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An Economic Evaluation of Iranian Horticultural Research and Extension Policy: The Case Study of Almond Late Flowering Cultivars

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Abstract

This paper examines the economic effects of investment in developing and introducing Almond Late Flowering Cultivars (ALFC) in a period of 52 years from 1968 to 2020, developed in Sahand Horticultural Research Station (SHRS), using the economic surplus model and field survey data. ALFC make almond supply curve move less to the left when there is a chilling case, thus affect the economic surplus of producers and consumers. Results showed that because of ALFC, economic surplus of producers and consumers had been increased about 0.4 and 0.6 million US Dollars, respectively that the share of consumers from benefits was 58 percent. The social net present value of ALFC regarding to the cost of research and extension was about 0.1 million US Dollars. It was identified that the internal rate of return in developing and introducing of ALFC had been about 11%. The findings expressed that if the research investment in ALFC could keep the position of almond supply curve unchanged unless the weather conditions, then the economic surplus of producers and consumers would decreased 3 and 4.2 million US Dollars less annually, respectively and internal rate of return in almond research would be 33 %. Comparing the results showed that the introduction of late flowering cultivars could reduce the loss only 4 % per hectare. The results illustrated that investment in R&E of almond could make supply curve shift less in chilling situation because of decrease in cultivation cost, but it is necessary to enhance almond yield too. The findings identify that the efficiency of current system of R&E for almond is low. So it is a necessity to find ways for make better the R&E performance in Iran.

Keywords:
Research and Extension, Economic surplus model, Late flowering Almond, Chilling, Benefit distribution

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INTRODUCTION

Governments intervene in agricultural markets to reallocate and redistribute inputs and incomes. Because countries do not have the same economic situation, the motives and objects of intervention will be different. In developing countries, more attention has been paid to self-sufficiency and food security but developed countries try to increase revenues by improving the quality of products. Implementation of agricultural policies are because of imbalance between private and social objectives which is called market failure where goods or services are produced less or more than social optimum amount. Governments to deal with market failure in agriculture markets use different policies like marketing, input, credit, mechanization, land reform, irrigation and research. Each of these policies has effects on income distribution and inputs allocation. Among them, agricultural research policy aims to increase growth, equity and food security in the agricultural sector by distribution new technology. Agricultural research policy produces knowledge by basic, strategic, applied and adaptive projects (Hosseini, 2006). To decide about the volume of resources which should be paid for agricultural research policy and efficient allocation of these resources among research projects, personnel and equipment, we need information which obtains through the economic assessments of research. Economic assessments have been done by economic researchers to prioritize research options and also review the results of research have been done before (Alston *et al.,* 1995).

A few numbers of studies on economic research evaluation in Iran has been done but they are growing. These studies pay more attention to assess agricultural research policy on annual crops like studies of Hosseini *et al*. (2007, 2006 and 2009) in sugar beet and Khaledi and Hosseini (2004) in rice cultivars, but so far there is no study to assess economic effects of research in horticulture sector in the country. Gotsch and Burger (2001) and Gotsch and Wohlgenate (2001) studied the economic effects of improved Cocoa varieties in Malaysia using economic surplus method with parallel and pivotal shifts in supply carve as a ex ante study. The current work is an ex post research evaluation and internal rate of return will be calculated; also a wide survey was used to gather the data directly from farm and did not impose any primary assumption for success of new varieties. In our study discarding function will be calculated and it tries to identify the economic effects of almond research which has been done in SHRS.

Almond industry is economically important in Iran. Almond needs enough cool to have good yield, but its flowers are sensitive to temperature reduction. So in spring when cool weather comes back which is called chilling, causes reduction in yield and we lost lots of production. Chilling threatens almond horticulture in Iran. For example in 2004 chilling reduced almond production from 120000 tones in 2003 to 70000 tones (the Ministry of Jihad-e-Agriculture) .Statistics show that production in 2007 is still less than 2003. In 2009 the loss for almond orchards of East Azerbaijan province was estimated to be about 21 million US Dollars (12 present of all chilling loss). Late chilling in spring is the most important factor that reduces and limited the production meaningfully, so every year part or all of the production has been lost and this reduction when we consider the total production, price and other economic factors is completely high. This reduction can be illustrated by left supply shift in economic surplus approach. Because of splitting the loss among all producers and consumers and not being the law to control property rights, during years we always have had this loss which can be called some kind of market failures, so the government of Iran had established some horticultural research stations since 1968 to invest on some late flowering cultivars of almond that its results showed up about 1994 by introducing seven new almond varieties that can bypass the late chilling in spring. From the year of 1994, extension efforts have been done and now we can see the results on the fields. So, this study tries to analyses the economic effects of Iranian research and extension (R&E) efforts on almond by estimating shift parameter (k-parameter), calculating social gain, NPV, IRR and accounting the research results using economic surplus model.

