International Journal of Agricultural Management and Development (IJAMAD)
Available online on: www.ijamad.com
ISSN: 2159-5852 (Print)
ISSN:2159-5860 (Online)
DOI:10.5455/ijamd.169832

A Survey on the Current Status of Mechanization of Paddy Cultivation in Iran: Case of Guilan Province

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Received: 20 September 2014,
Accepted: 14 December 2014

Abstract

This study investigated the status of mechanized power and self-propelled rice cultivation machinery in Guilan Province in northern Iran. The raw data was obtained from 2013 statistics of the Agricultural Jihad Organization of Guilan province. Power per unit of area, mechanization level, area per unit of self-propelled machinery, and mechanization requirement were calculated for eastern, western and central Guilan. The mean power per unit of area for eastern, western and central Guilan was 2.22, 2.07, and 3.09 $hpha^{-1}$, respectively. The total mechanization requirements were determined to be 0%, 73.39%, 99.28%, and 52.47% for land preparation, transplanting, weeding, and harvesting operations, respectively. The area per self-propelled rice machinery was 111.38, 3777.97, and 358.99 ha for rice transplanter, weeder, and combine harvester, respectively. This indicates that there is insufficient mechanization for rice weeding and that there is an urgent need to increase the machinery available for this agronomic operation in the paddy fields of Guilan Province.

Keywords:
Rice, paddy, power, Mechanization index, mechanization requirement

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INTRODUCTION

Decreasing manual labor requirements is an important aspect of farm mechanization. Less number of labors is needed to complete the cultivation process by mechanized farm compared to traditional farm (Rahman *et al*., 2011). Manual cultivation of agricultural production is time-consuming and expensive. Mechanization of agricultural operations has been undertaken in many parts of the world to increase the income of farmers and promote the economic interests of agriculture (Singh, 2006). Agricultural mechanization is the application of agricultural machinery to land preparation, crop residue management, plant protection, harvesting, and threshing to produce crops. It adds value to the agricultural products and provides power for farm operations such as irrigation (Karale *et al.*, 2008). There is growing interest in mechanization of agricultural operations among farmers to decrease production costs and increase farm income (Singh, 2006). Decreasing the exertion of agricultural work and increasing its appeal, the area under cultivation and production per unit area are the other important benefits of agricultural mechanization (Almassi *et al.*, 2006).

Of agricultural products, mechanization of rice as the world's second staple food is of special importance. Submerged cultivation and difficult working conditions in paddy fields make its cultivation labor intensive, expensive, and energy intensive. The total time required for traditional production of rice is estimated to be over 1780 man-hours ha^{-1} (Pateriya and Datta, 2012). Labor shortages during growing season and the low speed of manual cultivation compared with mechanized farming also are very important problems.

The mechanization of agriculture has been considered to be a major factor in the development and sustainability of rice production by the Iranian Ministry of Agriculture. Thus far, efforts in this area have not been sufficient and development of new approaches to solve this problem is still under consideration.

Codification of policies, plans, and models for agricultural development in different areas of the world requires detailed knowledge and analysis of the existing conditions. Without these studies, any planning, whether it is short, medium or long term, will fail (Loveimi and Almassi, 2003). An appropriate model can only be provided after all the possibilities and limitations for each district are studied. Cultural, geographic, economic and social differences mean that one model may not be effective for all parts of the world (Shahbazi, 1989).

Researchers have examined the quantity and quality of agricultural mechanization in different regions and countries and have developed and implemented several indicators. Ampratwum *et al*. (2004) found that the mechanization index (ratio of mechanical power to total mechanical, animal and human power) in Oman was 75% and the power per unit area was 1.1 kW ha^{-1}. They proposed the use of at least 916 double-axle tractors after 2002, to increase the mechanization index to 81% in Oman. The problems of mechanization of small hold farmers in the central strip in Nigeria were investigated by Yohanna *et al*. (2010). Their study showed that the level of mechanization (ratio of machine tools to total number of machines and manual tools for each cultivation operation) for cleaning products was 21.54%, land preparation was 24.62%, planting was 3.85%, spraying was 86.15%, fertilizing was 2.13%, weeding was 3.08%, harvesting was 40%, processing and storage of the product was 7.69%. Paman et al. (2012) studied the power available to small paddy fields of Riau province in Indonesia. They showed that, although access to farm power increased from 1997 to 2006, access to agricultural power in the region was low. The total power required to produce white rice, including plowing, preparing the nursery, planting, weeding, fertilizing, pest control, harvesting, threshing, transportation, cleaning, drying and converting the paddy to white rice was 418 kw (561 hp) per hectare on average. They recommended that farmers should be encouraged to use mechanical power for timely fulfillment of farm operation and increased productivity. Firouzi (2014) examined the mechanization indicators of paddy cultivation for five major districts in the city of Langarud in northern Iran. The results

