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Analytical hierarchy process for evaluation of general purpose lifters in the date palm service industry

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Iran is the second world producer of date palm. Most of the date palm cultural operations are still harvested manually, because a mechanized method that covers all the needs is not available. General-purpose lifters of various models are used for date palm service in some orchards, but growers do not use them broadly. This research was conducted to evaluate and classify 10 different available lifters in the market and find the most suitable. Three machine principle features including length, working height and machine price were selected to compare lifters using Analytical Hierarchy Process (AHP). This approach was a basic method to select the most suitable alternatives. To apply the technique, data of tree spacing, tree yields and tree trunk heights were recorded in nine orchards for 25 randomly selected trees. Based on the results, among 10 different machines, a drown type, hydraulic actuated platform with 11 meters of working height were found as a more suitable machine for date palm service.

Keywords: Date palm service, lifters, analytical hierarchy process

Introduction

Date is one of the most important fruits in more than 30 countries. Dates are spread around the desert regions of the world. The date total world production is approximately 6.8 million tonnes and Iran date production is about 900 thousand tons (Anonymous, 2006). Over the period of 1999 to 2001, Egypt, Iran, Saudi Arabia and Pakistan has been producing 61 percent and Iraq, Algeria, United Arab Emirates, Oman and Sudan 29 percent of the date total world production (Zaid, 2002). The quality of dates palm using mechanized cultivation methods would be improved. There is a major interest in the mechanization of harvesting operation, because most of the harvesting is done manually. The most popular palm cultural operations carried out in orchards are pollination, dehorning, pruning, fruit thinning, bunch bending, bunch bagging, pesticide control and harvesting. Pollination is carried out in spring. Dehorning, pruning, fruit thinning, bending and bagging of bunches and pesticide controls are carried out in summer. Harvesting is used the most labours consuming that is carried out in autumn. Brown (1983) reported that among cultural operations, harvesting, pollination and pruning were the most labours intensive work accounting for more than 80 percent of the total production costs.

The most difficult part of date palm service has been reached to the crown of the date palm trees. There are two methods of date palm service, traditional and mechanical. Using the leaf bases to climb the tree in Iran, Iraq and Libya is a traditional way (Nixon, 1969). Some workers use a belt to secure themselves to the tree (Dawson, 1962). In Africa especially in Algeria People dig holes in to the tree trunk to climb it easier (Rohani, 1998). They may hammer pegs in to the tree trunk, move to next tree on the leaves, or move on a rope. Date growers in USA use ladders to reach the fruits (Nixon, 1969) and the most of cultural operations are done mechanically.

The most of date palm cultural operations are still being done manually in majority of date producing such as Iran, because a mechanized method that covers all needs is not available. General-purpose lifters of various models are alternatives of date palm service and are used in some orchards in the country. This research was carried out to evaluate and classify these lifters and to find the most suitable one for the studied area. The Analytical Hierarchy Process (AHP) according to the method of Saaty (2000) being a systematic decision approach was used as the research method. It was designed to solve the complex multiple criteria problems. There were two kinds of comparisons possible to find the best alternative in a decision making process. The first was done absolutely method, in that each alternative concept was absolutely compared with some set of criteria and second kind was relative comparison with alternative concept, and was compared to each other using measures defined by the criteria. The AHP's method used as the second method.

Materials and methods

Climbing the tree and reaching the fruits is the hardest part of date palm service, therefore attempts for mechanization of this operation has been focused on methods of lifting the workers to the crown of trees. To find the most suitable machine among existing machines in Iran, the important characteristics of these machines were measured. The authors contacted three big manufactures of lifters in Iran. Important machine features were found through catalogues and consulted technicians. Important features were selected as machine sizes, machine working height and Prices (Table. 1). To find out the essential rang of sizes and dimensions for an ideal machine, tree row spacing and distance to nearest tree, tree yield and tree trunk height were measured for 25 random selected trees in nine different orchards in Bam and Shahdad date orchards and recorded in Table 2. The lifter prices were compared with a base farmer's affordable machine price, found from another research (Shamsi *et al*., 1998).

An overview of AHP for evaluation

The Analytical Hierarchy Process method has been found to be an effective and practical approach that can consider complex and unstructured decisions (Partovi, 1994). The selection of the methodology is based on the characteristics of the problem and the consideration of the advantages and drawbacks of some of methodologies. The decision-maker judges the importance of each criterion in pair-wise comparisons. The outcome of AHP is a prioritized ranking or weighting of each decision alternative (Hafeez *et al.,* 2002). However, the concepts of the development and the structure of the model would be similar and can be applied to different decision making processes including lifter selections in a particular country. Basically, there are three steps to be considered in decision making problems by AHP constructing hierarchies, comparative judgment and synthesis of priorities that described as follows.

