Precision Agriculture in Mexico; Current Status and Perspectives

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Abstract Precision agriculture is not for big agriculture properties only, studies have demonstrated that by using precision agricultural techniques, the increase in yields remain proportionate between large and small plots of land. Additionally, with a significant decrease of the price of technology, precision agriculture is little by little becoming affordable even to smallholder farmers. In Mexico it is urgent to apply precision agriculture techniques due to the fact the pressure for food production, and the poverty desperate situation of small farmers, although there is the pretext that the machinery and equipment used in this technology is too expensive. Information Communication Technologies (ICTs) play a key role in precision agriculture: for instance, by integrating GPS (Global Positioning System) and wireless technology into production processes, farmers are able of knowing the exact amount of fertilizer, water, etc., needed for each portion of land, so to maximize the yield per acre, thereby exists the possibility of using smart phones in the country because there is a growth of 52.6 million smartphones in 2014. Likewise, is feasible to use Unmanned Aircraft Systems (Anonymous, 2014). Since the country already exists company that manufactures the equipment so that eventually increases the usability of these increasingly larger amount. In this paper highlights that in the country there is no interest in precision agriculture, but it is possible to reverse this situation if the lines of research are promoted on the issue by the schools of mechatronics to undergraduate, master's and doctoral degrees, as they are more than 100, in support of the four schools that have precision agriculture formal courses.

Keywords Agriculture; Mexico; Mechatronics; Smart phones; Unmanned aircraft systems

1 Introduction

The surface of agriculture in Mexico is 31.2 million hectares, where 29.9 are agricultural, 1.3 are natural, pasture grasses and planted some time in 5 years. There are 5.5 million units of production and the agricultural area in 2007 was 30.2 million hectares of which 13.9 are annual crops, perennial crops 8.8, where 7.5 million hectares were not sown. Mexico has 119,715,000 inhabitants and ranks No. 11 after China, India, United States, Indonesia, Brazil, Pakistan, Bangladesh, Russia, Nigeria and Japan. From 2005 to 2010 the population increased by 9 million representing a growth of 1% per year so that by 2015 we can consider that the population around 125 million, representing an increase in food needs. It is a challenge, according to sector experts, can be met only from the practice of sustainable agriculture capable of producing more with less water and energy, and innovation and technology as tools. The urban population increases; the rural population decreases; this situation means that to increase food production to reach the limit of the agricultural frontier is the only way to increase productivity and deal with the use of agricultural machines. In Mexico exist 3.8 million agricultural parcels, 60% measures 2.1 hectares on average, totaling 4,788,000 hectares (one quarter of the total cultivated area) and 2,280,000 small-scale owners.

The present demand in the consumption of food is without doubt one of the factors that originate the planning of new politics for the modernization in the country. The requests nowadays in the production of the modern agriculture are oriented toward the systems that reduce the use of supplies and maximize performances and utilities. A system that offers these results is the agriculture of precision (Reynolds, 2006).
2 Background Knowledge

2.1 Precision agriculture concepts

There are 5 different types of agricultural mechanization; Hand tools, animal traction, simple mechanization, mechanization motor, sophisticated technology (precision agriculture, agricultural robots, and agricultural expert systems (Negrete, 2006) then being precision agriculture is the last stage of agricultural mechanization, which should tend all agricultural systems.

So that precision farming is the application of technologies and management principles of the spatial and temporal variability associated with all aspects of agricultural production in order to improve crop productivity and environmental quality (Mantovani and Magdalena, 2014).

Currently, the main tools that enable the application of precision agriculture are the systems of global navigation satellite systems (GNSS) and geographic information systems (GIS). GNSS (popularly known as GPS) receivers are providing satellite signals the user data on its geographical position and altitude, as well as allowing better plan the route to follow to carry out demonstrations and then estimate the extent of distances covered. When the receiver is connected to the agricultural machinery used to harvest or in a user-defined, you can register data on the geographical location of sampled data, facilitating the georeferencing and the subsequent mapping of the information gathered in the country.

GIS softwares are composed of several modules dedicated to the storage and processing of data with known geographic location (geoprocessing) that allows pattern analysis, integration and spatial modeling, monitoring, simulation and presentation details lot of information in map form, graphs, figures and multimedia systems (Landau et al., 2014).

The availability of precise global positioning systems and relatively inexpensive, combined with performance monitors, provide the opportunity to register and instantly map the crop yields at harvest. A yield map is a spatial representation of performance data recorded during the harvest of a crop. Spatial representation is commonly done using a vector format and point coordinates (x, y, z) associated with a projection system (latitude and longitude) geographically reference points. Yield maps are derived from data collected by a combine that includes a global positioning system (GPS), together with a system of sensors to calculate the amount of grain harvested per unit area. The information obtained by the sensors and GPS, is stored in a centralized console that interfaces with the user (Melchiori et al., 2014). There are performance monitors grain crops, cotton, sugarcane and mani.Uno of the main requirements in precision agriculture is to map the spatial and temporal variability in production units. This mapping is essential for localized treatment of crops and can be done basi-cally in two ways: in situ and remotely (Melchiori et al., 2014).

