Solutions for fast development of precision agriculture in Iran

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Abstract: A descriptive survey method was carried out to assess to effective factors on precision agriculture (PA) adoption and to find out practical solutions for development of PA in Iran. The research population included 450 people from agricultural specialists, experts, researchers. A sample of 117 was constituted using proportional stratified sampling based on the Cochran formula. Data were collected using questionnaire. The questionnaire was validated by a panel of experts, and the reliability index was established by a Cronbach's coefficient. Computed Cronbach's alpha score obtained 81%. All survey data were analyzed using the Statistical Package for Social Sciences (SPSS 16.0). The most important solutions for development of PA in Iran were categorized in four fields, namely, economical, managerial, technical and human resource.

Keywords: adoption, factor analysis, precision agriculture, solution

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1 Introduction

Increasing pressure for food security and decreasing environment pollutions has focused attention on increasing the efficient use of agricultural resources (Schmoldt, 2001). Precision agriculture (PA) is a new concept for sustainable utilization of agricultural resources. The PA describes a suite of information technology (IT) based tools which allow farmers to electronically monitor soil and crop conditions and analyze treatment options (Aubert et al., 2012). The PA is defined as the management of spatial and temporal variability of fields to improve economic returns and reduce environmental damage. It allows farmers to recognize variations of time and space in the production resources and apply treatment with a much finer degree of precision than previously possible (Aubert et al., 2012) and involves crop management according to field variability and site-specific conditions (Seelan et al., 2003). Currently the available commercial technologies include Global Positioning Systems (GPS), Geographic Information Systems (GIS), yield monitors, Remote Sensing (RS), and Variable-Rate Applicators (VRA) (Robertson et al., 2012). By using site-specific knowledge, PA can target rates of fertilizer, seed and chemicals for soil and other conditions (Bongiovanni and Lowenberg-Deboer, 2004) depending on soil type, the type of culture to plant according to current soil conditions, and the quantity of pesticides to use on a specific crop (McBratney et al., 2005). There is no doubt that the extension of PA in agriculture will have considerable relevance for economical and ecological aspects, food quality and food security (Robert, 2002). Some reasons for development of PA are required to reduce costs and environmental pollution, obtain sustainable agriculture, increase yield and productivity, improve information based management and decision-making (Du et al., 2008), increase the efficiency of resource use, reduce the uncertainty of decisions required to control variation on farms (Schellberg et al. 2008), increase profitability (Chen et al, 2009; Batte and Arnholt, 2003), reduce risk (Batte and Arnholt, 2003) and increase the number of correct decisions per unit area of land with associated net benefits (McBratny et al., 2005).

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Worldwide, investments on PA adoption and development have considerably increased during the past decades. Zhang et al. (2002) reviewed an overview of worldwide development and current status of PA technologies based on literatures. They found some barriers need to be overcome before PA technologies can be widely implemented (Zhang et al., 2002). Mcbratney et al. (2005) showed that the development of proper decision-support systems for implementing precision decisions remains a major stumbling block to adoption. Other critical research issues were discussed, namely, appropriate criteria for economic assessment of PA, insufficient recognition of temporal variation, lack of whole-farm focus, crop quality assessment methods, product tracking and environmental auditing (Mcbratney et al., 2005). Jochinke et al. (2007) determined challenges and opportunities for adoption of PA in an Australian broad acre cropping system. They determined initial cost of the technology as an important factor on adoption (Jochinke et al., 2007). Reichardt et al. (2009) studied adoption, challenges and training activities of PA in Germany. Several interviews were conducted with farmers who had experienced using PA techniques. Results showed that 40%–50% of farmers did not know about PA. Results indicated that there were substantial educational deficits regarding PA. The main problem faced within the teaching of PA was lack of suitable teaching materials. Furthermore, many teachers, lecturers and advisors did not have PA training themselves (Reichardt et al., 2009). Silva et al. (2011) investigated the adoption and use of PA technologies in the sugarcane industry of Brazil. They concluded that companies that adopted and used PA practices reap benefits, such as managerial improvements, higher yields, lower costs, minimization of environmental impacts and improvements in sugarcane quality (Silva et al., 2011). Sheng Tey and Brindal (2012) investigated factors influencing the adoption of PA technologies. They found that significant factors influencing the adoption of PA technologies categorized in seven fields such as: socio-economic, agro-ecological, institutional, informational, farmer perception, behavioral and technological factors (Sheng Tey and Brindal, 2012). Aubert et al. (2012) tested a model explaining the difficulties of PA technology adoption in Canada. The model drew on theories of technology acceptance and diffusion of innovation and was validated using survey data from farms. Findings highlighted the importance of compatibility among PA technology components and the crucial role of farmers' expertise (Aubert et al., 2012). Jensen et al. (2012) assessed the economic profitability of adopting various PA technologies in Denmark. The results showed that the benefits of adopting this new technology was positive with increasing income to farmers and a reduction in fuel consumption and pesticides/herbicides use (Jensen et al., 2012).

