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Analysis of Economic Impacts of Agricultural practices on reducing damages on rain fed fig orchards caused by drought in Estahban region, south of Iran

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Abstract:

Estahban County is the greatest region of fig production in the world. About two millions of fig trees are exposed to death due to severe drought in the last five years. Moisture deficiency has reduced physiological indexes especially fig yield. The economy of this region is drastically dependent on fig production. Then reduction in fig yield has a very negative influence on the life of people. To prevent these damages, this experiment was accomplished on Green variety of fig trees to assess the effect of drought stress in Estahban region. The experiment consisted of 7 treatments and five replications and continued for three years. The goal of this research was to find the best treatments for damage reduction of drought in the rain-fed fig orchards. The best treatments with the best economic and technical characteristics were selected and recommended by TOPSIS method.

The results showed, considering the yield of tree as the criteria for selecting the best treatment, the mechanical elimination of weeds is the most successful method against the drought. But the survey study showed that horticulturists also consider other factors such as skin color, size of fruit, time of ripening, fruit size, damage on tree and treatment cost. On the basis of these factors application of herbaceous mulch, severe branch heading back and weed elimination are the best treatments respectively, for reducing the damage of drought on fig orchards.

Key words: *rain fed fig, drought, multi criteria decision making, Iran*

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Introduction:

Fig is the most important rain fed horticultural product cultivated in Estahban County in Southern Iran since several decades ago, with an area of about 22000 ha. This region is the greatest zone of fig production in the world. Unfortunately the region faces many challenges due to frequently severe drought which has imposed water crisis on this area. In recent years about two millions of fig trees, are exposed to death because of severe droughts. The economy of this region is heavily dependent to fig production. Therefore, reduction in fig production has negatively influenced on the life of people. Thus finding the best solution to reduce the damage of drought on rain fed fig trees is necessary.

In the previous researches it has been showed that trees with severe branch heading back are more resistant to drought. Winter plowing, weed elimination in the early growth period to decrease the competition between fig trees and weeds in soil moisture absorption, increase the resistance of trees in severe drought condition. Infiltration operations reduces the soil erosion and prevents run off, increasing the resistant of fig trees in drought condition as well (Ido1983). Using matters such as white paint, wood glue, lime in solution prevent expose to severe sun radiation on main trunk, preserve the fig trees from complete drought (abo-rawash et al,1991).

Previous studies showed that the qualitative and quantitative impacts, cost and the ease of implementation are different. Until recently, most agricultural economic studies considered farmers to behave in a Profit maximizing goal. In this condition decision making is clear and easy. But numerous studies have proven that farmers behave according to many objectives such as risk-adverse, income sustainability etc. (Hazell and Norton, 1986; Romero and Rehman, 1987).

Decision making in management has been always complicated especially if there were more than one criterion under consideration. Multiple criteria decision making (MCDM) has been often applied for complex decisions in construction when a lot of criteria were involved (Antucheviciene et al.2010). In this research a multiple criteria decision making method was employed to select the best treatments according to multiple criteria among seven treatments.

Decision making is the study of identifying and choosing alternatives based on the values and preferences of the decision maker. Making a decision implies that there are alternative choices to be considered, and in such a case it needs not only to identify as many of these alternatives as possible but to choose the one that best fits with goals, objectives, desires, values, and so on (Harris 1980).

The goal of this research was to find the best agro- economic treatments for damage reduction of drought in the rain fed fig orchards in Estahban region.
For this purpose an experiment was carried out on Green variety of fig trees with seven agro activity treatments in fig research station in Estahban county in 2004- 2007.