Establishment of a structural hierarchy

This step allows a complex decision to be structured into a hierarchy descending from an overall objective to various 'criteria' and 'sub-criteria' until the lowest level. The overall goal of the decision is represented at the top level of the hierarchy. The criteria and sub-criteria contributing to the decision are represented at the intermediate levels. Finally, the decision alternatives or selection choices are laid down at the last level of the hierarchy (Fig. 1).

According to Saaty (2000) a hierarchy can be constructed by creative thinking, recollection and using people's perspectives. He further noted that there was no set of procedures for generating the levels to be included in the hierarchy. Zahedi (1986) remarked that the structure of the hierarchy depended upon the nature or type of managerial decision. Also, the number of the levels in a hierarchy depended on the complexity of the problem being analyzed and the degree of detail of the problem that an analyst requires to solve (Zahedi, 1986). As such, the hierarchical representation of a system may vary from one person to another.

Establishment of comparative judgments

Once the hierarchy has been structured, the next step was to determine the priorities of elements at each level ('element' here means every member of the hierarchy). A set of comparison matrices of all elements in a level of the hierarchy with respect to an element of the immediately higher level were constructed so as to prioritize and convert individual comparative judgments into ratio scale measurements. The preferences are quantified by using a nine-point scale. The meaning of each scale measurement is explained in Table 3. The pair-wise comparisons are given in terms of how much element A is more important than element B. As the AHP approach is subjective methodology information and the priority weights of elements may be obtained from an expert.

The proposed evaluation system

Ranking the lifting machines using traditional evaluation methods based on other evaluation methods is not précised, if it is not impossible. "AHP" is particularly suited to model the relationship between variables in environments that are either ill-defined or very complex. It is based on the assumption that when faced with a complex decision the natural human reaction is to cluster the decision elements according to their common characteristics.

It involved building a hierarchy (Ranking) of decision elements and then making comparisons between each possible pair in each cluster (as a matrix). This gave a weighting for each element within a cluster (or level of the hierarchy) and also a consistency ratio (useful for checking the consistency of the data).

Alternative evaluations by AHP have three steps as follows: construction of hierarchies, comparative judgment using weight calculation for each parameter and synthesis of priorities.

The first step in construction of hierarchies was graphical illustrated the problem. It helped to clear aims, criteria and alternatives (Fig. 1).

Hierarchy values determination

The expert allocated a value to each lifter of Table 4 as shown in Table1. In Table 4, the relative value of each parameter to itself was equal to 1. The diameter of matrix of tables 4 was equal to 1. If relative value of A to B is 2 then relative value of B to A would be 0.5.

The ultimate value of each machine the following steps were conducted to find out as name of different machines which were written in the first row and column of table 4, pair of machines were compared using numbers of Table 1, values of each sell were divided to the sum of its column to find its normalized value and then the normalized matrix was constructed (Table 5), relative weight of each machine for parameters such as working height to other machines was the average summation of cells values of corresponding row in normalized matrix. Parameters were classified (Table 6), compared and normalized using the same method explained for Table 4. Final weight of each machine was the summation of each lifter value for parameters (Table 6) multiply by its relative value (weight) of parameter (Table 9). The results are shown in Table 10.

Results

The characteristics of existing machines (Table.1) entered to the proposed AHP system and for each machine the output extracted. According to the results, the available lifting machines evaluated and ranked in Table 10. It shows that Balan Sanat (DML 12 and EHs 1000) have the maximum score and are more suitable to be used for date palm service in described Iranian date orchard conditions. Totally 80 % of machines have very low scores. This shows why growers don't widely use the machines to service date palm trees.

Data analysis of Table 2 showed that 90% and 100% of the trees were over 3 and 2.6 meters away from their nearest tree, respectively. The table showed that 90% and 100% of tree row spacing were over 3.8 and 3.5 meters, respectively. It also showed that 100% of trees across rows spacing are over 4.1 meter. Maximum tree yield was about 1280 N (Mazloumzadeh *et al.*, 2008). The yield is harvested in 4 to 5 stages in this region and considering worker weight to it, the lifter deals with a maximum payload of about 1100 to 1300 N. All lifters payload were over 1300 N and in acceptable range. With respect to orchards study, for studied region a lifting machine must be able to reach to a height of maximum 13.5 meter. Machine needs to have length of less than 3 meter. Entirely the investigation showed that none of existing lifters are completely suitable for date palm service industry; therefore, there is enough room for new designs.

