An assessment of rice cultivation mechanization in Northern Iran (Langarud County in Guilan Province)

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Key words: Mechanization index, mechanization level, power.

Abstract

The present study reviewed the status of mechanized power and self-propelled paddy cultivation machinery in Langarud County in the province of Guilan in northern Iran. The data was collected in 2012 by questionnaire from paddy farmers and mechanization corporations in five rural districts (Chaf, Divshal, Gelsefid, Komleh, and Otaqvar). The following mechanization indices were calculated for each rural district and the entire region: unit area power, mechanization level, area per tractor, area per machine, and mechanization requirement. The results showed that the mean unit area power was 1.37 hp ha⁻¹. There was considerable difference between mechanization indices in the rural districts. The regional mechanization requirement for land preparation was 0, for transplanting was 81.50%, for weeding was 94.97%, and for harvesting was 43.20%. The area per four-wheeled tractor was 176.42 ha, and cultivated area per machine for transplanting was 416.36, for weeding was 2081.80, and for combine harvesting was 88.21 ha. This indicates that there is insufficient mechanization for weeding followed by transplanting and that there is an urgent need to increase the available machinery for these operations in the paddy fields of Langarud County.

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http://dx.doi.org/10.12692/ijb.5.3.110-115 Article published on August 08, 2014
Introduction

Agricultural macro-planning requires sufficient knowledge of the status of mechanization for the different types of farm and garden produce in a region. The use of power and machinery are aspects of agricultural mechanization that are required for planning of agricultural mechanization by region and by country. Researchers have investigated the use of qualitative and quantitative mechanization indices to evaluate the development of mechanization in agronomic operations.

Min-Li and Ren Pu (2000) determined farm mechanization indices for the level mechanization for planting and harvesting, unit area power, and economic indices of farmer annual income and agricultural acreage per farmer to determine the level of agricultural mechanization in China. Their recommendations for improving the application of technology in agriculture depended on the current state of technology and the climate and topography of the area. Zangeneh et al. (2010) assessed the mechanization status (level of mechanization and mechanization index) of potato farms in Iran by an artificial neural network (ANN) model. Abbasi et al. (2011) determined the unit area power in Kabudarahang County in the province of Hamedan in Iran to be 0.79 hp. Their estimates revealed that this index should be increased to 1.33 hp ha⁻¹. Ozmerzi and Berek Barut (1998) determined the unit area power in Turkey to be 1.73 kW ha⁻¹, which is higher than the world average. In the province of Antalya, the unit area power was 3.9 kW ha⁻¹, which exceeds both Turkish and global averages. Mora and Albrecht (1992) investigated the level of mechanization on 47 farms with areas of 2 to 10 ha located in the province of Krosno in southeastern Poland. They found that the level of mechanization was 74-79% on larger farms and that size and fragmentation of the farms were the main obstacles to mechanization in the region.

The results of the farm mechanization index in South west of Nigeria showed that the average level of mechanization in Ogun and Osun States were 31.3 % and 28.6 %, respectively and the average level of mechanization in the two States was 30.6 % (Olaoye and Rotimi, 2010). Khambalkar et al. (2012) used an index termed “mechanization requirement” and determined values of 38.47% for primary tillage, 96.64% for secondary tillage with rotovator, 29.27% for secondary tillage with cultivator, 75.72% for inter-row agronomic operations (inter-row weeding), 63.05% for pesticide spraying, and 57.26% for planting for the 2010-2011 agricultural season.

Traditional cultivation of rice in Iran increases costs, thus decreasing farming profits. As a result, the level of income is low, and farmers are forced to change their rice fields into orchards or use their lands for other high-income activities. Therefore, in order to increase farming income, the development of mechanization is essential. With implementation of mechanization, the cost of cultivation may be reduced to a considerable level (Roy and Bezbaruah, 2002).

To develop a successful mechanization plan, the status of current conditions and potentials should be studied. A review of the literature showed that some researches were conducted to study the mechanization indices in Iran (Abbasi et al., 2011; Zangeneh et al., 2010, Rasooli Sharabiani and Ranbar, 2008; Loveimi and Almasi, 2003), but no study has focused on the evaluation of paddy field mechanization in north of Iran. Therefore, this research aims to determine the mechanization indices including unit area power, mechanization level, area per machine, and calculate the mechanization requirements for transplanting, weeding, and harvesting the rice in Langarud region at north of Iran. Determination of these indices, particularly for mechanization requirement can advance macro-regional planning in agricultural sector.

