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The most Appropriate Winter Cultivation in Mazandaran Province of Iran using Analytical Hierarchy Process (AHP)

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ABSTRACT: The energy analysis is necessary for stable management of resources to produce agricultural product and also determination of consumed energy in each production step, obtaining a base for resources protection, helping in stable management and presentation of related diplomacy are premium of this process. Prosperous applying of quantitative methods can redound to accurate, reliable and economic solutions with reasonable time. Analytical Hierarchy Process (AHP) method can change a multi-dimension problem to a single-dimension problem. According to importance of above subjects and input value increasing in agricultural system, high tendency of agriculture's for further production and intensification of difference plantation in Mazandaran province (Amol city) of Iran, investigation of appropriate pattern of winter cultivation (Lettuce, Bersim Clover, Broad bean) can be effective on winter cultivation system stability. The result demonstrated that in criteria priority according to experts' evaluation, economic, social, technical criteria were more available than ecological and political criteria. The result illustrated that for economic, social and technical stability in winter cultivation system stability in Amol, Lettuce, Bersim Clover and Broad bean are appropriate respectively. For realization of ecological stability, Broad bean, Bersim Clover and Lettuce are appropriate respectively and for accessibility to political stability in winter cultivation system, Broad bean and Bersim Clover are in the first level.

Keywords: Winter Cultivation, Bersim Clover, Broad Bean, Lettuce, AHP.

INTRODUCTION

In recent years the trend towards increased energy consumption in the world and also in Iran has caused farmers to use more energy to produce food products. Necessity of study on different planting patterns in the agricultural sector due to limited natural resources and adverse effects resulting from improper use of different sources of energy on the environment and human health is inevitable. The decision to select the best model of cultivation which consists of spatial and temporal conditions of cultivation and ecologic, economic and social excellences require a comprehensive and logical model that is able to be linked to the qualitative and quantitative parameters. Mathematical techniques of decision are appropriate tools for the prioritization of objectives and programs. Analytical Hierarchy Process (AHP) is a response to human need for investigation of quality problems which have not any criteria for measurement. This method solve the complexity of the problem caused by various factors with step by step focus on these factors and then combining the results of this review. The sharp rise of population and demand for food and crops led to intensive arable lands are not cultivated. However, variety of crops is usual in rice-rich countries and other crops are cultivated in second half of year (Hatirli *et al*, 2005). Among presented solutions, cultivation of some second cultivated crops in addition to increasing of farmer's income, nitrogen and creation of suitable cover for farms, prevent from dust erosion and cause to stable development of agriculture sector of Mazandaran province. According to above, necessity of this study is based on two main bases; First, position of second cultivation in Mazandaran and second, necessity to achieve a sustainable system in agriculture district which present best pattern of autumnal cultivation (Bersim Clover, Broad Bean, Lettuce).Iran has 5th global rank in continental variety and is producer and exporter of spices of crops and vegetables. Iran with production of over 100 thousand tons of lettuce per year has 16th rank in global production. Lettuce plant as second cultivation was cultivated in farms of Amol county every year. Its cultivation begins in August and September and its product id obtained in January until April. Amol county has first rank of lettuce cultivation in Mazandaran province. About 2455 hectares of farmland in Amol was under cultivation of lettuce in 2014.

Experiments show that this plant is suitable for yield of rice and biological stabilization of Nitrogen. About 6800 hectares of farmland in Amol was under cultivation of Clover in 2014. Mazandaran has the first rank of clover's production in Iran country. This plant is an inexpensive product that does not need to spend much time and energy. In addition, clover has high-value forage yield and supply fodder for livestock in summer and autumn and is effective help to enhance soil fertility and reduce consumption of nitrogen fertilizer.

Fig. 1. (a) Lettuce, (b) Bersim clover, (c) Broad bean.

