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A Pattern to Distribute Tractor Power from the Viewpoint of Energy Case Study: Isfahan Province in Central Region of Iran

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Abstract: One of the important problems in agriculture, especially in developing countries, is the shortage of tractor power in agricultural fields. In this study distribution of available tractor power among townships of Isfahan province was investigated. Output energy from fields of each township and also potential energy of available tractors was calculated for three years. These two factors helped to present a mechanization index (w). This index shows amount of output energy relative to available tractor power for each township. Through all townships, Barkhar and Meymeh had maximum value of this index (9.45) and Semmirom had minimum of that (1.36). Townships were classified according to amount of their need to tractor power using mechanization index (w) and degree. This pattern can be used to distribute power among townships. Also, in order to raise mechanization index (w) and degree was recommended to use appropriate agronomical pattern so that operations needing to tractors must be optimally spread during year.

Key words: Tractor power · mechanization degree · energy · mechanization level

INTRODUCTION

Today, tractor is one of the most important power sources I n agriculture. Effect of tractor power on agriculture is considerable [1]. The use of modern technology during latter decades resulted in rapid growth of farm production. Tractors and farm machinery are important samples of this modern technology [2-4]. The quality of inputs of mechanization and consequently land and labor productivity in both situations, may differ considerably [5-7]. Mechanization planning requires the quantitative assessment of a mechanization index and its impact on agricultural production (yield) and economic and energy factors (cost of cultivation, deployment of animate and mechanical power, economic advantage and energy ratio). Several authors have studied the status of mechanization with reference to the intensity of power or energy availability and its impact on increasing the agricultural productivity. Giles [8] reviewed power availability in different countries and demonstrated that productivity was positively correlated with potential unit farm power. The impact of tractorization on the productivity of land (yield and cropping intensity) and economic growth (income and employment) were previously assessed [9]. The trends of European and Asian countries were, however, distinctly different. Binswanger [10] defined the status of mechanization by the growth of mechanically power operated farm equipment over traditional human and animal power operated equipment. Rijk [11] reviewed the growth of mechanization in different Asian countries and suggested computer software (MECHMOD) for the formulation of strategy for mechanization policy based on economy of using animate and mechanical power for different field operations. Singh and De [12] reviewed the methodologies adopted by several authors to express a mechanization indicator. A major defect in quantifying a mechanization indicator based on the ratio of mechanical tractive farm power to total farm power is that it does not bring to light the actual use scenario. Whilst unit farm power could be considered as indicative of potential power availability, it may not necessarily be fully utilized on the farms. This may depend upon availability of diesel fuel and electricity and adequate workload. The majority of the farmers in developing countries use tractors for transport of agricultural and non-agricultural commodities.

Mechanization index (IE) expressed by the percentage of machine work (EM) to the sum of manual (EH), animal (EA) and machine work (EM) expressed in energy units, as suggested by Nowacki [13], has been accepted for model forecasting using Eq (1):

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$$IE = \frac{EM}{EH + EA + EM} \quad (1)$$

Despite this, in developing countries such as Iran, shortage of tractor power is one of the most important problems in agriculture. For an agricultural enterprise, tractors are the most expensive farming input after farm buildings [14]. Therefor, available tractor should be used as much as possible. Demirci [15] suggested that minimum tractor usage should be 650 h a year and effective usage should be 850–1000 h a year in Turkey. Sabanci *et al*. [16], in their study of agricultural mechanization in Turkey, concluded that more emphasis should be placed on improvements such as transition to small but powerful tractors, increasing the annual usage of tractors, diversifying agricultural machinery to use tractors more effectively with planning of mechanization. In this way, it was expected to make better use of mechanization in terms of economics and management.

For macro-level planning, distribution of tractors among different regions must be on the basis of the amount of their need to tractor power. Proper distribution of tractors will cause to increase annual usage of tractors and consequently to increase the mechanization level thorough out the regions. In this study, it is embarked that a pattern to distribute tractors among the townships of Isfahan province be presented to improve the mechanization of the province by describing mechanization indexes.

MATERIALS AND METHODS

The province of Isfahan covers an area of approximately 107,027 square km and is situated in the center of Iran (Fig. 1). The province usually experiences a moderate and dry climate and temperature on the whole, ranging between 40.6 and 10.6°C on a cold day in the winter season. The average annual temperature has been recorded as 16.7°C and the annual rainfall on an average has been reported as 116.9 mm. This province has 20 townships that their geographical characteristics were presented in Table 1.