MATERIALS AND METHODS

Almond research changes the value of annual production and maintenance costs in the orchards. In this study economic indicators like NPV, Benefit - Cost Ratio and internal rate of return as a tool for decision making are used to assess economic impact of late flowering almond varieties on the profitability of cultivation. The ability of almond garden to produce with increasing age will decrease, so it is necessary to get these changes in the study. In order to consider these dynamics in the calculations related to the shift parameter of supply function in different years, the indicator that was introduced by Gotsch and Burger (2001) is used. Not enough information about the economic effects of research in the agricultural sector, including the benefits, costs and their distribution among various economic groups exist. There are different methods to evaluate the economic effects of research. However, the dominant approach is economic surplus model (Norton, Ganoza and Pomareda, 1987; Alston *et al.*, 1995; Gotsch and Burger, 2001; Gotsch and Wohlgenant, 2001; Hosseini, Hassanpour and Sadeghian, 2009).

Suppose development and introduction of ALFC can increase resistance of trees to chilling in spring, so by reducing damage almond supply curve will shift less to left. The graphical model is the way to identify the economic effects and results of possible changes in supply curve. Figure 1 shows how the chilling affects the supply

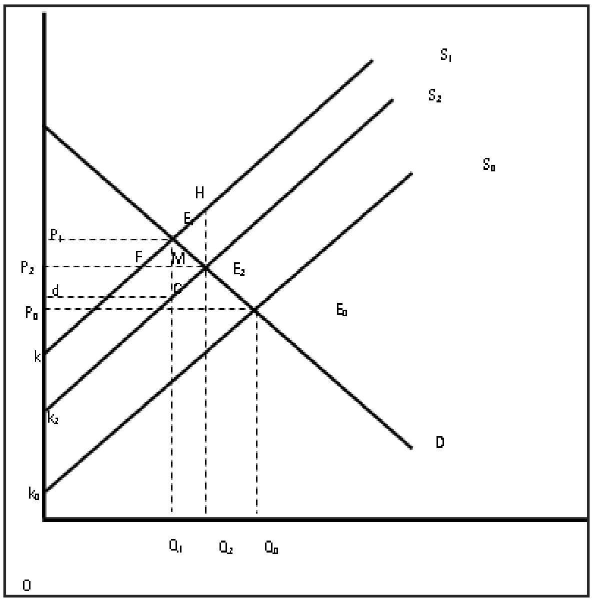

Figure 1: The effects of almond R&E in chilling condition

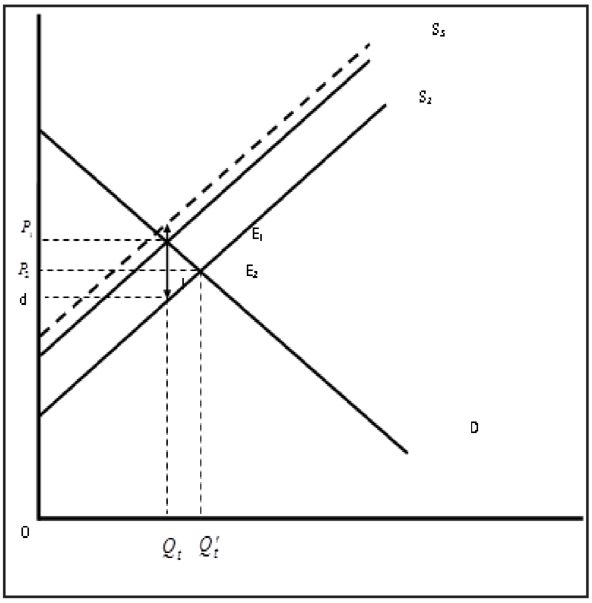

Figure 2: The components of shift parameter

curve with and without of late flowering cultivars. The original supply curve is S_0 with old almond cultivars when there is no chilling. D identifies the demand curve for almond. Chilling reduces the almond orchards production and shifts the supply curve from S_0 to S_1. To decrease the damage the government tries to develop and introduce some new cultivars by investing on R&E. S_2 shows the supply curve with ALFC in chilling situation. In figure 1 E_0, E_1 and E_2 are the equilibriums.