Worldwide, investments in research and technology on PA have considerably increased during the past decades (Schellberg et al., 2008). Despite the availability of tools and applications that support sophisticated decision making and operation, the adoption of PA technology among farmers remains surprisingly low (Aubert et al., 2012). So, understanding underlying factors that influence the adoption of PA and finding out solutions for its development is vital. Accessing to these solutions help faster facilitation of PA adoption. So, the main objective of this research was to assess to effective factors on Pa adoption and to find out the most important solutions for faster development of PA in Iran.

2 Materials and methods

A combination of descriptive and analytical methods was used as a methodology of this study. The research population included agricultural specialists, researchers and experts. Our research area does not include farmers because PA in IRAN is passing through research stage and there are not many farmers who tried PA in practice. A sample of 117 was constituted out of a total population of 450 by Cochran formula. A questionnaire was developed as the main and basic method of information gathering to achieve goals. The questionnaire included fixed choice questions which the statements were collected after literature review of research and interviews by PA specialists. To find out solutions for

PA development, firstly, the effective factors on PA adoption in Iran were extracted from literature reviews. Content and face validity were established by a panel of experts. Minor wording and structuring of the instrument were made based on the recommendation of the expert panel. A pilot study was conducted with 30 specialists (not included in the sample population), to determine the reliability of the questionnaire. Computed Cronbach's alpha score obtained 81%, which indicated that the questionnaire was highly reliable.

All survey data were analyzed using the Statistical Package for Social Sciences (SPSS 16.0). According to diversity of effective factors on PA adoption, factor analysis was used to prioritize them. Then, based on PA adoption factors, solutions for PA development in Iran were proposed.

3 Results and discussion

Prioritizing effective factors on PA adoption in Iran is shown in Table 1. As shown, the highest priorities refer to attention to modern extension methods for PA, agricultural mechanization development, accessing to knowledge about PA capabilities and abilities, cost of PA technologies and the number of experienced specialists in PA field, other important factors were accessibility to software and hardware, PA equipments and satellite imagery, farmers trust to modern technologies and financial justification of PA. The results of this section show that the extension of technology and modern methods in agriculture is the most important effective factor in adoption of PA technology. So, agricultural education and extension should be considered before any other actions in order to develop PA in Iran. Education can be planned in different levels from primary to advance for experts and specialist based on their needs. Also, results of Table 1 show that most of effective factors on PA adoption refer to human field.

Based on effective factors on PA adoption, solutions for PA development were proposed. According to the solutions and their nature, they were categorized in different fields, namely, economical, managerial, technical and human resource which is shown in Table 2.

