PROSPECTS AND CHALLENGES FOR PRECISION FARMING IN TURKEY

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ABSTRACT

Turkish Agriculture can be characterized by small farm scales causing low productivity and inefficient use of production inputs. On the other hand, with its potential of reducing the environmental impact and increasing the productivity, precision farming approach is being considered as a new revolution in agriculture. Precision farming takes the variability of the field into account, in terms of soil fertility, yield, pest distribution, soil compaction, etc, and allows the application of right inputs at the right amount onto the right location. However, in order to benefit out of this advanced technology for saving inputs, energy and ecology, some extra investments should be made which requires an appraisal study for various farming conditions.

Since this technology is rather new or even unknown for Turkish farmers, this paper describes the current social, economical and physical situation of farming systems and examines the prospects for precision farming applications in Turkey.

Introduction

In recent years, the Turkish agricultural sector has had serious problems such as decrease in both crop and animal production, lower yields, higher input prices and higher production costs, loosing competitive power in foreign markets, and consequently very low level of productivity. Besides, in order for the economical development, measures such as diminishing the financial support to farmers and farming businesses, increasing costs of production inputs such as seed, fertilizer, spray, machinery, etc., and decreasing crop prices have been taken by the government all of which are negatively affecting the sector and primarily the farmers. As a result, the farming technology level can not make any progress but rather regresses and all interrelated sectors including Agricultural Machinery Manufacturing in Turkey is facing a real challenge of survival and integration into Common Agricultural Policy of the European Union (EU).

Until the last decade, depending on the power source and the stage in the mechanization process, there have been mainly three levels of technology considered to be used in agriculture; hand-tool technology, animal-draught technology and mechanical-power technology. Voss (1975) stated the following four stages in mechanization process;

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1. Hand tools are used with a very little capital investment,
2. Human labour is supplemented by animal power for primary and secondary tillage and for pumping water,
3. Mechanical power is introduced to some but not all operations,
4. All operations in the crop production are completely mechanized with power equipment. No electronic components are included.

However, none of the above mentioned technologies and the stages of the development of agricultural mechanization could have dealt with in-field variability of crop and soil conditions. Today, technology has reached a level that allows a farmer to measure, analyze and deal with in-field variability that was known to exist previously but wasn't manageable. The ability to handle variations in productivity within a field and maximize yields has always been a desire of the farmer, especially the farmer with limited land resources. The recent development of microprocessors and other electronic technologies are new tools available to help all farmers reach this goal. (Anon.,1997). This new approach of farming is called Precision Farming (or Precision Agriculture) and the technology behind it is called Variable Rate Application Technology.

In accordance with these recent developments in Information and Communication Technologies (ICT), the following two stages of mechanization can be added to those listed above;

5. Intermediate Level of Information Systems (IS) and Information Technology (IT) use in agricultural production. At this level, a farm owns a personal computer and software capable of supporting stock keeping, historical records and analyzing what-if models. Monitoring system is installed on a farm tractor to display the forward speed, PTO speed, distance traveled, fuel consumption and work rate. Besides, sprayers may have a control and data logging facility. No spatial information is required or used.
6. Precision Farming as an Advanced level of ICT application in agriculture. This level comprises the IT components of level 5 but with enhanced capabilities providing full spatial understanding and treatment of agricultural operations, eg. Soil and yield mapping, tractors donated with agricultural bus system, GPS based instrumentation systems, variable rate application technologies. Increase in yield, reduction of inputs and their costs and environment are the major concerns of this level of technology use.

On the other hand it is also important to know that precision farming technologies is in a very dynamic state of change and therefore the information provided within this paper represent a picture of the current time.

An Overview of Turkish Agriculture

According to the Food and Agricultural Organization of the United Nations (FAO) statistics, in comparison with the developed countries and despite its lower level of productivity and technological structure, Turkey is one of the major agricultural producers and has an important production potential. Table 1 shows the amount and area of some agricultural products of Turkey and EU. Approximately 40% of vegetables and 27.5 % of fruits of the EU are being produced in Turkey.

Total population and land of the country is approximately 64 millions capita and 78 million ha, equivalent to 17% and 25% of the EU, respectively. The agricultural shares in

total and economically active population of Turkey are about 32% and 47.6% respectively.
As part of its European strategy for Turkey the Commission has proposed a programme along the lines of the approach followed for the candidate countries from Central and Eastern Europe to help Turkey to bring its farm policy in line with the CAP. The Commission's services and the Turkish authorities have already started a process of policy comparison in the area of arable crops.

Table 1. Summary of Agricultural Production and Structure Statistics of Turkey in comparison with the European Union (*FAO, 2000 and Grethe,1999*).

