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# Important Tips in Precision Farming management (A; review)

**[1]A.R. Jamshidi, [2]T. Maghsoudi and [3]M. Aghapour Sabaghi**

[1]*Department of Agricultural Mechanization, Collage of Agriculture, Shoushtar Branch, Islamic Azad University, Shoushtar, Iran.*
[2-3]*Department of Agricultural Management, Collage of Agriculture, Shoushtar Branch, Islamic Azad University, Shoushtar, Iran.*

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ABSTRACT

Precision Farming has evolved over a number of years and in the same way various definitions have been used. This definition was developed by me in 1996 and still serves its purpose today. Precision Farming is the management of arable variability to improve economic returns and reduce environmental impact. This emphasizes the role of management not technology and identifies the impact on economics and the environment in a single framework. Precision Farming is a type of management or perhaps even a way of thinking. This idea is supported by the fact that Precision Farming is being implemented in cropping systems that cannot support expensive technologies. To be able to best utilize available resources, coherent management is needed at three levels: the strategic, the practice level and the operational. This paper identified a number of possible options at the strategic level such as best management practices (supported by the ASAE Guidelines), integrated crop management and integrated pest management, minimal crop risk, minimal financial risk and environmental protection. Five fertilizer and spray practices were identified, as well as four cultivation and seeding practices. How these practices are put into operation in the field remains with the farmer according to individual field conditions..



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## INTRODUCTION

Many farmers who have looked into Precision Farming have found themselves suddenly aware of the different conditions on their farms that previously they had ignored. Given that PF has the ability to measure and quantify these different forms of variability, some farmers consider they now have a better understanding of their fields and farms. I have heard this event being described as a ‘teachable moment’. No doubt that the sudden increase in available data has made Precision Farming very information intensive. There is an added burden, in the time taken to process the data into information. To many, this has overwhelmed them and they find this too time consuming and complex to handle. Improved methods need to be developed to provide timely information of known accuracy to support better decision-making. As PF was technology led, expensive equipment was used to trial ideas that could not be supported in a commercial environment. Similarly, it was found that the cost of sampling often outweighed the benefit from the data acquired. Economic results from PF have been mixed but if PF is seen a management choice and the economics taken into account, it can be a very useful technique. Most farmers over apply agricultural inputs (seed, fertilizer, spray, tillage) to reduce the risk that this factor will limit crop development [3]. One of the presumptions in PF is to increase the efficiency of the agronomic process by reducing the inputs whilst retaining the yield. As this is likely to increase the risk of failure, a clear risk assessment must be made and risk should be managed just like any other factor. Each farmer should clearly identify his or her attitude towards risk. As agriculture is a modification of the natural environment, what happens in agriculture will have an impact on the natural surroundings. With the rise of environmental awareness and efforts to reduce environmental impact, PF offers new opportunities for the environmentally aware manager. These opportunities can only be realized if environmental considerations are taken into account as part of the management process [2].

The principles of Precision Farming can be applied to every crop in every country.

What may differ will be the way in that it is put into practice. It is in the implementation that most costs occur. The way PF is put into practice will differ according to; crop requirement, economic environment and technological support. Each crop and each country is different.

**Corresponding Author:** A.R. Jamshidi, Department of Agricultural Mechanization, Collage of Agriculture, Shoushtar Branch, Islamic Azad University, Shoushtar, Iran

1. Precision Farming is a management process, not a technology.
2. Measure the spatial and temporal variability
3. Assess the significance of the variability in both economic and environmental terms
4. State the required outcome for the crop and the farm.
5. Consider the special requirements of the crop and the country
6. Establish ways to manage the variability to achieve the stated outcome
7. Consider methods to reduce or redistribute the inputs and assess the risk of failure
8. Treat crops and soil selectively according to their needs

Individual yield maps can accurately quantify the actual spatial variability of a crop when produced using the recommended methods. They are inherently historic as they are produced after harvest but help us understand significantly more about the crop yield. They can also be used to identify areas for targeted (usually expensive) sampling, especially in low yielding areas and can help quantify the damage caused by known factors such as animal's vermin or pH problems. When a series of yield data are brought together spatial and temporal trends can be deduced.PF data can be organized simply using existing file naming and sub directory structures to allow many data sets to be stored in a logical manner for easy retrieval. The sub directory naming convention is based on the farm name, field name, year and type. The file names are based on an abbreviated field name, type, and year as well as the normal file extension. Errors in yield data should be removed before mapping rather than attempting to reduce their impact by smoothing. Six main errors were identified; unknown crop width entering the header during harvest, varying time lag of grain through the threshing mechanism, the inherent 'wandering' error from the GPS, surging grain through the combine transport system, grain losses from the combine, sensor accuracy and calibration. The patented crop width sensing system will help with assessing the crop width and know the start of harvest [3].

Potential mapping was a technique that overcame the combine's inability to correctly measure the crop width entering the header and can help to compensate for the fill-mode and emptying errors.