Development and introduction of ALFC makes almond supply curve shift left less (S_2 instead of S_1). As a result adoption of late flowering cultivars increases almond production from Q_1 to Q_2 and decreases price from P_1 to P_2 in chilling. Therefore, the economic surplus will increase by the amount of $k_1E_1E_2k_2$. The shift parameter is calculated from the following relation:

$$k_t = \left[\frac{EY_t}{\varepsilon} - \frac{EAC_t}{1+EY_t}\right].P_t \qquad (1)$$

Where k_t, EY_t, EAC_t, P_t and ε are shift parameter, relative change in yield, relative change in cost, Almond price and short run supply elasticity of almond, respectivly. The components of shift parameter have been shown in figure 2.

As figure 2 shows the shift parameter has made from two components. The production changes (J) and cost changes from adoption of ALFC (I). The net effect produces the amount of supply curve shifts right. In the case of ALFC yield change seems to be negative but less than the reduction has been seen in production cost, so per unit production cost reduces. The per unit reduction from yield changes has been calculated from supply elasticity as relation below:

$$\frac{dP}{P}=\frac{1}{\varepsilon}.\frac{dQ}{Q} =\frac{1}{\varepsilon}.\frac{dY.A}{Y.A} =\frac{1}{\varepsilon}.\frac{dY}{Y}=\frac{EY_t}{\varepsilon} \quad (2)$$

Where dY/Y has been defined EY. The relation 2 translates proportionate changes in production to proportionate change in price. To get the second part of shift parameter we use the relation 3:

$$\frac{I}{P}=i=\frac{\frac{\Delta AC.A}{Q^{new}}}{\frac{AC.A}{Q^{old}}} =\frac{\frac{\Delta AC}{AC}}{\frac{Y^{mix}}{Y^{old}}} =\frac{\frac{\Delta AC}{AC}}{\frac{Y^{old}+\Delta Y}{Y^{old}}}=\frac{EAC_t}{1+EY_t} \quad (3)$$

Where i is relative change in per unit production cost as a result of changes happened in adoption cost, AC is per hectare variable cost, Y^{old} and Y^{mix} are almond yield per hectare without and with ALFC, respectively. The sum of relative changes from yield and cost makes net relative per unit cost reduction k_t which equals k_t/P_t.

The production ability of almond orchards depends on age and number of trees exists in garden, so the changes should be considered in yield calculation. To estimate the production changes the probability function was used (Gotsch and Burger, 2001; Kazianga and Masters, 2006) which is defined as follows:

$$disc_a=\frac{1-e^{-\frac{1}{r\mu}}}{1+e^{\frac{(\mu-a)}{r\mu}}} \quad (4)$$

Where $disc_a$ is discarding function and shows changes in tree number per hectare; r is the age effect of almond on tree number per hectare; μ is the age which 50 percent of removal has been done and a is the age group.

In this paper we closely follow the discarding function to calculate relative change in yield and cost by providing a way to get vintage matrix. The rows and columns of the vintage matrix are the age groups and years respectively. Each element in matrix shows the hectares of almond orchards in a specific age group and year. To get the future information relation 5 is stated as:

$$A_{i,t}=A_{i-5,t-5}-A_{i-5,t-5}\text{-}disc_a \quad (5)$$

Where $A_{i,t}$ is hectare of almond with age i in year t; $A_{i-5,t-5}$ is hectare of almond in five years ago and $disc_a$ is discarding that happens in each age group (a). To complete the matrix vintage for past years the relation 6 is defined as:

$$A_{i-5,t-5}=\frac{A_{i,t}}{(1-disc_a)} \quad (6)$$

It is possible to estimate the relative change in almond yield in chilling with late flowering cultivars as follows:

$$EY_t=\frac{(Y_t^{mix}-Y_t^{old})}{Y_t^{old}} \quad (7)$$

Where EY_t is relative change in yield with chilling and late flowering cultivars; Y_t^{mix} is the yield with old and late flowering cultivars together and Y_t^{old} is the yield without late flowering cultivars. To get yields the relation 8 is used:

$$Y_t=\frac{\sum_{i=1}^{I}A_{i,t}NY_i}{TA_t} \quad (8)$$

Where Y_t is almond yield with chilling; NY_i is yield for age i; TA_t is almond hectares in year t and $A_{i,t}$ is hectares of almond in age i and year t.