showed that the average mechanization level in the study areas was 1.37 *hpha*$^{-1}$. The mechanization requirements for land preparation was 0%, transplanting was 85.50%, weeding was 94.97% and harvesting was 43.20%. The mechanization of transplanting and weeding was deemed most important. Rasooli Sharabiani and Ranjbar (2008) investigated the status of farm mechanization in Sarab district in East Azerbaijan province in Iran. They showed that the overall power per unit of area in spring 2008 was 0.83 *hpha*$^{-1}$. The contribution to mechanization by animals was 1.24%, by humans was 2.23%, and by machinery 96.35% in the study area. Their results emphasized the importance of the use of machinery for agricultural activities in the region. Rasouli *et al*. (2010) studied the factors affecting farm mechanization of sunflower cultivation in Iran. Power per unit area was determined to be 0.5 kWha^{-1} (1.67 *hpha*$^{-1}$). Shahraki *et al.* (2012) studied the quantity and quality of agricultural mechanization in Sistan and Baluchistan Province in Iran using statistics from the Agricultural Jihad Organization. Their study showed that the degree of mechanization of agricultural activities, especially for harvesting in Sistan and Baluchistan was much lower than for most developing countries. The power per unit area (0.68 *hpha*$^{-1}$) was also low. They recommended consolidation of agricultural land, provision of appropriate technology, availability of appropriate educational and promotional programs, and support for agricultural mechanization service companies for provision of farm machinery to promote agricultural mechanization in Sistan and Baluchistan Province. Loveimi and Almasi (2003) investigated the status of mechanization in the northern region of Ahwaz in Iran and found that the average power per unit area was 1.1 *hpha*$^{-1}$.

To increase agricultural mechanization, the quality and quantity of mechanization should be evaluated in detail for each region. Macroplanning can best be performed with knowledge of existing conditions. The present study investigated the status of mechanized power and self-propelled rice cultivation machinery in Guilan province in northern Iran.

MATERIALS AND METHODS

This study was conducted in Guilan Province in northern Iran. Rice, peanuts, tea, olives, kiwi fruit, and vegetables are the major agricultural and horticultural products in this province, but most farmers cultivate rice in paddy fields. Total rice cultivation is about 237000 ha, which ranks second among the rice-growing provinces of the country. Its annual production is estimated to be about 700,000 tons of white rice, which ranks first in Iran.

The present study investigated the mechanization level of agricultural operations (land preparation, planting, plant protection, and harvesting), area per self-propelled rice machinery, mechanization requirements for each agronomical operation, and power per unit of area in 16 cities in Guilan Province. Raw mechanization data from 2013 statistics of the Agricultural Jihad Organization of Guilan Province was employed to prepare this study.

Mechanization level

This is a quantitative index of the mechanized agronomic activity and equals the area under mechanized cultivation divided by the total area under cultivation (Lak and Almassi, 2011). This index is used to determine the ratio of mechanized operations at different agricultural stages. The mechanization level is often estimated for individual crops especial operations separately (Lak and Almassi, 2011):

$$ML=A_M/A_C \quad (1)$$

Where: ML =mechanization level (%); AM = mechanized cultivated area *(ha)*; AC = total cultivated area *(ha)*.

Power per unit of area

This is a qualitative index used in macroplanning and development of agricultural mechanization. It is the ratio of the total drawbar power available in a region to the total area under cultivation (Lak and Almassi, 2011):

$$PPA=P_d/A_c \ (hpha^{-1}) \quad (2)$$

Where: PPA = Power Per unit of Area *(hpha*$^{-1}$*)*; P_d = total machinery power *(hp)*;

A_c = cultivated area *(ha)*.