	Turkey	European Union	Turkey as of EU (%)
Population Statistics (thousands, 1998, FAO estimates)			
Total Population	64,479	374,520	17.2
Agricultural Population	20,610	17,724	116.3
Agricultural Population (%)	32.0 %	4.7 %	
Area (million ha)	78	313	24.90
Agricultural Land (1000 ha)	39,677	147,690	26.86
Basic Economic Indicators			
GNP (1997) (billion ECU)	176	7,050	2.5
GNP per capita (1997) (ECU)	2,760	18,952	14.6
1998 Production (tons)			
Cereals	33,182,350	213,253,864	15.6
Fruits	15,987,545	58,095,906	27.5
Vegetables	21,742,712	54,148,580	40.2
Cotton	2,093,370	1,512,182	138.4
Olives	1,550,000	8,882,323	17.5
Tractors/1000 ha, 1997	33.0	91.0	36.3

Table 2 presents the current status of agricultural holdings in terms of distribution by number and area. According to Turkish State Institute of Statistics there are 3.9 million agricultural holdings with an average of 5.9 ha of scale. As can be seen in Table 2, 67% of agricultural enterprises are below 5 ha and they cultivate only 22.4% of total agricultural land.

Table 2. Distribution of Agricultural Holdings by number and area cultivated (*Turkish State Institute of Statistics, 1991*)

	Percentage Distribution (%)	
Holding Size Group (ha)	**By Number**	**By Area Cultivated**
0-2	**34.9**	5.9
2-5	**32.1**	16.5
5-10	**18.0**	19.9
10-20	**9.7**	21.0
20-50	**4.4**	19.9
50+	0.9	17.1

Another classification can be given by European Size Unit (ESU). The ESU is used to compare agricultural holdings within the EU countries. ESU is calculated by dividing the Standard Gross Margin of a farm by a constant amount of ECU (e.g. 1200 for 1995) and aims at eliminating the type and size differences of farms in comparison. The agricultural holdings within the EU are divided into 9 different economic classes defined by ESUs. Table 3 provides the classification of agricultural holdings of Turkey compared with EU, in accordance with the above-mentioned methodology.
Table 3 confirms that 90.69% of holdings are very small farms (below 4 ESU) compared to EU's average of 57.52% (Arslan, 1998). In other words, Turkish farmers are poorer and their productivity is lower than the EU farmers.

Table 3. Distribution of Agricultural Holdings in Turkey and EU by Economic Criteria. (*Arslan, 1998*)

Holding Group	**Size**	**ESU Range**	**Turkey**		**European Union (12 countries)**
			Number of farms	**% of total**	**% of total**
I	Very small	< 2	2,956,389	72.82	41.32
II		2 – <4	725,534	17.87	16.20
III	Small	4 – <6	198,310	4.88	8.52
IV		6 – <8	71,084	1.75	5.42
V	Below medium	8 – <12	44,899	1.11	6.68
VI		12 – <16	14,037	0.35	4.09
VII	Above medium	16 – <40	13,274	0.33	10.91
VIII	Big	40 – <100	2,220	0.05	5.49
IX	Very big	> 100	33,839	0.83	1.37

In Turkey almost all of the machinery and tractors used in agriculture are produced domestically and apart from those well-known and marketed brands, most of them are manufactured locally in order to meet the local market needs.
There are 5 agricultural tractor manufacturing establishments in Turkey with an existing capacity of 123,000 tractors per year. The agricultural machinery manufacturing technology, except tractors, conforms to the manufacturing technology levels 2 and mainly 3, as classified by UNIDO (1979). According to UNIDO, in manufacturing technology level 2, which comprises the small-scale industries, manufacture of agricultural equipment is carried out mechanically on a commercial basis and products manufactured are selected agricultural equipment, mainly pumps, crop protection equipment, etc., and they are situated in urban and semi-urban areas. In manufacturing technology level 3, which comprises the medium and large-scale industries, manufacture is carried out by conventional, semi-automatic and special purpose machine tools on a high volume, high precision and high investment basis.
1,023 manufacturers produced 111 different types of agricultural machines in 1998 and only 45.49% of their total production capacity could be used up. Majority of the establishments are small scale without any Research and Development facilities and lacking the required qualified personnel.

None of the Turkish manufacturers' products conforms to the mechanization level 5 as defined above. In other words, they do not donate their tractors or machinery with even basic electronic components, such as monitoring systems for speed control and display, fuel consumption display and workrate calculation.
The input use over time has steadily increased despite the past and current economical crisis and the agricultural policies drawn in accordance with the WTO agreement. Table 4 provides information about the use of fertilizers by 5-year periods.