The same way will use to estimate the relative change in cost. It is showed as below:

$$AC_t=\frac{\sum_{i=1}^{I}(A_{i,t}TC_{i,t})}{TA_t} \quad (9)$$

Where AC_t and $TC_{i,t}$ are average cost per hectare and total cost of one hectare almond in age i, respectively. As the parameter k is estimated, the changes in producer and consumer surplus can be estimated by using the relations 10 and 11 as follows:

$$\Delta PS_t = (k^* - Z) P_t Q_t (1 - 0.5 Z_t \eta) \qquad (10)$$

Where ΔPS_t is the change in producer surplus; k^*_t equals k_t / P_t; Z_t is relative change in equilibrium price and η is demand elasticity. To have the changes in consumer surplus the relation 11 is used:

$$\Delta CS_t = P_t Q_t Z_t (1 - 0.5 Z_t \eta) \qquad (11)$$

Where ΔCS_t identifies the change in consumer surplus. The other variables have been defined before. The total change in society economic surplus will be estimated by adding the changes of producers and consumers surpluses together using relation 12 as follows:

$$\Delta TS_t = k_t^* P_t Q_t (1 - 0.5 Z_t \eta) \qquad (12)$$

Comparing ΔTS_t with research and extension costs by NPV and IRR criteria will show the beneficiary of the social return in almond late flowering R&E. research.

Data

The published data do not separate concentrated almond orchards from mixed orchards and also there is no information about the area of different almond varieties in detail, so we use two stages stratified random sampling method to get data. To estimate the sample size the relation below will be used and samples are identified in two stages: First step: identify No. of cities in each strum, second step: identify No. of villages in each strums (Mendenhall, Ott, and Scheaffer, 1971).

$$n = \frac{\sum_{i=1}^{L} \frac{N_i^2 \delta_i^2}{w_i}}{N^2 D + \sum_{i=1}^{L} N_i \delta_i^2} \qquad (13)$$

Where n is number of city or village in each stage that randomly selected; N_i total number of each estrum; δ_i^2 is variance of almond area in each stage; w_i is a weight given to the estrums, approximating with almond cultivated area; N is total number of cities or villages in each estrum and D is variance of almond average area among estrums. In equation 13, i denotes number of estrums. Using equation 13, cities of Ajabshir, Azarshahr, malekan and Jolfa were randomly selected from 19 cities of East Azerbaijan province where ALFC were developed and cultivated. There were nine villages among 248 villages of these four cities that hat plenty almond orchards, so in the second stage of sampling the information of almond orchards in 6 randomly selected villages were collected by filling out the questionnaire in the year of 2009. To have enough information for calculating yield in different age groups and with and without chilling conditions from almond orchards the questionnaire were filled out for three years of 2007, 2008 and 2009 by interviewing. Pre test of questionnaire was done by expert of horticulture and filling questionnaire in some village. The questionnaire was filled out from 143 almond orchards. Analyses of 143 almond orchards in table 1, showed that there were mostly irrigated almond orchards in the study region and the variety using in local and late flowering almond orchards were hard and soft shell kinds, respectively. Results also shows that only 30 percent of almond orchards using late flowering

Table1. Number and percentage of almond orchards in the sample

Almond varieties	Shell quality	Irrigation				total	percentage
		Irrigate orchards	Percentage	Non-irrigate orchards	percentage	92	64
local	Hard	90	63	2	1.5	8	6
	Soft	4	4	2	1.5	18	13
ALFC	Hard	18	13	0	0	25	17
	Soft	25	17	0	0	143	100
total		139	97	4	3		

almond till 2009 and adoption of ALFC with soft shell is more than hard shell varieties.

Table 1, identifies that the varieties with hard shell are mostly planted and 77.5 percent of almond orchards use these kinds of varieties. Of course in orchards that use ALFC the percentage of variety with soft shell is more instead of local orchards. As majority of the orchards have been planted with local hard shell and late flowering soft shell, so this paper uses the information of these orchards to calculating shift parameter, changes in surpluses and research and extension (R&E) efficiency by estimating IRR and NPV.

