Investigation of agricultural mechanization status in corn production of Iran

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Abstract: For determination and assessing the effect of agricultural mechanization in irrigated corn of Iran, two indicators have been used: cultivated area (ha) and yield (kg/ha). Several regression models have been built, using Mechanization Level (ML) and Mechanization Ownership (MO) of all agricultural operations, as input, and cultivated area and yield as output, separately. The survey was carried out by means of data obtained from Agricultural Ministry of Iran in the period of 2001-2008. The results revealed that mechanization ownership of planting and harvesting have a significant effect on cultivated area of corn in Iran with 95% and 99% confidence, respectively. Based on obtained results, agricultural mechanization has an important role in improvement of corn production in Iran. Levels of mechanization in each agricultural operation have different effects on yield improvement. Policy makers can consider important factors between mechanization inputs to improve the corn production of Iran.

Keywords: yield, regression model, mechanization

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1 Introduction

Agricultural mechanization includes three main power sources: human, animal, and mechanical. The manufacture, distribution, repair, maintenance, management and utilization of agricultural tools, implements and machines is covered under this discipline with regard to how to supply mechanization inputs to farmers in an efficient and effective manner. Mechanization technologies keep changing with industrial growth of the country, and socio-economic advancement of the farmer. Whereas declining interest in agriculture of the landowners and non-availability of the agricultural labor for field operations may be one of the major socio-economic issues in highly industrialized nations, increasing land and labor productivity with dignity are the mechanization requirements of the developing countries. Mechanization technology is, therefore, location-specific and dynamic. The quality of inputs of mechanization, and consequently land and labor productivity in both situations, may differ considerably (Gifford and Rijk, 1980; Singh, 1997, 2000; Singh and Chandra, 2002).

Several authors have studied the status of mechanization with reference to the intensity of power or energy availability, and its impact in increasing the agricultural and labor productivity. Giles (1975) reviewed power availability in different countries, and demonstrated that productivity was positively correlated with potential unit farm power. The NCAER (1981) assessed the impact of tractorization on the productivity of land (yield and cropping intensity), and economic growth (income and employment). The trends for

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European and Asian countries were, however, distinctly different. Binswanger (1982) defined the status of mechanization by the growth of mechanically power-operated farm equipment over traditional human and animal power operated equipment. Rijk (1989) reviewed the growth of mechanization in different Asian countries, and suggested computer software (MECHMOD) for the formulation of strategy for mechanization policy based on economics of use of animate and mechanical power for different field operations.

It is of utmost importance to examine whether the use of machines has been economical or not. Singh (1986) on the basis of a sample of 35 combine harvesters studied, reported that the average area covered by a combine harvester of small size was 192.1 acres of wheat and 173.6 acres of paddy. With an average rate of US$ 210 per acre, annual gross return of US$1219 was estimated while the annual fixed and operating costs worked out to US$ 776 thus showing a net profit of US$ 442 during 1984-1985.

Screening products, populations, or territories for exceptional changes in the demand for products or services is an important management activity, whether to prevent losses or to take the advantage of opportunities. In either event, managers must make decisions that interrupt normal operations and reallocate resources. To trigger such activity, time series monitoring has the purpose of automatically detecting outliers and structural changes in time series data, such as step increases or decreases, as soon as possible after they occur and with sufficiently few false alarms (Editorial, 2009). Spatial and temporal changes in precipitation and temperature patterns will thus have major impacts on the viability of both dry land and irrigated farming (Benhin, 2008).

The ability of crop simulation models to predict growth and yield as influenced by the environment, agronomic practices and crop traits suggests that such models can identify traits to increase yield potential (De Wit, 1965; Lu, 1993; Reynolds et al., 1996). Hung and Tang (2006) studied the effects of the five key agronomic factors (sowing date, seedling density, Nitrogen application, Phosphate application and Potassium application) on wheat yield to build up the production management models. Their results indicated the differences in the importance of the respective factors to wheat yield between different ecological environments. In another study, Knox et al. (2010) assessed the spatial and temporal impacts of climate change on irrigation and yield for sugarcane grown in Swaziland by combining the outputs from a general circulation model, a sugarcane crop growth model and a GIS. Al-Karablieh et al. (2002) forecasted wheat production in Jordan. Based on their work, the variables affecting wheat production in the selected region are the early monthly rainfall and cultivated areas of wheat; in the presence of these variables, temperature and number of rainy days have insignificant effects on the prediction of wheat output. Analysis showed that rainfall is the major factor in increasing wheat production.