Table 1 Effective factors on PA adoption and development in Iran

Effective Factors	C.V	Priority
Attention to modern extension methods for PA	0.103	1
Agricultural mechanization development (Farm machinery and new technologies)	0.117	2
Accessing to knowledge about PA capabilities and abilities	0.139	3
Costs of PA technologies	0.148	4
Number of experienced specialists in PA	0.152	5
Government attention and support for development and investment of PA	0.165	6
Number of skilled and capable managers in specialty sections	0.185	7
Accessing to necessary infrastructures for PA development	0.189	8
Motivating agricultural graduates to participate in agricultural activities	0.201	9
Knowledge of agricultural beneficiaries and managers about PA	0.202	10
Development of information technology management	0.221	11
Methods of farming (traditional or modern)	0.229	12
Size of farms	0.243	13
Using advisory services for agricultural management	0.246	14
Relationship between university and beneficiaries	0.249	15
Financial justification of PA	0.269	16
Farmers trust to modern technologies	0.288	17
Accessibility to software and hardware, equipment and satellite imagery	0.338	18

Table 2 Solutions for development of PA in Iran

Field	Solutions
Economical	Decreasing cost of PA equipments and accessories Determination of profitability and economical justification of PA Improving financial situation of farmers Increasing investment on modern technologies Increasing size of farms
Technical	Improvement of knowledge about PA and its technologies Accessing to satellite imagery and PA equipments (software and hardware) Using advisory services in farm management Using modern methods of farming
Managerial	Completion of necessary infrastructures for development of information technology and PA and attention to PA development in strategic plans Codification of a comprehensive plan for PA and modern technologies development Development of agricultural mechanization Determination of plant pattern Development of non-governmental organizations Aid and support of government for PA development Using skilled and capable managers in specialty sections
Human resource	Improving general and technical knowledge of agricultural beneficiaries and experts Reinforcement the relationship between beneficiaries and universities and between research and extension sectors Farmers trust for using modern technologies Correct transfer of knowledge and technology to farms and extension of modern technologies and PA by new methods Training experienced expert in PA field Motivating graduates to participate in agricultural activities

Sheng Tey and Brindal (2012) found economical and technological factors as influencing factors on PA adoption and development. Totally, proposed solutions for development of PA in Iran are: accessing to PA equipments and decreasing their costs, determination of profitability and economical justification of PA, improving financial situation of farmers, increasing investment on modern technologies, increasing size of farms, improving knowledge about PA and its technologies, training experienced specialists, managers and beneficiaries in PA field, using advisory services in farm management, using modern methods of farming, completion of necessary infrastructures for development of information technology and PA and attention to PA development in strategic plans, codification of a comprehensive plan for PA and modern technologies development, development of agricultural mechanization, determination of plant pattern, development of non-governmental organizations, development of information management, aid and support of government for PA development, reinforcement the relationship between beneficiaries and universities and between research and extension sectors, farmers trust in for using modern technologies, correct transfer of knowledge and technology to farms, motivating graduates to participate in agricultural activities.

The results of this study agree with the findings of below researchers because they noticed following items as important factors on PA adoption and development in their country: costs of PA technologies and equipment (Jochinke et al., 2007; Silva et al., 2007), profitability and economical justification of PA (McBratney et al., 2005), farmers knowledge and education on PA technology (Auernhammer, 2001; Kitchen et al., 2002; McBratney et al., 2005; Mackrell et al., 2009; Silva et al. 2011), size of farms (McBratney et al., 2005; Silva et al., 2011), ability to use technology hardware such as computer in PA application (Silva et al., 2011), training experienced specialists, managers and beneficiaries in PA field (Reichardt et al. 2009), crucial role of farmers' expertise (Aubert et al., 2012) and farmers financial situation (Jensen et al., 2012).

4 Conclusions

To assess effective factors on PA 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 PA development are categorized in four fields, namely, economical, technical, managerial and human resources. Bbased on the results, proposed solutions for development of PA in Iran were: decreasing cost of PA equipment and accessories (economical field), improvement of knowledge about PA and its technologies (Technical field), ompletion of necessary infrastructures for development of information technology and PA and attention to PA development in strategic plans (Managerial field), improving general and technical knowledge of agricultural beneficiaries and experts (human resources).

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References

Aubert, B. A., SchroederGrimaudo. 2012. IT as enabler of sustainable farming: An empirical analysis of farmers' adoption decision of precision agriculture technology. *Decision Support Systems*, 54(1): 510–520.

Auernhammer, H. 2001. Precision farming—the environmental challenge. *Computers and Electronics in Agriculture*, 30(1-3): 31–43.