Many researchers have used AHP to analyze the different processes.Fransisco *et al.* (2006), in Philippines concluded that the tomato cultivated is the best crop to increase farmers' incomes in the region.Teymori *et al.,* (2009), with a case study on agricultural crops in Birjand, found that the most important criteria were water resource and sustainable agriculture, respectively. Also, saffron, wheat and barley among winter crops and cotton among spring crops showed the highest priority and the lowest priority of them was corn. Wiley (2010) conducted a research on the sustainability of farming systems participatory evaluation in the Philippines and to compare 15 index (including economic, technical, ecological and etc) used. Thomas and Gunden (2012) studied about assess consumer attitudes toward the following food production systems, conventional, sustainable and organic, along five criteria: environmental concerns, food safety, food quality, wellness and community development concerns, by AHP. The result showed consumers view organic production systems as quite dissimilar to the other production systems. Also, the results indicate that consumers are unaware of the resources conservation, community development, and environmental benefits of organic food production and therefore, there is an educational opportunity for extension and other public entities to educate consumers on the broader systemic socioeconomic and conservation benefits of organic food production.

AHP method for comprehensive assessment on therice insect pest management scales was conducted, by Luo *et al.,* (2008). They found that rice organic planting for pest control are better than other. Also, other researchers such as (Datta, 1999), (Bhatta *et al.,* 2010) and (Miskolci, 2008) used the analytic hierarchy process in agriculture field.

MATERIAL AND METHODS

The library studies and field methods were used to gather information. In field research the questionnaire required that the final results of them were the average opinions of all experts. Output questionnaires were used in the process variablesweighting and after the analytic hierarchy process, the results were reported.

A. Analytic hierarchy process (AHP)

The AHP is a theory and process of measurement through pair wise comparisons based upon the judgments of experts to derive the priority scales (Saaty, 1980). This methodis one of the most suitable methods of multivariate discrete analysis and is used as an analytical tool in various branches of technology. The method is capable of systematically introducing different qualitative and quantitative factors in the decision-making model (Montazar & Behbahani, 2007). In this method, these steps should be followed (Saaty, 1992):

(i). Identify the overall goal. (In our case, winter cultivation appropriate pattern in Amol)

(ii). Identify criteria/sub-criteria that must be satisfied. (In our case, the criteria are technical, ecological, political, socialand economic)

(iii). Calculating the weights.

(iv). Computing inconsistency ratios.

Therefore, in this paper the model proposed by Saaty (1980) is based on the construction of a hierarchical model (with four levels: objectives, criteria, sub criteria and alternatives). Fig. 2 shows the research model diagram describing difference level of process (goal, criteria, sub criteria and alternatives).

The AHP method does not require quantitative information about each of the alternatives. Instead, it is based on the value judgments of the persons making the decisions (Berumen & Llamazares, 2007).

As already mentioned, all comparisons in AHP are made pair-wise. In this research, for pair-wise comparisons the values of Table 1 that proposed by Saaty (1980), was used.