Methodology:
A decision problem may have a single criterion or a single aggregate measure like gross income. Then the decision can be made implicitly by determining the alternative with the best value of the single criterion or aggregate measure. But when the numbers of the criteria and alternatives are given explicitly, problems of this type is a called multi criteria decision making (MCDM) problems (János Fülöp, 2011).
MCDM can be defined as a decision model which contains:
. A set of decision options which needs to be ranked or scored by the decision maker;
.A set of criteria typically measured in different units; and
.A set of performance measures which are the raw scores for each decision option against each criterion.
A minimum requirement for the MCDM model is at least two criteria and two decision options (Hajkowicz & Collins 2007). The MCDM model is represented by an evaluation matrix X of n decision options and m criteria. Let **C**1,.,**C***m* and **A**1,..,**A***n* denote the criteria and alternatives, respectively. A standard feature of multi-criteria decision making methodology is the *decision matrix* as shown below. In the matrix each row belongs to a criterion and each column describes the performance of an alternative. The score r*ij* describes the performance of alternative **A***j* against criterion **C***i*.

		A1	A2	A3	…	An
W1	C1	r11	r12	r13	..…	r1n
W2	C2	r21	r22	r23	… …	R2n
.	C3	r31	r32	r33	… …	R3n
.	…..	..…	……	..…	..…	..…
w_m	Cm	rm1	rm2	Rm3	..…	Rmn

As shown in decision matrix, weights *w*1,..., *wm* are assigned to the criteria. Weight *wi* reflects the relative importance of criteria **C***i* to the decision, and is assumed to be positive. (Fülöp, 2011). The weights of the criteria are usually determined on subjective basis. They represent the opinion of a single decision maker or synthesize the opinions of a group of experts using a group decision technique, as well.

Criteria are rarely of equal importance to the decision maker and a variety of methods are available to assign weights at either cardinal or ordinal levels of measurement. In this research we used a pair wise comparison. One of the most widely applied pair wise comparison techniques is the Analytic Hierarchy Process (AHP; Saaty 1987). These approaches involve comparing criteria in every unique pair giving *n(n-1)/2* comparisons. The comparisons can be made to attain criteria weights.

Since it is possible for X and W to contain a mix of qualitative (ordinal) and quantitative (cardinal) data, various scaling systems can be used to uniform these data. In the AHP, for example, decision makers are asked to express preference for one criterion over another in each pair on a nine point scale (Saaty 1987).

Cardinal numbers are normalized using the vector method, which allows one to maintain the range of variation for each criterion.

$$h_{ji} = \frac{r_{ji}}{\sqrt{\sum_{j=1}^{n}(r_{ji})^2}} \qquad (1)$$

Where h_{ij} is the normalized value of the j-th criterion for the i-th alternative. The Decisional Matrix obtained can thus be resolved by any method of multi-attribute analysis. We used the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), which is based on minimization of the distance from the ideal solution and maximization of the distance from the anti-ideal solution. TOPSIS is rational and relatively simple method developed by Hwang and Yoon (1981)

The underlying concept is that most preferred alternatives should not only have shortest distance from 'ideal' solution, but also longest distance from 'negative-ideal' solution. TOPSIS evaluates a decision matrix in several steps starting by normalizing columns and then multiplying values in columns is by corresponding weights of criteria. Then, best and worst value in each column is identified followed by creation of two sets of these values across all columns named ideal solution and negative-ideal solution, respectively.

$$V_i(\max) = \left\{ \left(\max V_{ji} \middle| i \in I \right) \text{و} \left(\min V_{ji} \middle| i \in I' \right) \right\},$$
$$V_i(\min) = \left\{ \left(\min V_{ji} \middle| i \in I \right) \text{و} \left(\max V_{ji} \middle| i \in I' \right) \right\}, \tag{2}$$

With ***I*** the set of criteria to maximize and ***I'*** the set of criteria to minimize. In the next step so-called separation measures for all alternatives are computed based on their Euclidean distances from ideal and negative-ideal solutions (across all criteria).

$$S_j(\max) = \sqrt{\sum_{i=1}^{m} \left[V_{ji} - V_i(\max) \right]^2}$$
$$S_j(\min) = \sqrt{\sum_{i=1}^{m} \left[V_{ji} - V_i(\min) \right]^2} \tag{3}$$

Finally, the relative closeness to ideal solution is calculated for each alternative, and alternatives are appropriately ranked.

$$C_j = \frac{S_j(\min)}{S_j(\min) + S_j(\max)} \tag{4}$$

Top-ranked alternative is with the shortest distance from ideal solution and TOPSIS guarantees that it also has the longest distance from negative-ideal solution.