The number of available tractors for each township and also their areas under cultivation and their crops yield were studied for 2003, 2004 and 2005, separately. Accumulated data was used in this investigation. Mean of drawbar power per unit area for a hectare (Mechanization Level) was calculated by Eq (2):

$$ML = \frac{P_a \times 0.75}{S_T} \quad (2)$$

Fig. 1: Geographical situation of Isfahan province in Iran

where ML is Mechanization Level (kW/ha), P_a is the total available power of tractor in each township (kW) and S_T is Total planted area (ha).

Ratio of mechanized operations to the total operations (Mechanization degree) was calculated by Eq (3):

$$MD = \frac{S_m}{S_T} \quad (3)$$

where MD is Mechanization degree and S_m is the area under mechanized operations (ha).

Mean of mechanization levels and degrees as well as planted area from 2003 to 2005 related to each townships of Isfahan province were individually presented in Table 2.

Potential energy of available tractors in a township means to use all the present tractors with their maximum power in total possible time so that maximum energy is producted tractors. Of course, it can not be occurred. It is imagined that the tractors are used with their maximum power for total workable hours. The workable hours was obtained by number of working days multiplied by 8 working hours. The unworkable days that tractors are unusable, are recognized by two factors. First, tractor is needed to work but it is unable because of inappropriate atmospheric condition. This is ordinarily occurred in cold part of year due to snowfall, rainfall, freezing, etc. second, days that tractor is able to work but it is not needed to work tractor becausethere isn't cultivated farm due to dry weather and water shortage to irrigate. This is ordinarily occurred in hot season of a year. Therefore the number of workable days is equal to the difference between total

Table 1: Geographical characteristics of townships of Isfahan province

Township	Longitude	Latitude	Area (km^2)	Altitude (m)	Township	Longitude	Latitude	Area (km^2)	Altitude (m)
Aran & Bidgol	51°29'	34°4'	6051	911	Khansar	50°19'	33°13'	962	2250
Ardestan	52°22'	33°23'	12572	1205	Khomeiny Shahr	51°32'	32°41'	190	1595
Barkhar & Meymeh	51°34'	32°52'	6950	1590	Lanjan	51°23'	32°23'	1192	1700
Chadegan	50°13'	32°32'	1200	2932	Mobarakeh	51°30'	32°21'	1111	1665
Falaverjan	51°31'	32°33'	339	1610	Na'een	53°05'	32°52'	33751	1545
Faridan	50°22'	32°58'	3255	2390	Najaf Abad	51°22'	32°38'	4090	1650
Ferydoun Shahr	50°7'	32°56'	2166	2530	Natanz.	51°54'	33°31'	3400	1650
Golpayegan	50°17'	33°27'	1636	1830	Semmirom	51°34'	31°25'	5231	2460
Isfahan	51°39'	32°38'	15520	1575	Shahreza	51°52'	32°01'	4427	1825
Kashan	51°27'	33°59'	10310	950	Tiran	51°9'	32°42'	1524	1640

Table 2: Mean of mechanization level, degree and planted area from 2003 to 2005

Township	Mechanization level (kW/ha)	Mechanization degree (%)	Area (ha)
Aran & Bidgol	1.33	0.64	8994
Ardestan	1.42	0.40	15405
Barkhar & Meymeh	1.35	0.45	21762
Chadegan	1.88	0.68	20072
Falaverjan	1.10	0.50	14074
Faridan	2.25	0.65	34048
Ferydoun Shahr	2.51	0.75	12033
Golpayegan	2.38	0.70	17933
Isfahan	2.66	0.72	72922
Kashan	1.80	0.50	6509
Khansar	2.39	0.63	3735
Khomeiny Shahr	4.26	0.42	4089
Lanjan	3.65	0.65	4752
Mobarakeh	3.47	0.06	14491
Na'een	3.36	0.62	2428
Najaf Abad	3.55	0.65	8680
Natanz.	1.80	0.40	6950
Semmirom	2.81	0.78	21426
Shahreza	2.45	0.70	14346
Tiran	4.11	0.40	8033

days (both workable and unworkable) and unworkable days during one year. In order to omit impact of area on the potential energy of available tractors for a region Eq (4) were:

$$E_P = \frac{E_{TP}}{S_T} \quad (4)$$

where E_P is the potential energy of available tractor in unit area (MJ/ha) and E_{TP} is the total potential energy of available tractors (MJ).