Materials and methods

Langarud County is located in eastern Guilan province in the north of Iran. The dominant farm and garden produce of the area is rice, tea, and vegetables. Most farmers cultivate rice in paddy fields and total cultivation equals about 10,000 ha, which ranks third
among the cities of the province. The following indices were investigated in the five rural districts of Langarud County in 2012: mechanization level for each agronomic operation (tillage, planting, weeding, harvest); unit area power; area per tractor; area per self-propelled rice machinery, and mechanization requirement.

**Mechanization level**
This is a quantitative index of the mechanized agronomic activity and is equal to the area under mechanized cultivation divided by the total area under cultivation. This index is used to determine the ratio of mechanized operations at different agricultural stages (Lak and Almassi, 2011).

**Unit area Power**
This is a qualitative mechanization index used in macro-planning and development of agricultural mechanization in any region. It is equal to the ratio of the sum of motorized power available in the region to the total area under cultivation. The unit area power is similar to the per capita power for agricultural land and shows the average power available per unit of cultivated agricultural land (Lak and Almassi, 2011). The unit used to describe this index is horsepower per hectare (hp ha\(^{-1}\)) or kilowatt per hectare (kW ha\(^{-1}\)). 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 weeder, 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 tractor**
This index determines the mean share of agricultural land worked by each tractor. It is obtained by dividing the total area under cultivation by the total number of four-wheeled tractors.

**Area per transplanter, weeder, and rice combine**
These indices determine the average area of land under cultivation worked by each self-propelled machine (transplanters, weeder, rice combines). Each index was obtained by dividing the total area under cultivation by the total number of the respective machine.

**Mechanization requirement index**
This index was calculated using a simple mathematical relation of 100 minus the mechanization level for each agronomical operation (Soliman et al., 2010; Kambalkar et al., 2010).

The data required was gathered using a questionnaire asking each farmer the area under cultivation, area under mechanized cultivation (land preparation, planting, plant protection, harvest), the technical specifications of all tractors and agricultural machinery allocated to each farmer and the companies offering mechanization services. The indices were calculated from the formulation after entering the data into the Excel environment.

**Results and discussion**
Mechanization level and unit area power of area were computed to assess the status of motorized power and rice machinery in the study region. Calculation of the unit area power included all motorized power (35 hp medium-sized and 60 hp large-sized tractors), two-wheeled tractors (power tillers with an average power of 7 hp), self-propelled weeder, self-propelled rice reapers (only built- in engine type), and rice/grain combines. Table 1 shows that the mechanization level of land preparation in all districts was 100%. Agronomical operations generally consist of energy-intensive and control-dependent operations. Primary and secondary tillage operations are energy-intensive (Almassi et al., 2006). This, in addition to time limitations for land preparation, the consequences for preceding operations caused by delays in land preparation, and the extreme physical endurance required brought about 100% mechanization for tillage in the agricultural districts.

Table 1 also shows that the mechanization level for transplanting was from 4.27% to 50% with an average of 18.5%. The high prices charged for transplanters
and technical problems associated with such machines, especially in non-aligned and irregularly-shaped plots, limited mechanization of transplanting the rice in all districts.

The mechanization level for weeding was less than 10% for all districts and had a mean of 5.03%, indicating that mechanization of rice weeding requires serious attention. The development of mechanization for rice weeding technically depends on the overall level of mechanization for transplanting rice. So, the transplanting mechanization is a prerequisite for mechanization of rice weeding. The mechanization level of weeding has the potential to increase to the mean value of the current transplant mechanization level (18.50%).

Table 1. Mechanization level (%) of farming operations and unit area power (hpa⁻¹) in paddy fields of Langarud county in Guilan, Iran.