Table 4. Average Annual Fertilizer Consumption of Turkish Farmers (*Kaplan et al, 2000*)

Fertilizer (N+P_2O_5+K_2O) Consumption (kg/ha)				
1973-1977	**1978-1982**	**1983-1987**	**1988-1992**	**1993-1996**
45	68	75	79	80

As can be seen in Table 4, although fertilizer consumption is very low compared to that of EU averages, it is almost doubled during the last 25 years. Likewise, the use of pesticides is steadily increasing. All of these chemicals applied in agriculture create not only soil and water pollution but also deficiencies of secondary and micro-nutrients in soil. Therefore, it seems to become more and more necessary to adopt efficient input use which could be mainly realized through precision farming.

Precision Farming

At the beginning of the 1990s, as the computer and sensor technology developed, electronics began to be applied to agriculture in various ways especially in the USA and Northern Europe. Increasing concern on environment and sustainability in agriculture has led researchers, equipment manufacturers and farmers use developing microprocessors and other electronic technologies in agricultural production in order to measure, analyze and deal with in-field variability that was known to exist previously but wasn't manageable.
Ardolino (1999) describes Precision Farming as "It is simply a different way of looking at farm management. It seeks to adjust practices to match variations of soils and terrain at much smaller increments within a paddock. Blackmore et al (1994) give the definition as; "Precision Farming is not simply the ability to apply treatments that are varied at local level, but must be considered as the ability to precisely monitor and assess the agricultural enterprise at a local and farm level and to have sufficient understanding of the process involved to be able to apply the inputs in such a way as to be able to achieve a particular goal. This is not necessarily maximum yield but may be to maximize financial advantage while operating within environmental constraints." In this definition, Blackmore points out two implications of PF; environmental and financial.
Just as agriculture was transformed from hand to horse-power and later from horses to tractors, this new transition is driven by technology and economics. The promises of existing products of PF include;

- maximizing crop yields, field performance and operating productivity in agricultural operations,
- measuring the performance of various seed types, hybrids, chemicals and soils,
- reducing fertilizer, chemical application costs

- reducing pollution through poor use of chemicals,
- tracking, mapping and analyzing field performance to the square meter, and therefore allows farmer to be able to know how well or poorly each part of a field is producing,
- helping to improve decision-making process in farm-management
- providing better farm records essential for sale and successions.

The technologies required within PF applications include (Reid, 1998);

- Positioning Systems, such as GPS, DGPS and GLONASS, to apply practices that require location information,
- Sensors and monitors, such as yield monitor, to measure the effect of PF,
- Mapping systems for displaying and analyzing the data collected through PF,
- Soil sampling and analysis to acquire information on soil characteristics, crop growth and development,
- Remote Sensing – a satellite technology used to get information on crop environment characteristics,
- Geographic Information Systems (GIS) to serve as part of decision support systems for PF,
- Variable Rate Technology (VRT) to enable the application of inputs as required.

There have been significant developments and considerable price falls of PF components as more companies enter the market to satisfy the increasing demand of farmers.
However, PF is still in its infancy. Only a few early adopters in the USA have more than four or five years of historical data. New tools are being developed each year. In the future, new sampling techniques will give better information about variation in field fertility. Sensing technology, such as electrical conductivity and near infrared imagery could revolutionize field management strategies. Farmers who have several years of historical data will be able to use these new tools when they become available Stombaugh et al (2001).

Challenges for the Future

The agricultural sector in Turkey is not able to achieve the performance level of production that can be obtained with the existing resources. In other words, the productivity level of agriculture is very low, which is due to small and scattered agricultural enterprises and rather high input costs. The major problems of the sector and challenges towards the adoption of advanced information technology can be listed as follows;

i. The trend in agriculture is towards sustainable and environment friendly production in agriculture. In this respect, organic farming or ecological farming practices and the consumer demand for their products are to a large extent increasing all over the world. It is therefore necessary to consider the production and implementation of appropriate machinery, such as computer aided production technologies, precision farming, zero-tillage techniques, multi-farm use organizations, etc.

ii. PF requires some degree of competence in the use of software and hardware, eg GPS, GIS, Remote Sensing, Computers, Sensors, Actuators, etc. However, currently there is almost no IT skilled people in rural areas who can train local technical workforce and farmers in this respect.