In each township, the amount production of diffirent cropes was multipled by their specific energy value individually. It was carried to calculate the produced energy in the agricultural section of each township. The mean output energy in unit area was calculated by Eq (5):

$$E_{out} = \sum_{i=1}^{n} \frac{EV_i.L_i.S_i}{S_T} \quad (5)$$

where E_{out} is the mean of output energy in unit area (MJ/ha), EV_i is the energy value of i crop (MJ/kg), L_i is the mean of yield of i crop (kg/ha) and S_i is the total planted area of i crop (ha).

E_{out} related to the townships were calculated for 2003, 2004 and 2005, individually. E_{out}, means how much energy produce in one hectare, on average. In order to recognize ratio of output energy in the agricultural section to the potential energy of available tractors, a mechanization index is offered by Eq (6):

$$W = \frac{E_{out}}{E_P} \quad (6)$$

where W is the ratio of the output energy to the potential energy of available tractors.

Mechanization index (w) related to each township was calculated for 2003, 2004 and 2005 separately. It is shown in Table 3 for all the townships. Because this index has no unit, it is comparable among various townships easily. From the energy aspect, the mechanization index (w) can be used to distribute the tractor power among the townships favorably.

The F test was used to determine significant the mechanization index (w) significant among the townships and the Duncan?s multiple ranges test was used to separate means at a 5% level of significance by using the computer software SPSS 12.0 (Version, 2003).

Table 3: Mechanization index (w) related to townships of Isfahan province

	Mechanization index (W)				Mechanization index (W)		
Township	2003	2004	2005	Township	2003	2004	2005
Aran & Bidgol	3.06	2.85	2.80	Khansar	3.25	3.47	3.61
Ardestan	7.20	7.12	7.26	Khomeiny Shahr	2.15	1.84	2.19
Barkhar & Meymeh	8.23	10.21	9.92	Lanjan	2.43	1.86	2.03
Chadegan	3.92	4.25	3.70	Mobarakeh	2.06	2.45	1.89
Falaverjan	8.14	9.27	9.00	Na'een	1.84	2.03	1.45
Faridan	5.21	5.64	5.72	Najaf Abad	2.19	2.35	2.52
Ferydoun Shahr	2.16	2.21	2.36	Natanz.	4.77	5.62	4.77
Golpayegan	4.16	4.38	4.32	Semmirom	1.43	1.14	1.52
Isfahan	4.29	4.81	4.78	Shahreza	3.12	2.72	2.90
Kashan	2.93	2.76	2.41	Tiran	2.13	2.28	2.25

RESULTS AND DISCUSSION

The mechanization index (w) showes how output energy in a township is produced by the agricultural section relative to the amount of available tractor power. Comparison of means related to the mechanization index (w) was shown in Table 4.

It is clear that the output energy depends on yield of crops and yield depends not only on available power in the township but also on importance and numerous factors such as soil texture, amount of rainfall, condition of irrigation and management level, etc. Therefore it is possible that some townships enough power of tractors is available but their output energy level is low. It occurs when other factors are unfavorable. Furthermore it is possible that in some townships this occur conversely. It means that shortage of the tractor power is principal restrictive factor in the farming of these townships. Therefore in some condition, shortage of tractor power for many townships is principal factor of restrictive and for other townships is slight factor. In other word, impact of shortage of tractor power on yield in the various townships is different. Accordingly, the amount of needs to new tractor power in unit area is different thorough townships.

Therefore some townships need to more tractor power than other townships. Distribution method of new tractors must be on the basis of their need intensity to new power. This method will have more productivity than other methods, because in this method new tractors are able to remove more limitation against the farming in the total area of province. In Iran distribution of tractor is typically done on the basis of the mechanization level. But it can not be a good index, alone and the Mechanization degree too. But the mechanization index (w) and the mechanization degree, together are able to manage distribution of tractors among townships, favorably.

Classification of townships according to their need to tractor: Townships of Isfahan province were grouped into four categories according to the mechanization index (w) and degree. Four groups were as follows: Group 1: in this townships the values of their mechanization index (w) and degree are low, Group 2: in this townships the value of their mechanization index (w) is low but their mechanization degree is high, Group 3: in this townships the value of their mechanization index (w) is high but their mechanization degree is low, Group 4: in this townships the values of their mechanization index (w) and degree are high. The low mechanization index (w) (in groups 1 and 2) may be due to either low yield of crops or high amount of tractor power in the region. In this townships, if the mechanization degree is high, shortage of tractor power has a little share on restrictive factors in farming. Furthermore, the high mechanization index (w) (in groups 3 and 4) may be due to either high yield or low amount of tractor power in the region. In these townships, if mechanization degree is low, shortage of tractor power has a big share on restrictive factors in farming. Therefore, the townships included in group 3 have priority to be allotted new tractors. Because they have both higher the mechanization index (w) and lower the mechanization degree compared to other townships. For instance Barkhar and Meymeh has priority to be allotted new tractors compared to Semmirom. Because their mechanization index (w) and degree are respectively, 9.45 and 0.45 for Barkhar and Meymeh, while for Semmirom the corresponding values are 1.36 and 0.62, respectively. But Chadegan and Kashan can not be compared together, because the mechanization index (w) and degree are 3.96 and 0.68 for Chadegan and 2.7, 0.5 for Kashan, respectively. Although mechanization index (w) of chadegan is higher than that of Kashan but its mechanization degree is not lower. Based on that, all the townships of Isfahan province were compared together.