The goal of precision farming is to manage small areas within the field of production to reduce the use of inputs (fertilizers, seeds, insecticides, etc.) and increase productivity to improve this renbalabilidad for farmers and to improve conditions environmental (Quiroz et al., 2000).

Productivity maps reveal whether or not there is variability in the plot in question of soil and crops for making decisions regarding the application of inputs, amount to provide increased productivity. This process uses computers, which perform variable rate application. So there is another option for that same application is the use of sensors in real time, each method has its disadvantages and advantages (Quiroz et al., 2000).

2.2 Implementation of precision agriculture in developing countries

To assess effective factors on Precision Agriculture adoption in Iran and so, to find out solutions for its faster development, a descriptive survey research was carried out. The results of this research indicated that the solutions for Precision Agriculture development are categorized in four fields, namely, economical, technical, managerial and human resources. Based on the results, proposed solutions for development of Precision Agriculture in Iran were: decreasing cost of Precision Agriculture equipment and accessories (economical field), improvement of knowledge about PA and its technologies (Technical field), completion of necessary infrastructures for
development of information technology and Precision Agriculture and attention to PA development in strategic plans (Managerial field), improving general and technical knowledge of agricultural beneficiaries and experts (human resources)(Bagheri and Bordbar, 2014).

2.3 Precision agriculture on small farms
Precision agriculture is not for big agriculture companies only: studies have demonstrated that by using precision agricultural techniques, the increase in yields remain proportionate between large and small plots of land. Moreover, with a significant decrease of the price of technology, precision agriculture is little by little becoming affordable even to smallholder farmers, who are the ones providing "over 80 per cent of the food consumed in large parts of the developing world, particularly Southern Asia and sub-Saharan Africa". Information Communication Technologies (ICTs)play a key role in precision agriculture: for instance, by integrating GPS (Global Positioning System) and wireless technology into production processes, farmers are able of knowing the exact the amount of fertilizer, water, etc., needed for each portion of land, so to maximize the yield per acre (Rodriguez, 2014).

Knob 2006 performed a work dedicated to the implementation of technical precision farming on a small property where I was concerned to manage an area of 10.9 hectares and found generally that the tools of precision agriculture can help producers make better and more detail each parcel of property destinada agricultural activities allowing increased production efficiency through management and rational use of inputs, reducing costs and increasing productivity.

Precision agriculture as it becomes a work methodology allows small producers to become less dependent on external inputs exploitation, improving the sustainability of small producers (Landau et al., 2014).

There are many obstacles to adoption of precision farming in developing countries in general and India in particular. Some are common to those in other regions but the others are specific to Indian conditions are as follows;Culture and perceptions of the users, Small farm size, Lack of success stories, Heterogeneity of cropping systems and market imperfections, Land ownership, infrastructure and institutional constraints, Lack of local technical expertise, Knowledge and technical gaps, Data availability, quality and costs(Shanwad et al., 2004).

3 Results
3.1 Precision agriculture in Mexico
Globally as an indicator there are about 20 countries that have incorporated intelligent systems and automatizacos in the application of agricultural inputs including the United States stand with 30,000 Argentina 1200, Brazil with 250, UK 400, Paraguay 4 and Mexico with zero (López , 2012).

3.1.1 Research
In the Antonio Narro Agrarian Autonomous University has given impetus to research in precision agriculture in the department of agricultural machinery and developed the following equipment; The whole transducer developed with two octagonal sensors extended ring with adjustable mounting at the bottom bar and a third sensor on top of the same bar. With a height differential between sensors allowing through a addition and subtraction analysis of deformations product of the magnitude and position of the ground reaction forces to tillage to measure the pulling force, the timing and weight transfer to the rear axle of the tractor.

The cart carries sensors developed double bars depth control system, to be coupled to different sensors to measure some physical properties agricultural soils, such as: resistance to penetration and soil failure, permissiveness and tillage power requirements.