The power per unit of area is similar to the

power per capita for agricultural land and shows the average power available per unit of cultivated agricultural land. The unit used to describe this index is horsepower per hectare *(hpha^{-1})* or kilowatt per hectare *(kWha^{-1})*. Because of the nature of rice cultivation and the fact that most equipment used in rice cultivation is self-propelled, all motorized power (two-wheeled and four-wheeled tractors, rice transplanters and weeders, self-propelled harvesters, rice combines) were included in the calculations. The actual power was calculated by multiplying the total rated power by 0.75.

Area per self-propelled rice machinery

This index determines the average area of land under cultivation worked by each self-propelled machine (transplanter, weeder, rice combine). This index was obtained by dividing the total area under cultivation by the total number of respective machines.

$$APSM=A_C/N_{SM} \quad (3)$$

Where: APSM= Area per self-propelled machinery *(ha machine^{-1})*; A_C= total cultivated area *(ha)*; N_{SM}= number of self-propelled machinery.

Mechanization requirement

This index was calculated using the simple mathematical relation of 100 minus the mechanization level for each agronomical operation (Khambalkar *et al.,* 2010; Zangeneh *et al.*, 2010).

$$MR=100-ML \quad (4)$$

Where: MR= mechanization requirement (%); ML= mechanization level (%).

Analysis of data

After entering the raw data into Excel software, the means of the mechanization indices were calculated. The measure of standard error (SE) was calculated for each part of Guilan (east, west, central) and for the whole province. This statistical criterion indicates variation in the indices. The SE was calculated by dividing the standard deviation of the data by the square root of the number of data.

RESULTS AND DISCUSSION

The important indicators for power per unit of area and mechanization level were computed to determine the level of mechanization of

Table 1: Mechanization level (%) of farming various operations and power per unit of area *(hpha^{-1})* in paddy fields of Guilan province.

Part of province	City	Mechanization level (%)				Power (unit area)$^{-1}$
		Tillage	Transplanting	weeding	harvesting	
WEST	Astara	100.00	32.28	1.09	29.06	2.00
WEST	Rezwanshahr	100.00	82.57	4.95	49.90	3.64
WEST	Talesh	100.00	51.00	0.18	29.81	3.26
WEST	Shaft	100.00	6.32	0.00	34.44	1.13
WEST	Somesara	100.00	9.60	0.23	69.59	1.98
WEST	Fuman	100.00	17.16	0.22	17.84	1.09
WEST	Masal	100.00	82.86	2.24	72.86	1.40
Average		100.00	40.25±12.35	1.01±0.68	43.36±8.05	2.07±0.38
CENTRAL	Anzali	100.00	21.06	0.13	76.45	2.83
CENTRAL	Rasht	100.00	8.99	0.00	53.08	1.91
CENTRAL	Roudbar	100.00	35.53	0.23	99.20	4.53
Average		100.00	21.86±7.67	0.79±0.07	76.24±13.31	3.09±0.77
EAST	Astaneh	100.00	21.48	1.57	59.19	2.64
EAST	Amlash	100.00	17.71	0.09	27.57	1.70
EAST	Roudsar	100.00	7.62	0.23	30.23	2.06
EAST	Siahkal	100.00	12.29	0.00	23.05	2.38
EAST	Lahijan	100.00	6.13	0.05	38.82	1.45
EAST	Langaroud	100.00	13.19	0.23	49.45	3.06
Average		100.00	13.07±2.39	0.36±0.24	38.05±5.70	2.22±0.24
Total (Mean)		100.00	26.61±6.26	0.72±0.34	47.53±6.18	2.32±0.29

Table 2: Area per unit of self-propelled rice machinery *(ha machine^{-1})* in the paddy fields of Guilan Province.