Batte, M. T., and M. W. Arnholt. 2003. Precision arming adoption and use in Ohio: case studies of six leading-edge adopters. *Computers and Electronics in Agriculture*, 38(2): 125–139.

Bongiovanni, R., and J. Lowenberg-Deboer. 2004. Precision Agriculture and Sustainability. *Precision Agriculture*, 5(4): 359–387.

Chen, W., R. W. Bell, R. F. Brennan, J. W. Bowden, A. Dobermann, Z. Rengel, and W. Porter. 2009. Key crop nutrient management issues in the Western Australia grains industry: a review. *Australian Journal of Soil Research*, 47(2): 1–18.

Du, Q., N. Chang, Ch. Yang, and K. R. Srilakshmi. 2008. Combination of multispectral remote sensing, variable rate technology and environmental modeling for citrus pest management. *Journal of Environmental Management*, 86(1): 14–26.

Jensen, H. G., L. Jacobsen, S. M. Pedersen, and E. Tavella. 2012. Socioeconomic impact of widespread adoption of precision farming and controlled traffic systems in Denmark. *Precision Agriculture*, 13(6): 661–677.

Jochinke, D. C., B. J. Noonon, N. G. Wachsmann, and R. M. Norton. 2007. The adoption of precision agriculture in an Australian broadacre cropping system—Challenges and opportunities. *Field Crops Research*, 104(1-3): 68–76.

Kitchen, N. R., C. J. Snyder, D. W. Franzen, and W. J. Wiebold. 2002. Educational needs of precision agriculture. *Precision Agriculture*, 3(4): 341–351.

Mackrell, D. Kerr, and L.V. Hellens. 2009. A qualitative case study of the adoption and use of an agricultural decision support system in the Australian cotton industry: the socio-technical view. *Decision Support Systems,* 47(2): 143–153.

McBratney, A., B. Whelan, T. Ancev, and J. Bouma. 2005. Future directions of precision agriculture. *Precision Agriculture*, 6(1): 7–23.

Reichardt, M., C. Jurgens, U. Kloble, and J. Huter, and K. Moser. 2009. Dissemination of precision farming in Germany: acceptance, adoption, obstacles, knowledge transfer and training activities. *Precision Agriculture*, 10(6): 525–545.

Robert, P. C. 2002. Precision agriculture: a challenge for crop nutrition management. *Plant and Soil*, 247(1): 143–149.

Robertson, M. J., R. S. Llewellyn, R. Mandel, R. Lawes, R. G. V. Bramley, L. Swift, N. Metz, C. Ocallaghan 2012. Adoption of variable rate fertiliser application in the Australian grains industry: status, issues and prospects. *Precision Agriculture*, 13(2): 181–199.

Schmoldt, D. L. 2001. Precision agriculture and information technology. *Computers and Electronics in Agriculture*, 30(1-3): 5–7.

Schellberg, J., M. J. Hill, R. Gerhards, M. Rothmund, and M. Braun. 2008. Precision agriculture on grassland: Applications, perspectives and constraints. *European Journal of Agronomy*, 29 (2-3): 59–71.

Seelan, S. K., S. Laguette, G. M. Casady, and G. A. Seielstad. 2003. Remote sensing applications for precision agriculture: A learning community approach. *Remote Sensing of Environment*, 88(1-2): 157–169.

Sheng Tey, Y., and M. Brindal. 2012. Factors influencing the adoption of precision agricultural technologies: a review for policy implications. *Precision Agriculture,* 13(6): 713–730.

Silva, C. B., S. L. R., Vale, F. A. C., Pinto, C. A. S., Muller, and A. D. Moura. 2007. The economic feasibility of precision agriculture in Mato Grosso do Sul State, Brazil: a case study. *Precision Agriculture*, 8(6): 255–265.

Silva, B. C., M. A. Moraes, and J. P. Molin. 2011. Adoption and use of precision agriculture technologies in the sugarcane industry of Sao Paulo state, Brazil. *Precision agriculture*, 12(1): 67-81.

Zhang, N., M. Wang, and N. Wang. 2002. Precision agriculture/a worldwide overview. *Computers and Electronics in Agriculture*, 36(2-3): 113–132.