Discussion

In this research the AHP was effectively applied as a decision support system for evaluation and classification of lifters in the date harvesting industry. Evaluation showed the Balan Sanat lifters are more suitable for date palm service because two similar models of this company get best score. With changes in working height they will bring better scores for date palm service industry. Lajvar and Ahrom Vazin company's lifters get low score for date palm service. These machines are suitable for heavy industry, although some of them have been used for date palm service. The research suggests that growers select EHs 1000 and DML 12 for date palm service in the studied region. Mazloumzadeh *et al* (2008), used a fuzzy system to classify these lifters and the classification results are approximately similar to each other, but their fuzzy system needs Matlab software and also needs a computer to evaluate every data. The use of specialized fuzzy analysis software perhaps prevents readers not familiar with the particular software package from having a detailed understanding of the results and this is the most limitation of the paper. The AHP system can be used to evaluate and classify similar systems without any new technologies.

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Table 1. Characteristics of available lifting machines in Iran.

Manufactory	Model	Working height (m)	Length (m)	Payload (kg)
Balan sanat	DML 12	12	4.10	160
Ahrom vazin	S.T.S SIMON B-9	11	5.10	170
Ahrom vazin	S.T.S-ZOOMB-14	14	3.36	500
Balan sanat	EHs 1000	10	1.41	130
Lajvar	AL 1200	14	6.60	200
Lajva	TL 1600	18	7.00	200
Lajvar	TML 900	11	5.40	150
Lajvar	AL 900	11	5.90	150
Lajvar	AL 1050	12.5	6.70	200
Lajvar	AL 1400	16	6.60	200

Table 2. The date palm tree sizes.

Tree No.	Tree trunk height (m)	Row spacing(m)	Across row spacing (m)	Distance to nearest tree (m)
1	8.2	3.5	4.2	4.1
2	7.6	5	7.1	3.2
3	9.4	4.2	5.3	4.5
4	7.7	4.5	5.5	3.5
5	10	6.1	6.2	5
6	7	5.2	7.2	5.2
7	6.5	3.8	4.1	4
8	14	3.5	5.4	2.5
9	16.4	4.3	6.3	3.1
10	17	4.1	6.7	3.9
11	14.2	5.7	6.9	3.6
12	14.1	4.9	5.2	4.9
13	13.3	4.8	6.1	3
14	12.1	5.7	7.1	3.7
15	16.2	5.1	6.3	3.1
16	11.2	4.8	5.9	2.8
17	6.5	5.1	5.5	3.2
18	7.2	3.9	4.5	3.5
19	6.5	4.4	7.3	3.2
20	7.5	5.1	6.7	3.5
21	8	4.8	6	2.9
22	10.1	3.8	5.8	3.6
23	9.5	4.5	5.9	2.5
24	8.3	4	4.5	4.3
25	7.9	4.9	5.1	3.8

Table 3. Pairwise comparison values (Adapted from Saaty, 2000; Hafeez *et al.,* 2002).

Preference weights/ level of importance	Definition	Explanation
1	Equally preferred	Two activities contribute equally to the objective
3	Moderately preferred	Experience and judgment slightly favor one activity over another
5	Strongly preferred	Experience and judgment strongly or essentially favor one activity over another
7	Very strongly preferred	An activity is strongly favored over another and its dominance demonstrated in practice
9	Extremely preferred	The evidence favoring one activity over another is of the highest degree possible of affirmation
2,4,6,8	Intermediates values	Used to represent compromise between the preferences listed above
Reciprocals	Reciprocals for inverse comparison	

Table 4. Preferences of objective for working height of lifter.

	A	B	C	D	E	F	G	H	I	J
A	1	3	0.25	5	0.25	7	3	3	0.5	0.5
B	0.33	1	0.2	3	0.2	3	1	1	0.2	0.5
C	4	5	1	7	1	7	5	5	3	5
D	0.2	0.33	0.14	1	0.14	0.5	0.33	0.33	0.2	0.33
E	4	5	1	7	1	7	5	5	3	4
F	0.14	0.33	0.14	2	0.14	1	0.25	0.25	0.2	0.33
G	0.33	1	0.2	3	0.2	4	1	1	0.25	0.5
H	0.33	1	0.2	3	0.2	4	1	1	0.33	0.5
I	2	5	0.33	5	0.33	5	4	3	1	3
J	2	2	0.2	3	0.25	3	2	2	0.33	1

Table 5. The normalized values of Table 4.