The objective of this study was to conduct a preliminary assessment of production factors effects on corn production in Iran. Secondly, technological factors were used for modeling corn yield in the period of study (2001-2008).

2 Material and methods

One way to know about what inputs are crucial in the production of corn output is to calculate elasticities of corn output with respect to these inputs. These elasticities, which are the measurement of how responsive a variable is to a change in another, can be found by estimating a production function with an appropriate functional form. To know about what inputs are crucial in the production of corn output, the study estimated Cobb-Douglas production.

The study proposes the following specification of production function:

$$\ln Y_i = \alpha_0 + \sum_{j=1}^{9} \alpha_j \ln(x_{ij}) + e_i \quad (1)$$

where, Y_i denotes corn output per hectare the ith year; x_{ij} the vector of inputs used in the production process; α_0, constant term; α_j, represent coefficients of cost inputs which are estimated from the model; and e_i is the error term. Log corn output per hectare is assumed to be function of different sets of factors such as cost of inputs and mechanization ratio in different stages of corn production.

For studying production system of irrigated corn we used two indices which provide information about mechanization status of corn farms of Iran. Equation (2) (Banaeian and Zangeneh, 2011) shows the Mechanization level of farms, by dividing area of corn farms those agricultural operations done by farm machinery to the total area of farms or in other words total area of farms which needs mechanized operations.

$$ML = \frac{A_m}{TA} \times 100 \quad (2)$$

where, ML is the mechanization degree, dimensionless; A_m is the mechanized area of farms, ha; and TA is the total area of farms or all of farms needs mechanization, ha.

Second index used in this study is the Mechanization Ownership (MO) (dimensionless) that introduces proportion of mechanized farmers (M_f) to the total number of corn farmers (TF) (Banaeian and Zangeneh, 2011). This index determines the distribution pattern of machinery users in crops. According to some domestic cultures, distribution of farm machinery is so important because farmers in some regions like to maintain their independence and only done themselves operations and don't work on strange farms. This situation has negative effects of agricultural system, whereas full capacity of agricultural machines could not be employed. Equation (3) shows the MO index.

$$MO = \frac{M_f}{TF} \times 100 \quad (3)$$

Study on mechanization of corn farming operations in Iran was conducted in the period of 2001 to 2008. The survey was carried out by means of data obtained from Ministry of Agricultural Jihad (MAJ). Data was collected from all over Iran provinces. Data was including mechanization ratio based on area of machinery use and number of wheat farmers who use agricultural machinery into the whole of studied area and farmers for modeling area of cultivated land and corn yield as output.

The coefficients that obtained from estimating Cobb-Douglas production function were important. They told us how much corn output per hectare is influenced in percentage terms due to one percent change in the independent variable and on the other hand these coefficients are used for finding predicted values of wheat output in nationwide and aggregate level. Forecast needs two important pieces of information. These are a) future value of inputs used in corn production and b) the parameters (elasticities) that link inputs to corn output. The elasticity parameters are obtained from the estimated production function as mentioned above.

3 Results and discussion

There are differences between the ML and MO in each operation. Mechanization ownership is related to the number of farm machinery owner and has a specific capacity limited by national conditions governing agricultural growth potential. It is ideal to be able to get the full mechanization of the farms that they are 100% mechanized. Difference between the current value of MO and its ideal value can be reduced by using system of agricultural machines exploitation as much as possible. Improving the system of agricultural machinery usage can increase the degree of mechanization and will show its positive results on improving corn yield. If the difference of ML and MO for each of the operations increase, the potential in the agricultural machinery will operate properly.

Various sets of input data for modeling sugar beet production were used. Totally seven models for the study of corn production in Iran was built as their profile can be seen in Table 1. Each of the seven models will be discussed subsequently.

Table 1 Data sets for modeling corn production in Iran

No.	Inputs/%	Output
1	ML of all operations	Yield, kg/ha
2	ML of all operations	Cultivated land, ha
3	MO of all operations	Yield, kg/ha
4	MO of all operations	Cultivated land, ha
5	ML of planting and crop management	Cultivated land, ha
6	MO of planting and crop management	Yield, kg/ha
7	MO of planting and crop management	Cultivated land, ha

Table 2 shows elasticities of dependent variable (corn output per hectare) with respect to independent variables the set number 1 (ML of all operations). This set includes ML of land preparation, planting, crop management and harvesting as input and corn yield as output. Based on the output of this model, ML of all operations has no significant effect on corn yield. The Standardized coefficient (Beta) indicates the importance and influence of each input on the output. Based on Beta value ML of planting is the most important factor in this model.