The experimental trees were selected from fig research station in Estahban County. Experiment treatments were:1- severe branch heading back 2-winter plow 3-weed elimination 4-application of white paint on main trunk 5-application of stone mulch 6-application of herbaceous mulch and 7-The control treatment.

Characteristic such as width, number, yellowish, sunburn, temperature and water potential of leaf, time of ripening, skin color, size of ostiole and dry fruit diameter, yield and moisture profile in tree umbrageous amount were considered. In addition, socio-economic consequences of drought on the gardeners and gross income of each treatment were calculated using the current prices of inputs and outputs.

In this research experiment treatments are options. Criteria were selected among the characteristics that be considered and were ranked according to their importance. In the following column ‘‘objective’’ the distinction is between those criteria which the producers wish to be maximized (i.e., yield per hectare) and those criteria which the producers wish to be minimized (i.e., performance cost). Set of criteria are as follows:

Table (1): type and weight of criteria

criteria	Type of data	Objective	weight
yield	Quantitative	max	0.267
Treatment cost	Quantitative	min	0.035
skin color	Qualitative	max	0.059
time of ripening	Qualitative	max	0.026
size of ostiole	Qualitative	max	0.093
size of dry fruit	Quantitative	max	0.155
Yellowish of leaf	Qualitative	min	0.364

The survey study showed that in drought condition, the first priority of fig producer was to preserve the life of trees. So, the last column in table 1 yellowish of leaf has the highest weight between all considered characteristics, because it is the main indicator of tree death.

Results and discussion

In this research various characteristics were considered, but among them, seven characteristics including yield, performance cost, skin color, time of ripening, size of ostiole, size of dry fruit and yellowish of leaf are more important and have the main role for selecting the best treatment. Some of these factors such as skin color, size of ostiole and size of dry fruit affects the price of fig and the time of ripening affects the time of market supply. The low cost is an important factor on adoption of treatment by poor producers. In drought condition, not only the yield of tree decreased, but also the tree itself was exposed to death, therefore, high preference must be given to the treatment that prevents the tree death.. In this research the yellowish of leaves is a good indicator of the death risk of tree. The pair wise comparison indicated that this criterion has the most important for fig producers.

Among the considered characteristics for selecting the best treatment, yield, cost and the number of yellowed leaves are quantitative and these measures are involved in primary decision matrix directly. Other characteristics are qualitative and the measures of them convert to cardinal number by saaty index, as follows:

criterion	measure	Characteristic range				
Skin color of fruit	Ordinal amount	Light yellow		Light brown		Dark brown
	Cardinal equivalent	9		5		1
Ostiole size of fruit	Ordinal amount	Completely open		Semi open		closed
	Cardinal equivalent	9		5		1
dry fruit diameter	Ordinal amount	AA		A		B
	Cardinal equivalent	9		7		2
time of ripening	Ordinal amount	Very premature	premature	Semi ripen	Late ripen	Very late ripen
	Cardinal equivalent	9	8.5	8	3	1

Source: findings of study

In the next stage, the fruits obtained from each treatment were classified in separate category based on criteria measurement, then by using the following equation the score of each treatment for each criterion was calculated.

$$adjective\ \text{score}=\sum_{i=1}^{n} PiSi$$

Pi = percentage of fruit that possessed of characteristic i

Si = cardinal measure of characteristic i

n = characteristic range

Calculated score is weighted mean of one treatment for each characteristic. These scores register into decision matrix for selecting the best treatment. (Table 2)