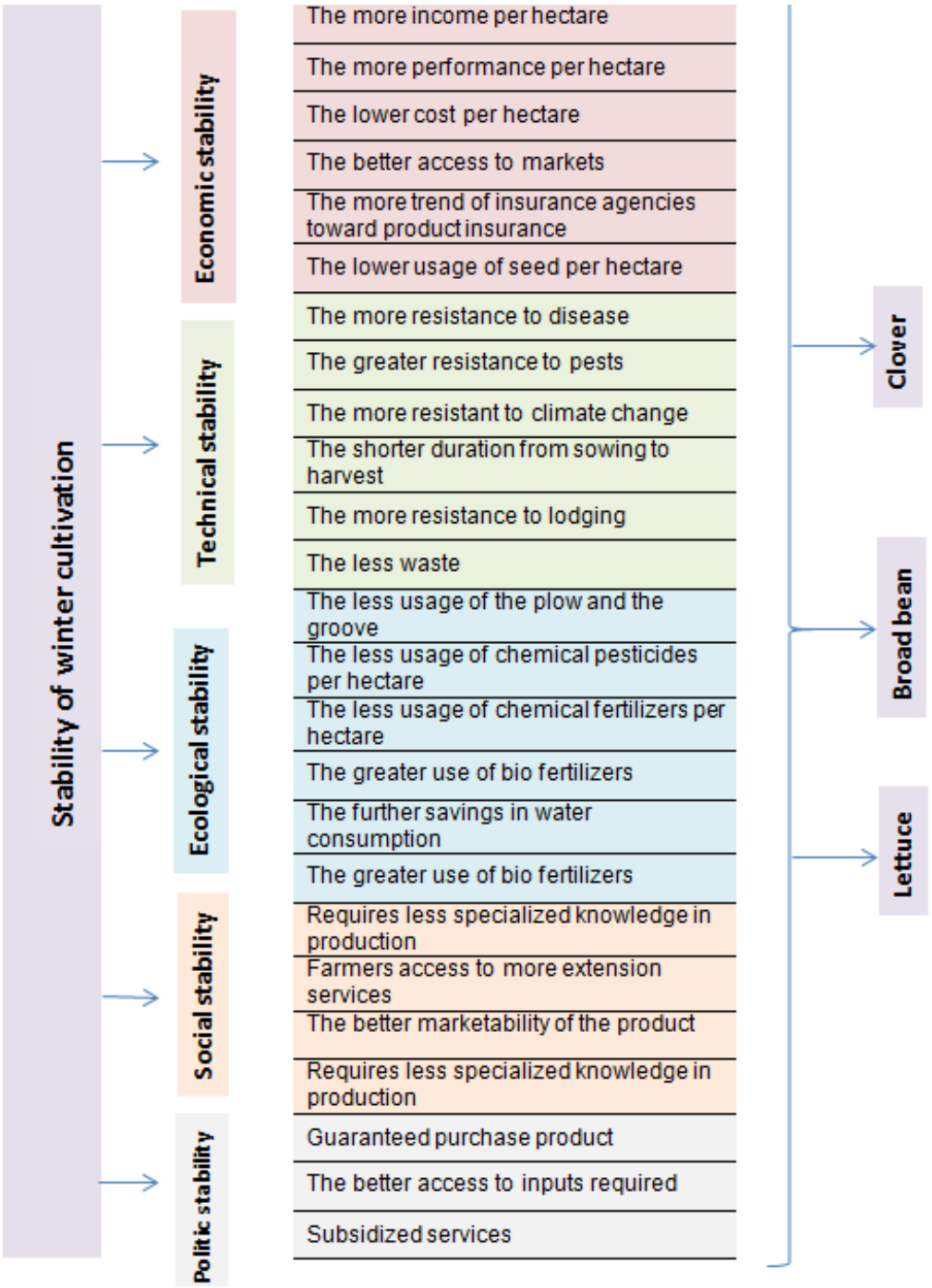

Fig. 2. AHP model.

Table 1: Preference values of pair-wise comparisons (Saaty, 1980).

Num. values	Verbal terms	Explanation
1	Equally important	Two elements have equal importance regarding the element in higher level
3	Moderately more important	Experience or judgement slightly favours one element
5	Strongly more important	Experience or judgement strongly favours one element
7	Very strongly more important	Dominance of one element proved in practice
9	Extremely more important	The highest-order dominance of one element over another
2, 4, 6, 8	Intermediate values	Compromise is needed