Part of Province	City	Transplanting	weeding	Reaper	Combine harvester
WEST	Astara	37.65	640.00	94.12	3200.00
WEST	Rezwanshahr	21.37	555.56	103.09	333.33
WEST	Talesh	70.43	5329.00	134.34	1141.93
WEST	Shaft	220.46	14330.00	114.64	3582.50
WEST	Somesara	147.22	4662.00	63.57	570.86
WEST	Fuman	167.11	6935.00	62.48	4623.33
WEST	Masal	32.11	7000.00	34.15	1166.67
Average		99.48	5635.94	86.63	2088.37
CENTRAL	Anzali	54.77	803.33	15.35	344.29
CENTRAL	Rasht	289.93	10389.33	82.02	1326.30
CENTRAL	Roudbar	88.87	3377.00	99.32	375.22
Average		144.53	4856.56	65.56	681.94
EAST	Astaneh	130.94	3928.33	179.92	130.94
EAST	Amlash	145.83	875.00	233.33	437.50
EAST	Roudsar	267.50	5350.00	356.67	205.77
EAST	Siahkal	113.69	2217.00	158.36	4434.00
EAST	Lahijan	243.02	23816.00	517.74	154.65
EAST	Langaroud	115.19	4550.00	700.00	100.00
Average		169.36	6789.39	357.67	910.48
Total (Mean)		111.38	3777.97	91.09	358.99

paddy fields in Guilan Province. All engine power including small and medium power tractors (average respective power of 35 and 60 *hp*), 2-wheeled tractors (power tillers with an average power of 7 *hp*), self-propelled rice machinery (rice transplanters, weeders, reapers and combine harvesters) were considered when calculating the mechanization level.

Table 1 show the mechanization level (ML) of land preparation in all sections of Guilan province Province is 100%. Farming operations generally include energy-intensive and control-dependent operations. Primary and secondary tillage are energy-intensive operations (Almassi *et al.*, 2006). This attribute, the limited time for tillage, and the negative effects of delay in land preparation on on time the other agronomical operations and the degree of mechanization of tillage for all cities in Guilan is 100%.

The lowest level of mechanization for rice transplanting was 6.13% in Lahijan in eastern Guilan followed by 6.32% in Shaft in western Guilan. The highest level of mechanization also was determined as 82.86% in Rezvanshahr followed by 82.57% in Masal in western Guilan, which represents a relatively desirable state of mechanization for rice transplanting in this region. The low level of mechanization for transplanting in Lahijan may be attributed to the small size, irregular geometry and dispersal of the paddy fields. Success in full implementation of land consolidation projects can improve the mechanization indicators for transplanting. The high cost of rice transplanting machinery and technical issues associated with their operating, problems in the preparation and supply of seedlings are the other important barriers for development of mechanized rice transplanting in Guilan province.

Table 1 show that the average mechanization level for rice weeding in Guilan is very low (about 0.72%). The mean values for mechanization level of rice weeding operation in western, eastern and central Guilan were determined to be 1.01, 0.36, and 0.79, respectively. The lesser mechanization level for rice weeding in comparison with other agricultural operations is unfavorable and requires more attention than the other agronomical operations.

It should be noted that mechanized rice weeding technically depends on the mechanization of transplanting. Transplanting should be mechanized

before mechanizing the rice weeding operation. Table 1 show that the possibility of developing mechanization of rice weeding in Masal and Rezvanshahr are 82.86% and 82.57%, respectively. Indeed, these values are the mechanization levels of rice transplanting operation in Masal and Rezvanshahr, respectively. The shortage of rice weeding machinery in Guilan and the high price of rice weeders also effect the development of mechanization of rice weeding.

The average mechanization level of rice harvesting operation is desirable at 47.53%. The mechanization level of rice harvesting in central Guilan (76.24%) was higher than those of eastern and western Guilan (at 38.05% and 43.36%, respectively). This emphasizes the need to provide rice harvesting machinery to farmers in western and eastern Guilan. The physical strain associated with manual harvesting, high cost of manual harvesting, and the sensitivity to delays in rice harvesting caused by unstable weather at harvest time in northern Iran rank mechanization of harvesting as second to land preparation.