Table(2)- primary decision matrix

Characteristics / Treatments	skin color	size of ostiole	size of dry fruit	premature	Yield (gr per tree)	Treatment cost(Rial per tree)	Yellowish of leaf
branch severe heading back	4.86	3.56	7.72	4.72	11375	20000	19
winter plough	4.73	3.49	7.43	4.36	13298	72000	38

weed elimination	4.83	3.53	7.89	4.53	14931	84000	30
white paint on main trunk	5.30	3.60	7.80	4.41	9353	68000	44
stone mulch	4.75	3.59	7.11	4.35	10627	214400	42
herbaceous mulch	4.95	3.44	7.33	4.39	14797	59000	21
control treatment	5.34	3.62	7.63	4.45	12471	48000	42

Source: findings of study

Because of difference in the type and measurement scale of characteristic, to achieve to homogenous data, the primary matrix must be free scale by equation (1). This process was accomplished and the results are shown in table (3).

Table (3) - free scale decision matrix

Characteristics / **Treatments**	skin color	size of ostiole	size of dry fruit	premature	Yield (gr per tree)	Treatment cost
branch severe heading back	0.37	0.45	0.45	0.47	0.42	0.08
winter plough	0.36	0.44	0.44	0.44	0.49	0.29
weed elimination	0.37	0.44	0.46	0.45	0.55	0.33
white paint on main trunk	0.40	0.45	0.46	0.44	0.35	0.27
stone mulch	0.36	0.45	0.42	0.43	0.39	0.85
herbaceous mulch	0.38	0.43	0.43	0.44	0.55	0.23
control treatment	0.41	0.46	0.46	0.44	0.46	0.19

Source: findings of study

By multiple the characteristic weight vector(table1) to free scale decision matrix(table2), the rhythmic free scale matrix for characteristic and treatment were attained(table4). The last two row of table 4 represent the ideal and anti- ideal values for the characteristics. In the next stage, the distance of each treatment from the ideal and anti-ideal points is calculated by means of the Euclidean distance (equation 3). Finally the preference index (Cj) was calculated by equation (4). The results of these operations are shown in table (5).

Ranking of alternatives is based on *C*i: the highest *C*i identifies the best solution. So, herbaceous mulch treatment has most priority against drought condition in fig gardens in Estahban County.

Table (4) - rhythmic free scale decision matrix

Characteristics / **Treatments**	skin color	size of ostiole	size of dry fruit	premature	Yield (gr per tree)	Treatment cost	skin color
branch severe heading back	0.022	0.042	0.070	0.012	0.112	0.003	0.087
winter plough	0.021	0.041	0.068	0.011	0.131	0.010	0.173
weed elimination	0.022	0.041	0.072	0.012	0.147	0.012	0.137
white paint on main trunk	0.024	0.42	0.071	0.012	0.092	0.010	0.20
stone mulch	0.021	0.42	0.065	0.011	0.105	0.030	0.191
herbaceous mulch	0.022	0.040	0.067	0.011	0.146	0.008	0.096
control treatment	0.024	0.42	0.071	0.012	0.123	0.007	0.191
ideal solution	0.024	0.42	0.072	0.012	0.147	0.003	0.087
negative-ideal solution	0.021	0.040	0.065	0.011	0.092	0.03	0.20

Source: findings of study

Table (5) - Distance of treatments from ideal solutions and the preference of treatment

Treatments	Distance from ideal solution	Distance from anti- ideal solution	Relative closeness to ideal solution	Treatment preference
branch severe heading back	0.035	0.119	0.77	2

winter plough	0.088	0.052	0.37	4
weed elimination	0.051	0.086	0.63	3
white paint on main trunk	0.127	0.022	0.15	6
stone mulch	0.117	0.016	0.12	7
herbaceous mulch	0.012	0.12	0.91	1
control treatment	0.108	0.04	0.27	5

Source: findings of study

The results showed, if we consider the yield of tree as the criterion for selecting the best treatment, the mechanical elimination of weeds is the most successful method against drought condition (table 2). But the survey showed that fig producers consider other factors such as skin color, size of fruit, time of ripening, fruit size, damage on tree and treatment cost. On the basis of these factors application of herbaceous mulch, severe branch heading back, that result in lower yield, are better than to weed elimination treatment recommended by TOPSIS method to reduce the damage of drought on fig orchards.

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