Table 4: Comparison of means related to mechanization index (w)

Township	(w)	Township	(w)	Township	(w)
Barkhar & Meymeh	9.454a	Isfahan province	4.057fgh	Ferydoun Shahr	2.243kl
Falaverjan	8.083b	Chadegan	3.957gh	Tiran	2.220kl
Ardestan	6.858c	Khansar	3.443hi	Mobarakeh	2.133kl
Faridan	5.523d	Shahreza	2.913ij	Lanjan	2.107kl
Natanz.	5.167de	Aran & Bidgol	2.903ij	Khomeiny Shahr	2.062kl
Isfahan	4.627ef	Kashan	2.700jk	Na'een	1.773lm
Golpayegan	4.287fg	Najaf Abad	2.353jkl	Semmirom	1.363m

The means with minimum common letter are not significantly different (P<0.05) according to Duncan's multiple ranges test.

Table 5: Classified town ships on basis of their priority to be allotted new tractors

First priority	Next priorities
Aran & Bidgol	Ferydoun Shahr, Lanjan and Semmirom
Ardestan	Aran & Bidgol, Chadegan, Faridan, Ferydoun Shahr, Golpayegan,, Isfahan, Kashan, Khansar, Khomeiny Shahr, Lanjan, Mobarakeh, Na'een, Najaf Abad, Semmirom and Shahreza
Barkhar & Meymeh	Aran & Bidgol, Chadegan, Falaverjan, Faridan, Ferydoun Shahr, Golpayegan,, Isfahan, Kashan, Khansar, Lanjan, Mobarakeh, Na'een, Najaf Abad, Semmirom and Shahreza
Chadegan	Ferydoun Shahr, Semmirom and Shahreza
Falaverjan	Aran & Bidgol, Chadegan, Faridan, Ferydoun Shahr, Golpayegan,, Isfahan, Khansar, Lanjan, Mobarakeh, Na'een, Najaf Abad, Semmirom and Shahreza
Faridan	Chadegan, Ferydoun Shahr, Golpayegan,, Isfahan, Semmirom and Shahreza
Ferydoun Shahr	Semmirom
Golpayegan	Ferydoun Shahr and Semmirom
Isfahan	Ferydoun Shahr and Semmirom
Kashan	Na'een and Semmirom
Khansar	Ferydoun Shahr, Lanjan, Najaf Abad and Semmirom
Khomeiny Shahr	Na'een and Semmirom
Lanjan	Semmirom
Mobarakeh	Na'een and Semmirom
Na'een	-
Najaf Abad	Semmirom
Natanz.	Aran & Bidgol, Chadegan, Ferydoun Shahr, Golpayegan,, Kashan, Khansar, Khomeiny Shahr, Lanjan, Mobarakeh, Na'een, Najaf Abad, Semmirom and Shahreza
Semmirom	-
Shahreza	Ferydoun Shahr and Semmirom
Tiran	Na'een and Semmirom

Consequences of performed comparisons are shown in Table 5. As seen in this table, for example, Khansar has priority to be allotted in comparison with Ferydoun Shahr, Najaf Abad, Lanja and Semmirom townships.

One of the important factors which are caused to prevent promotion of the mechanization degree is peak of operations needing to tractor. In some townships, their agronomical patterns are inappropriately so that most farming operations must be carried out within short limit of time. It is caused to decrease the mechanization degree because available tractors are not able to carry out all the farming operations within that short limit of time. These regions will need to more tractor power in order to increase the mechanization degree. Increasing of tractor power in these regions will cause to increase in the mechanization degree, but decrease in mechanization index (w). It is occurred due to inappropriate agronomical patterns because tractors remain unused within a long time of year. Therefore it is suggested that in each township, appropriate agronomical patterns are selected so that operations that need tractors be optimally spread during year.

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