The average Power Per unit of Area (PPA) in paddy fields of Guilan province was 2.32 hpha-1 (Table 1). The power per unit area for central Guilan (3.09 $hpha^{-1}$) was higher than those of the eastern and western Guilan (2.22 and 2.07 hpha-1). These values are less than those reported by Ampratwum *et al*. (2004) in Oman, Rasooli Sharabiani and Ranjbar (2008) in Sarab, Shahraki *et al.* (2012) in Sistan and Baluchistan, and Loveimi and Almassi (2003) in northern Ahwaz. However, it should be noted that rice cultivation is more labor intensive than cultivation of other types of agriculture and requires more power.

The Average area Per Self-propelled rice Machinery (APSM) is shown in Table 2. According to the results, there is only one transplanter for every 111 ha of paddy fields in Guilan province. This index in Rasht is about 290 ha per machine. While manual transplanting provides uniform crop stand but it is quite expensive and needs a lot of labor besides involving a lot of drudgery (Manjunatha *et al.*, 2009). Singh *et al.* (1985) stated that rice transplanting needs about 250-300 man hours ha^{-1} which is about 25% of the total labor requirement for rice cultivation. More consideration should be paid for this aspect of rice mechanization in Guilan.

There is only one rice transplanter for every 3778 ha of paddy fields (Table 2). Depending on the type and density of weeds in the paddy field, 10 to 15 workers per hectare are needed for rice weeding (Alizadeh, 2011). This illustrates the high labor force needed for manual compared to mechanical weeding and suggests that mechanization requires special consideration.

The mean area per rice combine was 359 ha, which is relatively good compared with weeding machinery. The higher area per combine harvester can be attributed to the independence of mechanization of rice harvest from the other operations (transplanting and weeding) and the difficult

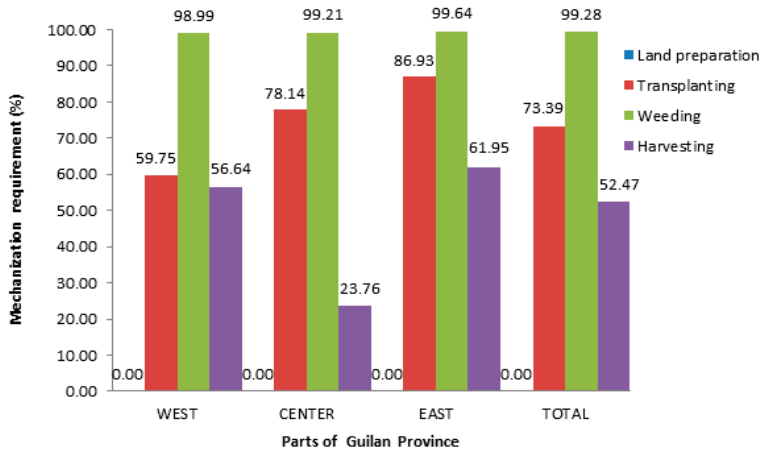

Figure 1: Mechanization requirement for various agronomic operations in paddy fields for different parts of Guilan province.

conditions for rice harvesting. The importance of timely harvesting of rice, limited time for harvest and cost-intensiveness of manual harvesting of paddy rice are additional factors.

Figure 1 shows the Mechanization Requirements (MR) for agronomic operations for paddy cultivation in Guilan Province. The mechanization requirement of land preparation equals zero.

The mechanization requirement of rice weeding operation in Guilan province is 99.28%. This figure underlines the urgency of removing barriers for development of mechanization of rice weeding in Guilan Province.

CONCLUSIONS

Results of this research indicated that except for tillage operation, there were considerable differences in mechanization level of various rice agronomical operations in three main regions of Guilan Province, Iran. The power per unit of area for central Guilan was higher than those of the eastern and western Guilan. The highest mechanization requirement was determined as 99.28% for rice weeding followed by 73.39% for rice transplanting operation. Therefore, increasing the machinery available for weeding operation needs to be given the topmost priority for mechanization of paddy cultivation in Guilan Province, Iran.

ACKNOWLEDGEMENTS

The author is grateful for the funding supplied by the Rasht branch, Islamic Azad University.

REFERENCES

1- Alizadeh, M.R. (2011). Field performance evaluation of mechanical weeders in the paddy field. *Scientific Research and Essays* 6(25), 5427-5434. http: //dx.doi.org/10.5897/ SRE11.1412

2- Almassi, M., Loveimi, N. & Kiani, S. (2006). *Farm machinery management.* Ferdowsi University of Mashhad Press, Mashhad, Iran, P. 282. (In Persian).