Table 2 Modeling effect of ML of all operations on corn yield as output coefficients

Model (No.1)	Unstandardized coefficients		Standardized coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	2527.3	1711.8		1.47	0.23
Land preparation	16.8	22.8	0.1	0.73	0.51
Planting	106.03	52.8	1.03	2.00	0.13
Crop management	-22.1	67.0	-0.20	-0.33	0.76
Harvesting	8.09	14.2	0.10	0.56	0.61
R Square			0.937		
Adjusted R Square			0.852		
Durbin-Watson			3.088		

Note: Dependent Variable: Yield.

Hussain et al. (2006) used the total number of irrigations, seed rate (kg/acre), fertilizers (number of DAP bags per acre) and soil fertility (Nitrogen in percentage available in the soil). Their results showed that wheat yield was positively related to the quantity of seed rate, DAP and Nitrogen but negatively related to the number of irrigations.

Table 3 shows the relationship of ML of all operations and corn cultivated land. The results indicated that the proportion of corn farmers who have agricultural machinery to all of corn producers have no significant effect on corn lands. It is concluded that distribution of agricultural machines between farmers is not fairly and this allocation trend cannot affect or increase the lands of corn in Iran.

Effect of mechanization ownership in all operations on corn yield is modeled and its results have been presented in Table 4. As can be seen in this table MO of planting is the important factor for modeling the yield of corn. After planting next important factors are harvesting, crop management and land preparation, respectively.

Table 3 Modeling effect of ML of all operations on cultivated land as output coefficients

Model (No.2)	Unstandardized coefficients		Standardized coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-99884.0	177336.8		-0.5	0.61
Land preparation	586.7	2362.0	0.06	0.2	0.82
Planting	8594.4	5476.1	0.92	1.5	0.21
Crop management	-641.3	6943.0	-0.06	-0.0	0.93
Harvesting	945.5	1479.2	0.14	0.6	0.57
R Square			0.918		
Adjusted R Square			0.809		
Durbin-Watson			1.796		

Note: Dependent Variable: Cultivated land.

Table 4 Modeling effect of MO of all operations on yield as output coefficients[a]

Model (No.3)	Unstandardized coefficients		Standardized coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	2001.2	4233.1		0.47	0.66
Land preparation	-9.7	64.6	-0.05	-0.15	0.89
Planting	103.9	87.9	0.96	1.18	0.32
Crop management	-62.5	114.6	-0.54	-0.54	0.62
Harvesting	59.6	33.8	0.64	1.76	0.17
R Square			0.943		
Adjusted R Square			0.866		
Durbin-Watson			2.084		

Note: a. Dependent Variable: Yield.

The model No. 4 has notable results. The MO of all operations has significant results on cultivated land of corn. Harvesting and planting have positive effect, while land preparation and crop management have negative effect on corn lands. Excessive and unnecessary use and abundance of land preparation and crop management machinery by owner farmers in Iran caused negative effect on corn yield.

For developing corn lands it is better to increase the mechanization ownership of planting and harvesting. This approach can be accomplished using agricultural mechanization companies in all regions of corn centers.

For describing the effect of mechanization degree of planting and crop management operations on the status of corn production, multi stage modeling system has been used. Different outputs have been selected in the following modeling. Table 6 shows the summary of model No. 5. In this model 3 models have been constructed and in each step a new variable have been added to complete the model and reduce modeling error. Value of R^2 has been increased from 0.80 to 0.99. So the best model is the 3rd model which was selected for modeling ML of planting and crop management on cultivated land as output. All operations used for this model are planting, manure application and chemical application. The ML of planting is the most important factor both in this model and previous models. Table 7 illustrated the characteristics of built models.

Table 5 Modeling effect of MO of all operations on cultivated land as output coefficients

Model (No.4)	Unstandardized coefficients		Standardized coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-113898.1	110860		-1.02	0.38
Land preparation	-4249.1	1693.8	-0.25	-2.50	0.08
Planting	10334.9	2302.2	1.05	4.48	0.02
Crop management	-7472.2	3002.1	-0.72	-2.48	0.08
Harvesting	7849.8	885.9	0.93	8.86	0
R Square			0.995		
Adjusted R Square			0.989		
Durbin-Watson			2.026		

Note: Dependent Variable: Cultivated land.