The evaluation system of metering precision seed allows monitoring the quality and efficiency of metering mechanisms for service industry agricultural machinery as well as facilitate the teaching and research systems varying doses of seeds, planting prescriptions changes (Campos et al., 2014).
Tecnologico de Monterrey and Motorola have launched a joint project of precision agriculture in which first, you think quantify the spatial and temporal variability of various environmental factors affecting the productivity of alfalfa on irrigated systems by monitoring these factors through the systems of sensors in the ground and the atmosphere, providing the technology available from Motorola. In addition, it is intended to evaluate and develop new instrumentation and software to measure and analyze changes in the production of alfalfa, in response to the phenological variability of the plant throughout its cycle, which is being evaluated for three years, starting in the fall 2003. On the other hand, it seeks to determine the economic feasibility of the establishment of the components used in precision agriculture, in order to make the technology available to more producers. Finally, it attempts to develop an effective network for the transfer of technology among producers lecerne, which serve to disseminate among other producers of fodder, and from there spread it to different cultures within society (Gutiérrez and García, 2003).

As of 2010, the company Quetzal Aerospace, based in the Mexican state of Queretaro, began manufacturing drones (drone). A little more than four years after its opening, the company has stated its intention to use these airborne platforms to optimize the techniques of farmers, in order to promote the "precision agriculture" with the support of specialists from the Center for Scientific Research and Higher of Ensenada Education (CICESE) was detected that aerial unmanned platforms Quetzal Aerospace could be implemented to technological tasks applied to agriculture, the company Quetzal Aerospace consolidation airlines unmanned platforms as a service arises. That way, farmers can access these technologies without the need to purchase a drone or specific knowledge to operate, at an affordable cost (Anonymous, 2014).

So there are the same two manufacturers of drones, one of those companies that has begun to appear on the market is Unmanned Systems Technology International (USTI), thanks to his initiative may become the most representative organization in this area. Located in the municipality of Apodaca, Nuevo Leon, the company is originally from Nuevo Leon and started his sleep in late 2009. The other is is Dronetech SAPI de CV, a company located in the city of Monterrey, Nuevo Leon and dedicated to production no manned aircraft developed by Mexican human capital (Lara et al., 2015).

Precision agriculture is a new concept; with advanced tools such as tractors equipped with differential GPS, with a margin error rates between 50 centimeters and one meter; normal browsers are accurate to within three meters, while geodetic fail only a few millimeters or centimeters. As tractors roam the land, the terrain detected through some additions that make soil analysis, a kind of mobile laboratory; located missing and which nutrients in the required quantity dispensed. However, the price is extremely high, considered Ochoa Ibarra; the cost of the tractor as well as GPS, computer, software and tools necessary to make measurements over a million Mexican pesos. In Mexico, two tractors working only with those characteristics, one in Chihuahua and one in Sonora (Dávila, 2010).

The Graduate College developed for SAGARPA, through its deconcentrated Service Agrifood and Fisheries Information (SIAP), the study "Development of a comprehensive model of GIS and soil information as the basis for precision agriculture in sugarcane sugar. Stage I ". At this early stage the foundations of precision agriculture the sugarcane field, benefiting more than 130,000 sugarcane growers spread across 15 federal institutions are established. All this in coordination with other projects and institutions that participate in the Information System of the Sugar Industry (SIAZUCAR) (Anonymous, 2010).

(Saldanya et al., 2006) develop a yield mapping system for vegetables. A harvest assistance equipment was modified and instrumented to obtain yield maps. Instrumentation consisted in the implementation of a mass accumulation rate measurement system, which was used to determine weight of harvested broccoli (Brassica et al.), a sensor of distance travelled to determine harvested area and a Global Positioning System (GPS) to determine position of harvested area within the field. Results found in evaluation purpose tests of the yield mapping system showed an error of less than 2.69% in the weight data and 1.49% in the area data, whereas in yield mapping tests, the system worked properly without interfering with the harvesting methodology employed for field workers. Also, the comparison of yield maps obtained with the two GPSs of different precision,
confirmed that the less precise and lower cost GPS can be used to map yield. In the future, the yield mapping system can be used to assess the causes of yield variability and field workers performance.

The low profitability of grass production is largely due to the indiscriminate use of nitrogenous fertilizers, which adversely affects the environment and the farmer's economy. There are technologies such as hand sensors (eg, GreenSeeker) and spatial photographs that allow the identification of plant fertilization needs by means of the green index. There are also unmanned aerial vehicles, which capture large tracts of land in an aerial image, with the advantage of selecting the capture date and not being affected by the weather. Due to the above, (Aguilera et al., 2014) carried out a research work whose objective was to correlate the green index obtained with an aerial image and the GreenSeeker sensor. A plot of barley was established for calibration and validation, in which aerial photography was taken and measurements were made with the GreenSeeker sensor for the autumn-winter cycle 2013. An experimental design of a complete randomized block with three replicates was used. The best correlation of data showed an R2 of 0.9685 and was obtained with the GNDVI, which indicates that the analysis of the vegetation index can be obtained satisfactorily by means of aerial photography, thus saving time, material and human resources.