3- Ampratwum, D., Dorvlo, A. & Opara, L. (2004). Usage of tractors and field machinery in agriculture in Oman. *Agricultural Engineering International: the CIGR Journal of Scientific Research and Development.* VI, 1-9.

4- Firouzi, S. (2014). An assessment of rice cultivation mechanization in Northern Iran (Langarud County in Guilan Province). *International Journal of Biosciences*, 5(3), 110-115.

5- Karale, D.S., Khambalkar, V.P., Bhende, S.M., Amale, S. & Wankhede, P. (2008). Energy economic of small farming crop production operations. *World Journal of Agricultural Science*, 4(4), 476-482.

6- Khambalkar,V.P. Jyoti, P., Sachin, K., Dipak, B. & Shilpa, D. (2010). Energy and economic evaluation of farm operations in crop production. *Journal of Agricultural Science,* 2(4), 191-200.

7- Lak, M.B. & Almassi, M. (2011). An analytical review of parameters and indices affecting decision making in agricultural mechanization. Australian *Journal of Agricultural Engineering*, 2(5), 140-146.

8- Loveimi, N. & Almassi, M. (2003). Investigation of the status of mechanization in north of Ahwaz county. *Iran Journal of Science and Technology of Agriculture and Natural Resources, Water and Soil Sciences,* 7(2), 227-239. (In Persian).

9- Manjunatha, M.V., Masthana Reddy, B.G., Shashidhar, S.D., & Joshi, V.R. (2009). Studies on the performance of self-propelled rice transplanter and its effect on crop yield. *Karnataka Journal of Agricultural Science*, 22(2), 385-387.

10- Paman, U., Inaba, S. & Uchida S. (2012). Power availability and requirements for small-scale rice farm operations: A case in Riau Province, Indonesia. *American Journal of Agricultural Science Engineering and Technology*, 1(2), 27-36.

11- Pateriya, R.N. & Datta, R.K. (2012). Design modifications of Mat Type Rice transplanter. *International Journal of Advanced Technology & Engineering Research* (IJATER), 2(6), 87-91.

12- Rahman, M.S., Monayem Miah, M.A., Moniruzzaman & Hossain, S. (2011). Impact of farm mechanization on labor use for wheat cultivation in Northern Bangladesh. *The Journal of Animal and Plant Sciences,* 21(3), 589-594.

13- Rasooli Sharabiani, V. & Ranjbar, I. (2008). Determination of the degree, level and capacity indices for agricultural mechanization in Sarab Region. *Journal of Agricultural Science Technology*, 10, 215-223.

14- Rasouli, F., Sadighi, H. & Minaei, S. (2010). Factors affecting agricultural mechanization: a case study on sunflower seed farms in Iran. *Journal of Agricultural Science Technology*, 11, 39-48.

15- Shahbazi, I. (1989). Agriculture advancement: the requirements of change and renewal of agriculture. [Translation.] Publication of Agriculture Dissemination Organization, Tehran, Iran. PP. 22-35. (In Persian)

16- Shahraki, J., Shahrakizad, A., Yaghoubi, M. &

Esfandiari, M. (2012). A survey on the level of mechanization development in Sistan and Baluchestan, Iran. *Journal of Applied Sciences Research,* 8(4), 2267-2271.

17- Singh, G. (2006). Estimation of a mechanization index and its impact on production and economic factors a case studies in India. *Biosystems Engineering,* 93(1), 99–106.

18- Singh, G., Sharma, T.R. & Bockhop, C.W. (1985), Field performance evaluation of a manual rice transplanter. *Journal of Agricultural Engineering Research,* 32, 259-268.

19- Yohanna, J.K., Fulani A.U. & Aka'ama, W. (2010). A survey of mechanization problems of the small scale (peasant) farmers in the Middle Belt of Nigeria. *Journal of Agricultural Science*, 3(2), 262-266.

20- Zangeneh, M., Omid, M. & Akram, A. (2010). Assessment of agricultural mechanization status of potato production by means of artificial neural network model. *Australian Journal of Agricultural Science,* 4(5), 372-377.