductions in overall use of herbicides. They showed that herbicide resistance was avoided by spot therapies. They also cited multiple reports that reduced the use of herbicides.

5.2. Insecticides:

Researchers tested the impact on the development of insecticide resistance and natural enemy density in trade potato fields in Pensylvania of site-specific, integrated pathogen management (IPM). During the 1994 growing season, they performed field and laboratory tests in six 1.2 ha potato fields, three normal IPM fields and three site specific IPM fields. The scouting protocols and thresholds were specified in the IPM framework of Potato ES for the fields in standard IPM. In the 0.04 ha management block were sampled and sprayed individually for each site-specified IPM field. The findings of the statistical analysis demonstrate a significant rise in insecticide resistance from Colorado beetle to pre-season in all normal IPM areas. In comparison, in an unsprayed control and in two of the three location-specific IPM regions, there was little to no resistance improvement. In site-specific IPM fields the densities of parasitoids and pests were higher than in normal IPM fields and showed that site-specific IPMs could slow down the development of insecticide tolerance and maintain natural enemies.

6. Soil and Water Quality:

Soil and water quality are two important components of a sustainable farming method. Soil and water quality characteristics are inextricably linked. A good soil does not guarantee good water quality. However, poor soil is probably the cause of poor water quality. The researcher described the quality of the soil as' soil's capability to work productively and continuously while sustaining or enhancing the basis of the land, the environment and plants, animals and human health.' A soil's ability to act on and communicate with the atmosphere within ecological boundaries is outside of this system and forms the basis for assessing the possible environmental effects of soil management systems. PA has significant capacity to protect the environment, not just with respect to soil nutrients and chemicals but with a view to managing soil erosion and soil compaction. Soil compaction and water drainage impediments tend to be more prevalent than previously thought. The identification and analysis of these uncertainty factors indicates many new applications of PA and the need to develop new approaches for soil quality monitoring so that scientific remedial measures can be introduced.

6.1. Soil Density:

Scientists used spatial econometrics techniques in a five year soil density experiment in central Illinois undertaken by the Farm Journal Agricultural Magazine to perform spatial regression analysis on the impact of wheels and tracks on soil compaction, among other procedures, at a rotation of sodium corn. The spatial regression analysis used data for spatial autocorrelation and heteroscedasticity to track concentrations, soil-type polygons and other soil detail. The overall average advantage of maize tracks is 796.42 kg ha 1 year 1. The average total production of soybean was not impacted considerably by the procedure. In contrast with traditional tillage activity across the maize-soybean cycle, the gains analysis showed that track utilization benefits ranged from $2.47 to $69.16 ha1. The strongest response was to heavy, salty clay loam soils, while the lightly silt upland fields showed the smallest.

6.2. Soil Erosion:

In Bavaria, Germany, researchers demonstrated a reduction in environmental impacts and increased profits from using PA, using a MODAM model and experimental farming information. The model simulated land use on farms, measured economic returns and optimized farming using a linear programming method. An 11-year research introduced into farming the various aspects of productivity allows multi-target optimization and the measurement of reward. Results of the simulation model have shown that efficient and productive PA strategies for mitigation of soil erosion such as decreased tillage, methods for direct sieving, catch crops, etc.

Conclusions

PA may help manage these supplies in an environmentally sound manner if the inevitability of some future agricultural supply is understood. PA will monitor fertilizer, seed and chemical levels for soil and other conditions using site specific information. For instance, spatial management of N can decrease overall N application and reduce N over sensitive areas while maintaining profits. Another example is the spatial handling of insecticides and herbicides by adding them only when the problem exists may reduce overall uses of these chemicals. PA can be part of a economically viable program that is environmentally friendly. In case the need for external inputs is acknowledged, knowledge is also necessary to properly distribute external inputs spatially. Most of the papers examined shows that PA can in many ways contribute to the sustainable development of agriculture and reinforces the intuitive notion that PA can minimize environmental loads by using fertilizers and pesticides only if appropriate. PA environmental benefits are created by more precise use of inputs which reduce losses from excesses and reduced losses from nutrient imbalances (e. g. K deficiency which reduces N efficiency), weed escape, insect destruction, etc. Additional benefits include reducing the production of pesticide resistance. One drawback of the records being analyzed is that only a handful assessed atmosphere indexes explicitly, such as leaching using soil sensors. Most of them measured the environmental benefits indirectly by calculating the decreased chemical load. The area of environmental impacts of precision agricultural technology is one of the main research needs.

References

1. B. Sekhon, “Nanotechnology in agri-food production: an overview,” *Nanotechnol. Sci. Appl.*, vol. 4, no. 7, pp. 31–53, 2014.
2. B. Singh Sekhon, “Nanotechnology, Science and Applications Nanotechnology in agri-food production: an overview,” *Sci. Appl.*, vol. 7, pp. 31–53, 2014.
3. P. Singh and S. Ikram, “Nanotechnology in Food Packaging: An Overview,” *J. Adv. Mater.*, vol. 1, pp. 19–22, 2017.
4. A. Kumari and S. K. Yadav, “Nanotechnology in Agri-Food Sector,” *Crit. Rev. Food Sci. Nutr.*, vol. 54, no. 8, pp. 975–984, 2014.
5. C. Schader, J. Grenz, M. S. Meier, and M. Stolze, “Scope and precision of sustainability assessment approaches to food systems,” *Ecol. Soc.*, 2014.
6. A. Balafoutis *et al.*, “Precision agriculture technologies positively contributing to ghg emissions mitigation, farm productivity and economics,” *Sustainability (Switzerland)*. 2017.
7. K. Garbach, J. C. Milder, F. A. J. DeClerck, M. Montenegro de Wit, L. Driscoll, and B. Gemmill-Herren, “Examining multi-functionality for crop yield and ecosystem services in five systems of agroecological intensification,” *Int. J. Agric. Sustain.*, 2017.
8. O. Adeyemi, I. Grove, S. Peets, and T. Norton, “Advanced monitoring and management systems for improving sustainability in precision irrigation,” *Sustainability (Switzerland)*. 2017.
9. C. Cambra, S. Sendra, J. Lloret, and R. Lacuesta, “Smart system for bicarbonate control in irrigation for hydroponic precision farming,” *Sensors (Switzerland)*, 2018.
10. L. Zhang, I. K. Dabipi, and W. L. Brown, “Internet of Things Applications for Agriculture,” in *Internet of Things A to Z*, 2018.