Table 6 Model Summary[4] of Model No. 5

Model (No.5)	R Square	Adjusted R Square	Durbin-Watson
1	0.801[1]	0.767	
2	0.946[2]	0.924	
3	0.991[3]	0.983	2.511

Note: 1. Predictors: (Constant), Planting;
2. Predictors: (Constant), Planting, Manure application;
3. Predictors: (Constant), Planting, Manure application, Chemical application;
4. Dependent Variable: Cultited land.

Table 7 Modeling effect of ML of planting and crop management on cultivated land as output Coefficients

Model (No.5)		Unstandardized coefficients		Standardized coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-44701.4	59703.0		-0.74	0.482
	Planting	4161.3	848.0	0.89	4.90	0.003
2	(Constant)	-125058.5	40475.5		-3.09	0.027
	Planting	4891.8	522.8	1.05	9.35	0.000
	Manure application	56815.5	15486.1	0.41	3.66	0.014
3	(Constant)	-87646.4	20840.2		-4.20	0.014
	Planting	4082.8	308.0	0.87	13.25	0.000
	Manure application	48696.4	7494.9	0.35	6.49	0.003
	Chemical application	1803.9	416.3	0.26	4.33	0.012

Note: Dependent Variable: Corn cultivated area.

Model No.6 presents the relation between Mechanization Ownership of planting and crop management in predicting corn yield. In this case stepwise regression method has been used. Second model with R^2 of 0.97 can model the corn yield. Both factors in second model have significant effect on yield at 99% confidence. Mechanization ownership of planting and irrigation has positive and negative effect, respectively. With increasing MO of planting and reducing MO of irrigation, corn yield can be increased.

Table 8 Model Summary[1] of Model No.6

Model (No.6)	R Square	Adjusted R Square	Durbin-Watson
1	0.903[2]	0.887	
2	0.975[3]	0.965	2.558

Note: 1 Dependent Variable: Yield;
2. Predictors: (Constant), Planting;
3. Predictors: (Constant), Planting, Irrigation.

Table 9 Modeling effect of MO of planting and crop management on Yield as output coefficients

Model (No.6)		Unstandardized coefficients		Standardized coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3312.8	482.5		6.86	0
	Planting	58.1	7.7	0.95	7.49	0
2	(Constant)	1839.9	473.0		3.88	0.012
	Planting	86.1	8.5	1.40	10.04	0
	Irrigation	-815.7	215.5	-0.53	-3.78	0.013

Note: Dependent Variable: Yield

According to Table 10 for modeling the model No.7, totally two models have been built. The second model shows better results in modeling cultivated lands of corn using MO of planting and harvesting.

Table 10 Model Summary[3] of Model No.7

Model (No.7)	R Square	Adjusted R Square	Durbin-Watson
1	0.943[1]	0.933	
2	0.983[2]	0.976	1.325

Note: 1. Predictors: (Constant), Harvesting;
2. Predictors: (Constant), Harvesting, Planting;
3. Dependent Variable: cultivated land.

Based on the results of model 7, for increasing the corn cultivation in Iran it is better that planting and harvesting technologies be distributed between target populations of farmers. Corn production has its special characteristics, corn planters and harvesters (often combines) hardly required personally, because of existence of timeliness costs that can disturb farmers work. Development of corn lands can be occurred with the increasing mechanization ownership of harvesting and planting operations.

Table 11 Modeling effect of MO of planting and harvesting on cultivated land as output Coefficients

Model (No.6)		Unstandardized coefficients		Standardized coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-345785.9	59715.4		-5.79	0.001
	Harvesting	8195.5	825.6	0.97	9.92	0.000
2	(Constant)	-266416.9	42982.5		-6.19	0.002
	Harvesting	5111.5	1037.7	0.60	4.92	0.004
	Planting	2321.2	685.2	0.41	3.38	0.020

Note: Dependent Variable: Cultivated land

4 Summary and conclusions

In this study using mechanization indices, the production status of corn were evaluated in Iran. Various sets of input data were used for modeling corn production and totally seven models were built for Iran corn status analyzing. For this purpose mechanization inputs used in corn production were linked to corn output by parameters which were obtained from Cobb-Douglas production function for the period years. For achieving accurate view of situation, we used eight years' statistics from Agricultural Ministry of Islamic Republic of Iran. Regressive models have been used for modeling mechanization effect in different agricultural operations on corn yield and corn lands as output. Results showed that Agricultural mechanization has an important role in the improvement of corn production in Iran. Harvesting and planting have positive effect, so for improving the production status of corn in Iran, planting and harvesting mechanization should be considered seriously. While excessive and unnecessary use of land preparation and crop management machinery by owner farmers in Iran caused negative effect on corn yield.