The indiscriminate use of nitrogen fertilizers negatively affects the environment and the economy of the farmer. There are hand sensors and space images that diagnoses needs in grasses. However, Unmanned Aerial Vehicles capture large areas in an aerial image, and allow to select the capturing date and without problem of weather. The aim of this study was to employ an UAV to obtain multispectral aerial imagery that allow to generate nitrogen dose recommendations. Two plots were established for calibration and validation, one of barley for A-W 2013 cycle and another of corn for S-S 2014 cycle. In those plots aerial images were taken (multispectral cameras IXUS and S110) and measurements were performed with the GreenSeekerTM sensor. In barley was used an experimental design of randomized complete block with three replicates. The experimental design for the case of maize was completely random. The results of the statistical analysis ( p < 0.05) and linear regression between the measurements with the GreenSeekerTM and vegetation greenness index obtained from images indicated that it is possible to generate nitrogen recommendations from aerial images (Saldaña et al., 2016).

3.1.2 Education
In the Antonio Narro Agrarian Autonomous exist the course precision farming machinery, at the University of Guanajuato and Chapingo University the course named the precision agriculture. In the National Autonomous University of Mexico exist the course Remote Sensing Applied to Agriculture.

4 Discussion
In large scale farming, sophisticated technologies often based on crop sensors, global positioning systems, or remote sensing are being developed and used to carry out precision agriculture, computer are one option for accessing decision tools provided either via Internet. But computers are not always readily accessible by small scale farmers. Web-based mobile phones with Internet access provide another option.

In Mexico it is urgent that precision agriculture techniques due to the fact the pressure for food production, and the desperate situation of small farmers to apply, although there is the pretext that the machinery and equipment used in this technology is too expensive exists the possibility of using smart phones in the country because there is a growth of 52.6 million smartphones in 2014. (Alvarez, 2015) Likewise, so it is feasible to use drones Unmanned Aircraft Systems (Anonymous, 2014). Since the country already exists company that manufactures the equipment so that eventually increases the usability of these increasingly larger amount.

Exist the International Society of Precision Agriculture (ISPA) is a non-profit professional scientific organization. The countries represented Argentina, Australia, Botswana, Brazil, Canada, Chile, China, Malaya, New Zealand, Norva, Nigeria, Pakistan, Poland, Russia, Egypto, Saudi Arabia, Finland, South Africa, France, South Korea, Germany, Spain, Ghana, Sweden, India, Turkey, Iran, Ukraine, Israel, Uruguay, Italy, United States, Kenya, United Kingdom. But in Mexico there is no interest from researchers so we are not given due importance to this
technology for precision agriculture, evidenced by the fact of having no representation in that society, and this is the main obstacle to the development of precision agriculture in the country.

Despite the many obstacles listed earlier, business opportunities for precision farming technologies and yield monitor systems are immense in many developing countries. The scope for funding new hardware, software and consulting industries related to precision agriculture is gradually widening (Shanwad et al., 2004).

Precision farming is still only a concept in many developing countries and strategic support from the public and private sectors is essential to promote its rapid adoption. Successful adoption, however, comprises at least three phases including exploration, analysis and execution. The role of agricultural input suppliers, extension advisors and consultants in the spread of these technologies is vital. For instance, public agencies should consider supplying free data such as remotely sensed imagery to the universities and research institutes involved in precision farming research. Also, professional societies of agronomy, agricultural informatics, and engineering must provide training guidance in the use of technologies. The involvement of inter/disciplinary teams is essential in this. Small farm size will not be a major constraint, if the technologies are available through consulting, custom and rental services.

As indicated, the costs and availability of high resolution satellite imagery often limit their applications in Precision Agriculture (Zhang and Kovacs, 2012). Consequently unmanned aerial vehicles could be an inexpensive and more practical substitute for satellite and general aviation aircraft for high resolution remotely sensed data. Moreover, are immediately accessible as a tool for remote sensing scientists and farmers (Zhang et al., 2012).

5 Conclusion
In Mexico there is no interest of the agricultural research agencies in Precision agriculture, except timid research attempts. The universities directly involved as Chapingo University, the University of Guanajuato and the Antonio Narro Agrarian Autonomous University Autonomous perform some research in the form of thesis highlighting the latter by the amount of effort with the largest number of thesis.

As a strategy it is possible to promote the rapid development of precision agriculture in the country if institutions with lines of research in his graduate-level expertise in Mechatronics. There is in the country more than 150 schools offering Bachelor in mechatronics, and 10 postgraduate doctoral level and 19 postgraduate Master Level (Anonymous, 2010), which may include in its research the development of systems and equipment for precision agriculture. It should encourage the creation of more manufacturing companies and design Unmanned Aerial Systems.

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