<table>
<thead>
<tr>
<th>Rural district</th>
<th>Tillage</th>
<th>Transplanting</th>
<th>Weeding</th>
<th>Harvesting</th>
<th>Power (unit area)⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chaf and chamkhaleh</td>
<td>100.00</td>
<td>4.27</td>
<td>2.99</td>
<td>79.70</td>
<td>1.37</td>
</tr>
<tr>
<td>Otaqvar</td>
<td>100.00</td>
<td>48.54</td>
<td>0.00</td>
<td>40.78</td>
<td>2.38</td>
</tr>
<tr>
<td>Komleh</td>
<td>100.00</td>
<td>50.00</td>
<td>10.00</td>
<td>38.89</td>
<td>0.87</td>
</tr>
<tr>
<td>Divshal</td>
<td>100.00</td>
<td>11.64</td>
<td>5.59</td>
<td>52.17</td>
<td>1.12</td>
</tr>
<tr>
<td>Gelsefid</td>
<td>100.00</td>
<td>15.65</td>
<td>3.53</td>
<td>31.76</td>
<td>2.71</td>
</tr>
<tr>
<td>Total</td>
<td>100.00</td>
<td>18.50±9.67</td>
<td>5.03±1.66</td>
<td>56.80±8.42</td>
<td>1.37±0.36</td>
</tr>
</tbody>
</table>

Table 1 also shows that harvesting enjoys a higher level of mechanization than planting and weeding. The mean mechanization level for harvesting with rice combines in Langarud County was 56.80%. The physical strain associated with manual harvesting, high cost of manual compared to mechanized harvesting, and the sensitivity to delays in rice harvesting caused by unstable weather at harvest time in north of Iran contribute the rank of the mechanization level of harvesting as second only to land preparation.

The mean unit area power in Langarud was about 1.37 hp ha⁻¹. The last column of Table 1 shows that unit area power of the different districts was 0.87 to 2.71 hp ha⁻¹. The undesirable conditions for mechanization of agronomic operations in Gelsefid district, with a maximum unit area power of 2.71, are noteworthy. The higher mean value of the unit area power of area in this district can be attributed to tractor power, not to self-propelled rice machinery.

The degree of mechanization for transplanting and harvesting rice in Otaqvar district (Table 1) is similar to the corresponding values for Komleh district. The unit area power in Komleh (0.87 hp ha⁻¹) was less than that for Otaqvar (2.38 hp ha⁻¹). This suggests that improving the degree of mechanization is not only a function of the unit area power. Increasing the mechanization level and minimum unit area power is a result of better farm management (Almassi et al., 2008).

Fig. 1 also confirms the poor state of mechanization of weeding operation compared to other agricultural operations. So, the need for weeding and transplanting mechanization of rice cultivation were
94.97 and 81.50 percent, respectively, showing the necessity to more consideration of these aspects of rice mechanization in Langerud County in Iran.

Fig. 2 shows the mean area per tractor (four-wheeled) and area per self-propelled rice machinery (transplanter, weeder, combine harvesters) and indicates that on average only one tractor exists for every 176.42 ha of paddy fields in the county. Part of this shortfall can be resolved using two-wheeled tractors or power tillers, particularly in areas where a paddy field consolidation plan has not been implemented. Fig. 2 shows that only one rice transplanter exists for every 416.36 ha and only one self-propelled weeder exists per 2081.80 ha of paddy land. Labor force saving, timely planting and optimum planting density in mechanized paddy cultivation improve the productivity of rice production (Manjunatha et al., 2009). Besides, depending on the type and density of weeds in paddy field, 10 to 15 workers per hectare is needed for weeding. Therefore, the high labor force of manual compared to mechanical weeding suggests that mechanization of rice weeding in the region requires special attention.

The mean agronomic land per rice combine was 88.21 ha, which is relatively favorable status compared with transplanting and weeding. The higher acreage per combine harvester contributes to a) independence of rice harvest operation from the mechanization of transplanting and weeding, b) demanding conditions of rice harvest operation, c) the importance of timely harvesting the rice and time limitations at harvest season, d) cost-intensiveness of the manually harvesting of paddy rice.

**Conclusions**

It was concluded that the mean unit area power was 1.37 hp ha⁻¹ for paddy fields of Langerud County in Iran. There was considerable difference between mechanization indices in the rural districts of the region. Total mechanization requirement for land preparation, transplanting, weeding, and combine harvesting were calculated as 0, 81.50%, 94.97%, and 43.20%, respectively. Therefore, due to higher mechanization requirement for weeding followed by transplanting, there is an urgent need to increase the available machinery for these operations in the paddy fields of Langerud County.

**Acknowledgements**

The author would like to appreciate the support of the Rasht Branch, Islamic Azad University.

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