References

Al-Karablie, E. K., A. Z. Salman, and F. M. Fisher. 2002. Forecasting wheat production: The case of the Irbid region of Jordan. *Quarterly Journal of International Agriculture*, 41(3): 191-205.

Banaeian, N., and M. Zangeneh. 2011. Mechanization and economic analysis of wheat production in Iran. Agricultural mechanization in Asia, Africa and Latin America, 42(4): 15-27.

Benhin, J. K. A. 2008. South African crop farming and climate change: an economic assessment of impacts. *Global Environmental Change*, 18 (4), 666-678.

Binswanger, H. P. 1982. Agricultural mechanization: a comparative historic perspective. World Bank Report ARU-1, Washington.

Cobb, C. W., and H. Douglas. 1928. A theory of production. *American Economic Review*, 18(1):139-165. Supplement Papers and Proceedings of the Fortieth Annual Meeting of the American Economic Association.

De Wit, C. T. 1965. Photosynthesis of leaf canopies. Agricultural Research Reports, 663, PUDOC, Wageningen, the Netherlands.

Editorial. 2009. Introduction to time series monitoring. *International Journal of Forecasting*, 25(3):463-466.

Gifford, R. C., and A. G. Rijk. 1980. Guidelines for agricultural mechanization strategy in development. Economic and Social Commission for Asia and the Pacific (ESCAP), Regional Network for Agricultural Machinery.

Giles, G. W. 1975. The reorientation of agricultural mechanization for the developing countries. FAO Report on Effect of Farm Mechanization on Production and Employment. Food and Agricultural Organization (FAO), Rome, Italy.

Huang, G, and Y. Tang. 2006. Studies on management model for wheat production based on key agronomic factors. *World journal of Modelling and Simulation*, 2(1): 63-70.

Hussain, M., A. Saboor, A. Ghafoor, and M. Mohsin. 2006. Estimation of wheat production, forecasting and risk analysis. *Journal of Agriculture and Social Sciences,* 2(1): 60-62.

Kherallah, M., N. Minot, and P. Gruhn. 1999. Adjustment of wheat production to market reform in Egypt. Ministry of Agriculture and Land Reclamation and the Ministry of Trade and Supply in Egypt.

Knox, J. W., J. A. Rodriguez Diaz, D.J. Nixon, and M. Mkhawanazi. 2010. A preliminary assessment of climate change impacts on sugarcane in Swaziland. *Agricultural Systems*, 103(2): 63-72.

Lu, L. S. (ed.). 1993. New Advances in China Wheat Cultivation Researches. Agriculture Press, Beijing. (in Chinese).

NCAER. 1981. Implication of tractorisation for farm employment, productivity and income. National Council of Applied Economic Research, Parisila Bhawan, New Delhi.

Reynolds, M. P., S. Rajaram, and A. McNab (eds.). 1996. Increasing Yield Potential in Wheat: Breaking the Barriers. CIMMYT Press, Mexico, D.F, 225–229.

Rijk, A. G. 1989. Agricultural mechanisation policy and strategy—the case of Thailand. Asian Productivity Organisation, Tokyo, Japan.

Singh, G. 1997. Data book on mechanisation and agroprocessing in India after independence. Technical Bulletin CIAE/97/71, Central Institute of Agricultural Engineering, Nabi Bagh, Berasia Road, Bhopal, India.

Singh, G. 2000. Modernisation of agriculture in India (part I)—farm mechanisation. Agricultural Situation in India, Ministry of Agriculture, New Delhi.

Singh, G., and H. Chandra. 2002. Production and economic factors growth in Indian agriculture. Technical Bulletin No. CIAE/ 2002/91, Central Institute of Agricultural Engineering, Nabi Bagh, Berasia Road, Bhopal, India.

Singh, J. 1986. Economics of combine Harvesters. *Progressive Farming*, XXII(8), PAU, Ludhiana.