	A	B	C	D	E	F	G	H	I	J
A	0.070	0.127	0.068	0.128	0.067	0.169	0.133	0.139	0.055	0.032
B	0.023	0.042	0.055	0.077	0.054	0.072	0.044	0.046	0.022	0.032
C	0.279	0.211	0.273	0.179	0.270	0.169	0.221	0.232	0.333	0.319
D	0.014	0.014	0.038	0.026	0.038	0.012	0.015	0.015	0.022	0.021
E	0.279	0.211	0.273	0.179	0.270	0.169	0.221	0.232	0.333	0.255
F	0.010	0.014	0.038	0.051	0.038	0.024	0.011	0.012	0.022	0.021
G	0.023	0.042	0.055	0.077	0.054	0.096	0.044	0.046	0.028	0.032
H	0.023	0.042	0.055	0.077	0.054	0.096	0.044	0.046	0.037	0.032
I	0.140	0.211	0.090	0.128	0.089	0.120	0.177	0.139	0.111	0.192
J	0.140	0.085	0.055	0.077	0.067	0.072	0.089	0.093	0.037	0.064

Table 6. Lifter weight for parameters.

Manufactory	Model	Working height (m)	Length (m)	Price (Million Rial)
Balan sanat	DML 12	0.098845	0.112215	0.252229
Ahrom vazin	S.T.S SIMON B-9	0.046781	0.098576	0.119888
Ahrom vazin	S.T.S-ZOOM B-14	0.248677	0.158964	0.056175
Balan sanat	EHs 1000	0.021476	0.384963	0.243055
Lajvar	AL 1200	0.242291	0.031743	0.060057
Lajva	TL 1600	0.024101	0.018482	0.01838
Lajvar	TML 900	0.049746	0.075621	0.108749
Lajvar	AL 900	0.050634	0.060347	0.101884
Lajvar	AL 1050	0.139742	0.029544	0.02453
Lajvar	AL 1400	0.077708	0.029544	0.015053

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Table 7. Pairwise comparison matrix of parameters.

Parameter	Working height (m)	Length (m)	Price (Million Rial)
Working height (m)	**1**	**3**	**0.2**
Length (m)	**0.33**	**1**	**0.17**
Price (Million Rial)	**5**	**6**	**1**

Table 8. The normalized table number of 6.

Parameter	Working height (m)	Length (m)	Price (Million Rial)
Working height (m)	**0.157978**	**0.3**	**0.1459854**
Length (m)	**0.052133**	**0.1**	**0.12408759**
Price (Million Rial)	**0.789889**	**0.6**	**0.72992701**

Table 9. Relative weight of each parameter.

Parameter	Relative weight of each parameter
Working height (m)	0.201321
Length (m)	0.092073
Price (Million Rial)	0.706605

Table 10. Evaluation of Iranian lifters for date palm service industry using AHP

Manufactory	Model	AHP score
Balan sanat	DML 12	0.21
Ahrom vazin	S.T.S SIMON B-9	0.1
Ahrom vazin	S.T.S-ZOOMB-14	0.1
Balan sanat	EHs 1000	0.21
Lajvar	AL 1200	0.09
Lajvar	TL 1600	0.02
Lajvar	TML 900	0.09
Lajvar	AL 900	0.09
Lajvar	AL 1050	0.05
Lajvar	AL 1400	0.03

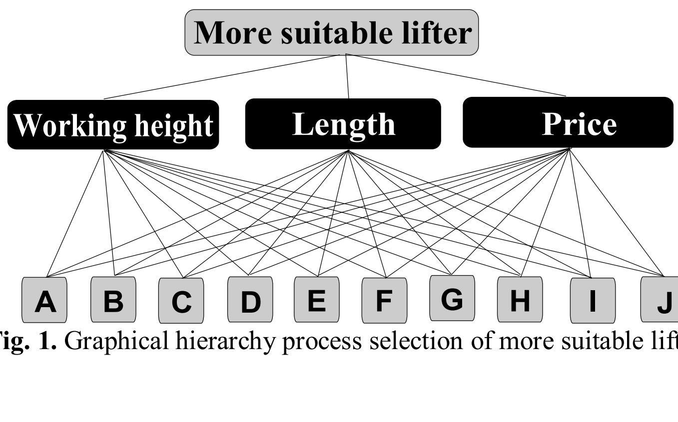

Fig. 1. Graphical hierarchy process selection of more suitable lifter.