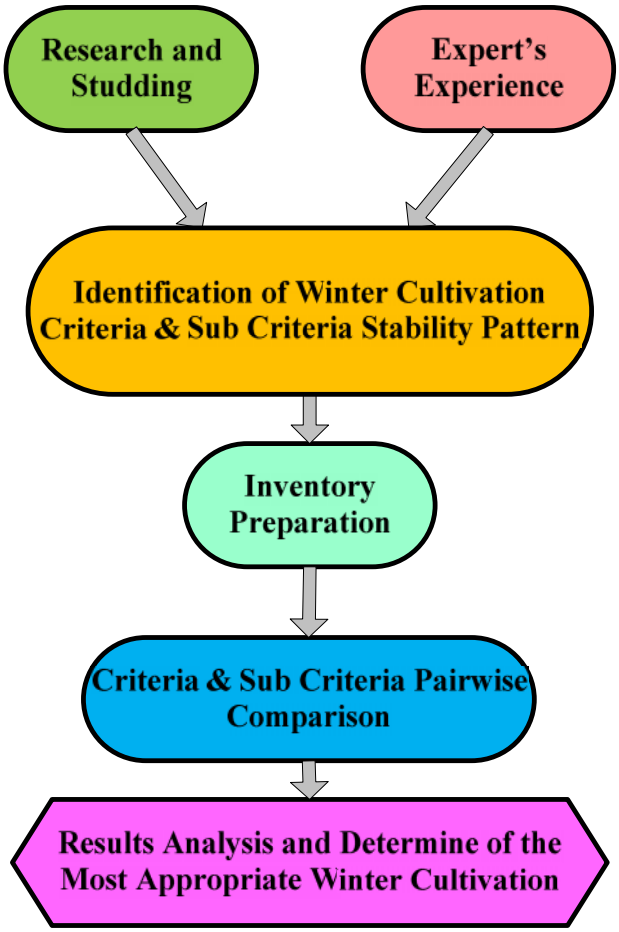

Fig. 3. Process of diagram.

B. Priority of criteria and sub criteria

Criteria and sub criteria pairwise comparison and weighting was done by experts and theirmean values were used to prioritize. In normal matrix of criteria and sub criteria paired comparison, the mean value was calculated for each row.Thus, by this average value, the weight of criteria and sub criteria and their priorities determined. Tables 2 to 7 describe the result of pairwise comparisons.

Table 2: Stability criteria of winter cultivation priority in Amol.

Criteria	Priority	The importance percentage	IR
Economic stability	1	55.2	0.09
Technical stability	2	17	
Social stability	3	17	
Ecological stability	4	7.3	
Political stability	5	3.5	

Table 3: Economic stability sub criteria of winter cultivation priority in Amol.

Sub criteria	Priority	The importance percentage	IR
The more income per hectare	1	52.2	0.1
The more performance per hectare	2	22.6	
Thelower cost per hectare	3	11.8	
The better access to markets	4	7.0	
The moretrend of insurance agenciestoward product insurance	5	3.3	
The lower usage of seed per hectare	6	3.0	

Table 4: Ecological stability sub criteria of winter cultivation priority in Amol.

Sub criteria	Priority	The importance percentage	IR
The moreresistance to disease	1	43.0	0.07
The greater resistance to pests	2	24.0	
The more resistant to climate change	3	17.7	
The shorter duration from sowing to harvest	4	7.3	
The more resistance to lodging	5	5.3	
The less waste	6	2.6	

Table 5: Technical stability sub criteria of winter cultivation priority in Amol.

Sub criteria	Priority	The importance percentage	IR
The less usage of chemical pesticides per hectare	1	52.2	0.13
The less usage of chemical fertilizers per hectare	2	23.8	
The greater use of biological control methods	3	10.0	
The greater use of bio fertilizers	4	6.5	
The less usage of the plow and the groove	5	4.9	
The further savings in water consumption	6	2.7	

Table 6: Social stability sub criteria of winter cultivation priority in Amol.

Sub criteria	Priority	The importance percentage	IR
To create more jobs	1	55.1	0.1
Farmers access to more extension services	2	25.3	
The better marketability of the product	3	14.2	
Requires less specialized knowledge in production	4	5.4	

Table 7: Political stability sub criteria of winter cultivation priority in Amol.