iii. As in many parts of the world, Turkish farmers are also typically conservative and resistant to new technologies and do not accept them unless they are fully convinced of their benefits.
iv. Technologies are often taken up quickly if they meet a perceived need of farmers and if there are sufficient incentives to encourage their adoption. However, Turkish Government's recent decisions are made towards cutting down all incentives, subsidies and any kind of support (except direct income support) to agricultural production.
v. Turkish farmers do not also enjoy record keeping which is highly important for PF applications.
vi. Small farm scale (average 5.9 ha) is another major obstacle to adoption of Information Technologies in Turkey
vii. PF components in terms of software and hardware are not available within domestic market and they are also very expensive for farmers with a majority of having a very low level of income.
viii. Apart from all financial and technical issues of adoption of PF, Turkish farmers are not also very much trained and concerned about sustainability and environmental issues,
ix. There is a considerable shortage of machinery and tractor usage in Turkish agriculture, which in effect avoids the use of modern technologies. Tractor power use per ha and total weight of machines per tractor are approximately 1.3 kW/ha and 4.2 tonnes, respectively, compared to 5–7 kW/ha and 12 tonnes in the EU. Low level of farm incomes, the instability of the agricultural sector because of wrong and inconsistent policies, high inflation rates, effects of the global crisis have all prevented the AMM sector from development.
x. It would be more rational to support the modernization of agricultural machinery manufacturing sector and R&D investments towards the use of advanced Information Technologies, and PF.
xi. Above all, Turkish machinery manufacturers are not fully aware of PF philosophy and its future..

Turkey, together with all other candidate countries, has agreed upon the e-Europe+ initiative of the EU towards an information society for all. This initiative set an ambitious goal for Europe for the next decade to become "the most competitive and dynamic knowledge-based economy in the world", to use the full potential offered by the Information Society and to avoid a further digital divide with the EU. Consequently an eEurope-like Action Plan was launched which would have a positive impact on the adoption speed of the *acquis* for telecommunications, electronic commerce, areas of financial and transport services, and many other areas of economic activity which could also include aspects of PF.

References

1. Anonymous, 1997. "*The Precision-Farming Guide for Agriculturalists*". An Agricultural Primer, John Deere Publ. No: FP401NC, Davenport, IA, USA.
2. Ardolino, A., 1999. "*What is Precision Farming*". The Commonwealth Ministers Reference Book 1998/99. page: 106-107, 1999.
3. Arslan A., 1998. "*Turkiye'deki Tarimsal Isletmelerin Avrupa Birligi Tipoloji Sistemine Gore Siniflandirilmasi*". Turkiye'de Tarimsal Yapi ve Istihdam ISBN 975-19-2131-7. State Institute of Statistics, Ankara, 1998.
4. Blackmore, B.S., P.N.Wheeler, R.M.Morris, J.Morris, R.J.A.Jones, 1994. "*The Role of Precision Farming in Sustainable Agriculture: A European Perpective*". Paper Presented at the 2nd Int.Conf.on Site Specific Management for Agricultural Systems in Minneapolis, USA, March 27-30 1994.
5. FAO, 2000. "*Statistical Database"*. Food and Agriculture Organization of the United Nations web site; http://www.fao.org, Rome, 2000.
6. Grethe, H., 1999. "*Möglichkeiten der Integration der Agrarsektoren der Türkei und der EU vor dem Hintergrund der Gegenwartigen Agrarpolitiken. Papier vorbereit für den Workshop*" Zukunftsperspektiven der Agrarproduktion in den EU-Landern und in der Türkei unter Berücksichtigung der Integrationsmöglichkeiten, 25-27 Oktober 1999, Izmir, Türkei.
7. Kaplan, M., M.Aktas, A.Gunes, M.Alpaslan, S.Sonmez, 2000. "*Evaluation of Turkish Fertilizer Use and Production*". Vth.Technical Congress on Turkish Agricultural Engineering, 17-21 January 2000, Ankara, Proceedings Book, page:881-900.
8. Reid, J.F., 1998. "*The Impact of Precision Agriculture on US Agriculture; an industry and an academic prespective*". Agric.Engng, 1304 W.Pennysylvania Ave., Univ.of Illinois, Urbana, IL, USA.
9. Stombaugh, T.S., T.G.Mueller, S.A.Shearer, C.R.Dillon, G.T.Henson, 2001. "*Guidelines for Adopting Precision Agricultural Practices*". Cooperative Extension Service, Univ.of Kentucky, College of Agriculture, PA-2. 2001
10. UNIDO, 1979. "*Appropriate Industrial Technology for Agricultural Machinery and Implements*". United Nations Industrial Development Organization (UNIDO), Monographs on Appropriate Industrial Technology No:4, UN, New York.
11. Voss, C., 1975. "*Different Forms and Levels of Farm Mechanization and their Effect on Production and Employment*". Meeting of the FAO/OECD Expert Panel on the Effects of Farm Mechanization on Production and Employment, 4-7 Feb 1975, FAO, Rome, Italy.