The drawbacks to this method are that the data needs to be recorded in tons since last reading and that no data should be removed from the data set.

To be able to correctly post process yield data into an accurate yield map, an indication of the start of harvest is needed to be able to account for the fill-mode error and help improve the dynamic lag model

To be able to correctly post process yield data into an accurate yield map, data from the combine should be recorded all the time the combine is moving, to allow compensation of the varying time lag in the grain transport mechanism [2].

To be able to correctly post process yield data into an accurate yield map, the width of the Standing crop entering the header should be measured. (Alternatively use potential mapping)

*Dynamic lag correction:*

To be able to correctly post process yield data into an accurate yield map, the changing time lag within the combine's transport mechanism should be measured and used to correct the position and yield data. Three modes were identified; fill-mode error, steady state (still affected by speed) and emptying mode error [4].

*Expert filter and automated mapping:*

The use of an appropriately written expert filter improved the overall quality of the yield data in a very repeatable way by identifying known errors and removing them. The automated mapping procedure significantly reduced the time to prepare a good quality yield map for presentation. These standard methods of processing the data allowed comparisons and trends to be evaluated with more repeatability than could be achieved otherwise.

*Spatial trend maps:*

Spatial trends in yield data can be quantified by calculating the average of the yield at each Point in a field over time and presented as a map.

*Inter year offset:*

Climatic, pest and disease conditions change from year to year that affects the overall yield of a crop. This temporal effect, now called the inter-year offset, can be quantified by comparing the difference between the arithmetic means of a field between years.

*Temporal variance maps:*

A temporal variance map show how different parts of the field react over time relative to the field mean. It is calculated by taking the square of a modified standard deviation, now called the standard temporal deviation [5].

*Classified management maps or spatial and temporal trend maps:*

A method has been devised to combine the spatial trend and the temporal variance maps into one map that can be used for management purposes. The classified management map used a continuous surface interpolated from the four classes but this proved to be unrealistic as the classes were not continuous. An improved method was used in the spatial and temporal trend map that allowed the classes to independent within each grid. Where adjacent areas had the same class, the areas grew into possibly homogenous management zones. The final map showed four classes. 1) Those areas which were yielding higher than average and gave a similar yield each year, 2), Those high yielding areas that varied from year to year, 3) Low yielding and stable areas, and 4) low yielding areas that were unstable [6].

*Multiple crop trends:*

Although methods were proposed to identify trends in multiple crops, it was seen to be unjustifiable on agronomic grounds, so this method was discontinued.

*Result:*

The spatial trend maps flattened out over time, which was surprising as individual yield maps often showed a large range in yield but as these patterns were not so consistent from year to year, they cancelled out over time. The implications of this seem to be far reaching. Firstly, if there is no consistency from year to year then we cannot use historical trends to predict what will happen the following year. Secondly, we cannot then use yield maps to help us formulate nitrogen fertilizer application maps. We can use yield maps to indicate the actual off take when we want to use a replenishment fertilizer strategy for phosphate and potash, which are relatively stable in the soil. Thirdly, if we cannot base the nitrogen application on previous trends and we have significant spatial variability within one year, we must use available crop, soil and climate data to guide the application, which leads us towards real-time canopy management [8].

*Inter-year variability can have the greatest impact on overall yield:*

When the temporal affects were split up into the inter-year offset and the temporal variance map, it was noted that the inter-year offset was much larger in terms of the overall yield, than the temporal variance. This gross effect was probably due to changing yearly climatic conditions, such as frost during germination, or drought at a critical growth stage. Pests and diseases were not considered to have an impact on the final yields in these trials

In the early days of PF it was considered reasonable that through selective use of fertilizer the total yield would increase. This has proven not to be the case. Moreover it has been found difficult to maintain the yields whilst reducing the inputs. One factor that has been repeated many times is the anecdotal evidence that quality factors can be managed better through PF techniques rather than quantity. This has been difficult to assess with the existing data available here, as this factor was not built in to the study [6,8].

*Conclusions:*

Here are four main conclusions that relate to the five objectives of the thesis: (Objective numbers from the Introduction are shown in brackets)

1. In Precision Farming management, strategies and practices were identified to provide the contextual framework to utilize yield maps as information, especially when taking into account attitudes to economic factors, risk and environmental impact.

• Precision Farming is the management of arable variability to improve economic returns and reduce environmental impact.

• 6 personal strategies, 5 fertilizer and spray practices, and 4 cultivation and seeding practices have been identified.

• Replenishment practice: Yield maps can be used to determine the nutrient off take of P and K through the crop biomass, which can then be replenished.

• Apparently, research has made current PF too complex and time consuming for most farmers to deal with by themselves.

• Precision farming research has been limited by the lack of an objective analytical paradigm that can deal with such complex systems as the growing crop and its environment. (Here is a real opportunity for future research)

• Careful economic analysis must be carried out when considering investments [1].

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