Sub criteria	Priority	The importance percentage	IR
Guaranteed purchase product	1	70.0	0.1
The better access to inputs required	2	22.1	
Subsidized services	3	7.9	

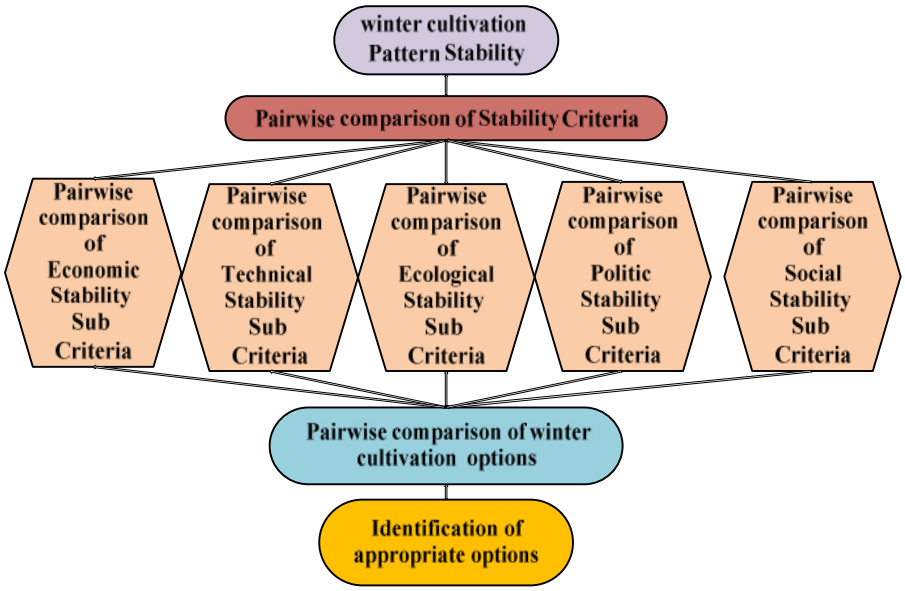

Fig. 4. Decision model in research.

RESULT AND DISCUSSION

To determine alternatives weight and the best of them, the comparisons should be combined for specification the order of priorities. The higher priority will assign to the higher weight.

(1) $\sum_{k=1}^{N}\sum_{i=1}^{M} W_k W_i(g_{ij})=$ (final weight of alternative) j

The weight ratio of alternative (j) to sub criteria (i) :g_{ij}
the weight of sub criteria (i) : W_i
The weight of criteria (k) : W_k
Below tables illustrated the priority of lettuce, bersim clover and broad bean with considering sub criteria stability.

Table 8: Priority of luttuce, bersim clover and broad bean with considering winter cultivation economic sub criteria in Amol city.

Sub criteria	Priority	The importance percentage	IR
The more performance per hectare	Bersim Clover	65.3	0.09
	Lettuce	28.7	
	Broad bean	7.8	
The more income per hectare	Lettuce	67.1	0.1
	Bersim Clover	23.2	
	Broad bean	9.7	
The lower cost per hectare	Bersim Clover	70.5	0.09
	Broad bean	23.7	
	Lettuce	5.8	
The better access to markets	Lettuce	62.7	0.08
	Broad bean	28	
	Bersim Clover	9.4	
The more trend of insurance agencies toward product insurance	Lettuce & Broad bean	47.4	0
	Bersim Clover	5.3	
The lower usage of seed per hectare	Lettuce	66	0.03
	Bersim Clover	24.4	
	Broad bean	9.6	

Table 9: Priority of luttuce, bersim clover and broad bean with considering winter cultivation technical sub criteria in Amol city.

Sub criteria	Priority	The importance percentage	IR
The shorter duration from sowing to harvest	Lettuce	77	0.17
	Broad bean	16.7	
	Bersim Clover	6.3	
The moreresistance to disease	Lettuce	73.3	0.09
	Broad bean	19.9	
	Bersim Clover	6.8	
The greater resistance to pests	Bersim Clover	63.6	0
	Lettuce &Broad bean	18.2	
The more resistance to lodging	Broad bean	71.4	0
	Lettuce&Bersim Clover	14.3	
The more resistant to climate change	Bersim Clover	66.3	0.1
	Broad bean	26.4	
	Lettuce	7.3	
The less waste	Bersim Clover	64.9	0.06
	Broad bean	27.9	
	Lettuce	7.2	

Table 10: Priority of luttuce, bersim clover and broad bean with considering winter cultivation ecological sub criteria in Amol city.

Sub criteria	Priority	The importance percentage	IR
The less usage of the plow and the groove	Bersim Clover	72.6	0.14
	Broad bean	15.2	
	Lettuce	12.2	
The less usage of chemical pesticides per hectare	Bersim Clover & Lettuce	40	0
	Broad bean	20	
The less usage of chemical fertilizers per hectare	Bersim Clover	64.5	0.1
	Broad bean	29.7	
	Lettuce	5.8	
The greater use of bio fertilizers	Bersim Clover, Broad bean & Lettuce	33.3	0
The further savings in water consumption	Bersim Clover, Broad bean & Lettuce	33.3	0
The greater use of biological control methods	Lettuce	66.7	0
	Bersim Clover & Broad bean	16.7	

Table 11: Priority of luttuce, bersim clover and broad bean with considering winter cultivation social sub criteria in Amol city.

Sub criteria	Priority	The importance percentage	IR
Requires less specialized knowledge in production	Bersim Clover	66.7	0
	Lettuce & Broad bean	16.7	
The better marketability of the product	Lettuce & Broad bean	46.7	0
	Bersim Clover	6.7	
Farmers access to more extension services	Lettuce, Bersim Clover & Broad bean	33.3	0
To create more jobs	Lettuce	70.2	0.09
	Broad bean	21.1	
	Bersim Clover	8.7	

Table 12: Priority of luttuce, bersim clover and broad bean with considering winter cultivation politic sub criteria in Amol city.

Sub criteria	Priority	The importance percentage	IR
Guaranteed purchase product	Lettuce, Bersim Clover & Broad bean	33.3	0
The better access to inputs required	Bersim Clover & Broad bean	44.4	0
	Lettuce	11.1	
Subsidized services	Lettuce, Bersim Clover & Broad bean	33.3	0

The final priority of winter cultivation products cope with stability criteria has demonstrated in Table.13.

Table 13: Priority of luttuce, bersim clover and broad bean with considering winter cultivation stability criteria in Amol city.

Criteria	Priority	The importance percentage	IR
Economic stability	Lettuce	50.2	0.1
	Bersim Clover	36.4	
	Broad bean	13.5	
Technical stability	Lettuce	43.8	0.07
	Bersim Clover	32.8	
	Broad bean	23.3	
Social stability	Lettuce	54.7	0.08
	Broad bean	27.6	
	Bersim Clover	17.7	
Ecologic stability	Broad bean	44.1	0.1
	Bersim Clover	34	
	Lettuce	21.9	
Politic stability	Bersim Clover & Broad bean	35.8	0.05
	Lettuce	28.4	
Final	**Lettuce**	**47**	**0.09**
	Bersim Clover	**32.4**	
	Broad bean	**20.6**	

Random consistency index (RI), in pair wise should be less than 0.1 and in this research the final value of IR, is 0.09. Therefore, it is satisfactory. According to economic stability, the more performance and income and lower cost per hectare, were the important sub criteria, respectively. In social stability, to create more jobs, farmer's access to more extension services and the better marketability of the product were the highest priority, respectively. The more resistance against disease, pests and climate change were the most importance sub criteria in technical stability, respectively. According to ecological stability, the most important sub criteria that the experts were emphasized were the less usage of chemical pesticides and fertilizers per hectare and the greater use of biological control methods that allocated the highest priority, respectively. According to expert's opinions, the most important sub criteria in politic stability were guaranteed purchase product, the better access to inputs required and Subsidized services, respectively. Prioritization criteria based on expert assessment conducting by hierarchical analysis indicates that economic, technical and social criteria are more important than ecological and political criteria. Figure 5, demonstrates sensitivity analysis of winter cultivation in Amol and describe the impact of criteria priorities changing. The priority of winter cultivation illustrates in figure 6.

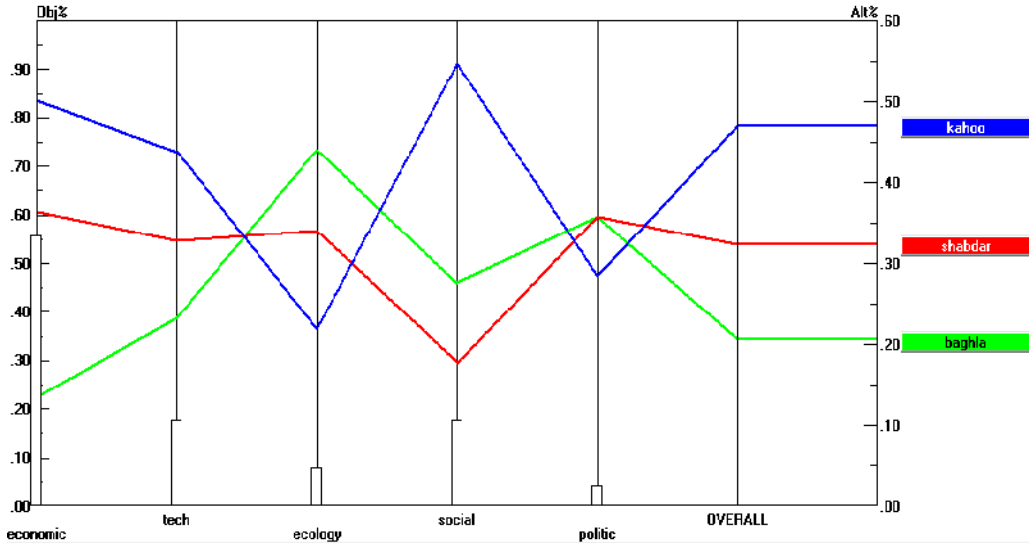

Fig. 5. Sensitivity analysis lettuce, clover and beans winter cultivation.

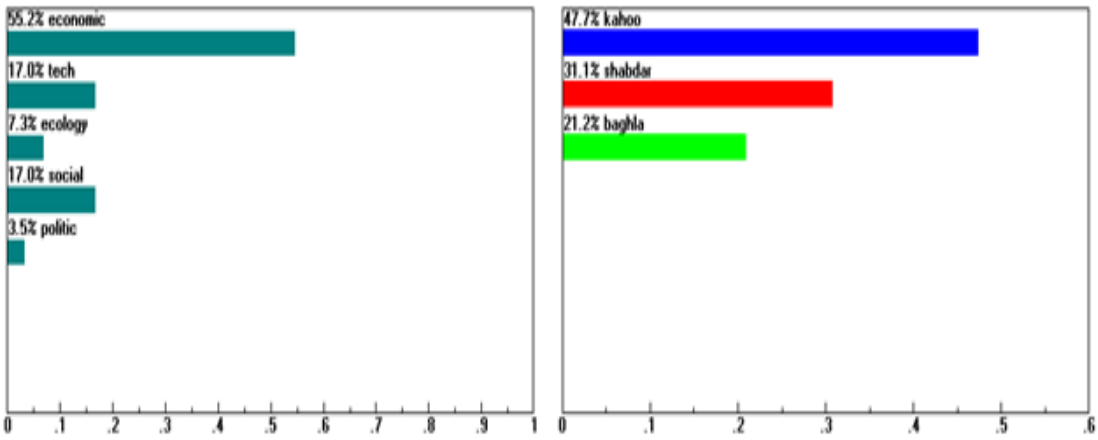

Fig. 6. Priority of winter cultivation in Amol.

CONCLUSION

The result illustrated that for economic, social and technical stability in winter cultivation system stability in Amol, Lettuce, Bersim Clover and Broad bean are appropriate respectively. For realization of ecological stability, Broad bean, Bersim Clover and Lettuce are appropriate respectively and for accessibility to political stability in winter cultivation system, Broad bean and Bersim Clover are in the first level.

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