RESULTS AND DISCUSSION

Evaluation of research activities in the agricultural sector will make better financial management of limited resources allocated to agricultural research. Chilling in spring reduces the production of almond, so find the solution for reducing the damage is a research priority. Volume of capital investment required for development of cultivars with the ability to escape the chilling is more than benefits received for each farmer, so private sector does not have enough willingness to make investment on research activities of late flowering cultivars. This situation in the economy is called market failure which is the main reason for government intervention in research and development of late flowering almond varieties. Result in the research activity carried out from 1968 to 1988 in Sahand Horticultural Station ended by introducing seven late flowering almond varieties. These cultivars were introduced through the extension agents since 1989 and continued till 2002. This study is the first economic study to analyses development and introduction of almond cultivars by applying an appropriate model.

Table 2: Tree intensities in almond orchards per hectare

Age groups	Tree intensity	
	Local	ALFC
1-5	777	711
6-10	1636	445
11-15	904	206
16-20	440	263
21-25	560	-*

* There are no orchards with ALFC with age of more than 20 years.

Table 3: Calculating discarding in different age groups of orchards

Age groups	Discarding amount	
	Local	ALFC
1-5	-1.25	0.1
6-10	-1.03	0.43
11-15	0.44	0.76
16-20	0.78	0.85
21-25	0.86	-

The almond orchards depending on shell quality and irrigation system are different and according to the varieties are divided in a big two categories of local and late flowerings.

The study needed the information of 52 years from 1968 to 2019 that contains R&E costs from 1968 to 2002 and adoption period from 1995 to 2019. The R&E cost were prepared by using related organizations and the orchards data were obtained by making vintage matrix for almond area and production. To get the vintage matrix from limited questionnaires data, discarding function was defined and calculation was done by using the information which presenting in table 2.

The table 2 shows that there is no fixed trend in tree intensity in local orchards but it is clearly decreasing trend in orchards with ALFC, so there are different discarding relation in local orchards according to age groups. Table 3, is prepared the discarding results in sample orchards.

Table 3, shows the rate of discarding in orchards with ALFC is more than the local orchards. Also in local orchards in 1-5 and 6-10 age groups the replanting exceeds the removing as the discarding becomes negative. Using the filed data and discarding relation, it is possible to make vintage matrix and calculate the shift parameter. Table 4, presents the results.

The results shows that ALFC could make almond supply curve move to left less in chilling conditions in most of years but this reduction is resulted from production cost reduction instead of yield increase so there is no evidence that introducing ALFC could be able to increase almond yield in chilling situations expect the years when orchards were mostly young. It is possible to calculate changes in producers and consumers surpluses because of ALFC using the information from shift parameter. Table 5, illustrated the results.

Table 4: Shift parameter of almond supply curve in chilling situation with ALFC

Year	Per unit production cost change from yield change	Per unit production cost change from average cost change	Shift parameter
1995	0.48	-0.08	0.57
1996	0.35	-0.06	0.41
1997	0.31	-0.06	0.37
1998	0.19	-0.04	0.23
1999	0.19	-0.04	0.23
2000	0.04	-0.06	0.10
2001	-0.03	-0.07	0.03
2002	-0.22	-0.16	-0.06
2003	-0.28	-0.20	-0.09
2004	-0.22	-0.17	-0.05
2005	-0.16	-0.12	-0.04
2006	-0.15	-0.12	-0.03
2007	-0.03	-0.12	0.08
2008	-0.08	-0.16	0.08
2009	-0.13	-0.16	0.03
2010	-0.08	-0.11	0.02
2010	-0.09	-0.11	0.03
2012	-0.08	-0.10	0.03
2013	-0.11	-0.14	0.03
2014	-0.10	-0.14	0.04
2015	-0.03	-0.08	0.05
2016	-0.04	-0.09	0.05
2017	-0.01	-0.06	0.05
2018	-0.02	-0.09	0.07
2019	0.00	-0.09	0.09
average	-0.01	-0.1	0.09

The results illustrated in table 5, shows that producers and consumers have been lost less in chilling situation except the years 2002 to 2006 when the shift parameter was negative by developing and introducing ALFC. Present value of changes in producers and consumers surplus was

Table 5: Changes in producers and consumers surpluses in Iran with ALFC

year	East Azerbaijan province production proportion	Shift parameter	Weighted shift parameter	Producer surplus change* (US dollars)**	Consumer surplus change (US dollars)
1995	0.31	0.57	0.18	60162	83851
1996	0.32	0.41	0.13	46299	64529
1997	0.32	0.37	0.12	38879	54187
1998	0.33	0.23	0.08	15653	21817
1999	0.33	0.23	0.07	13013	18137
2000	0.17	0.10	0.02	39385	54893
2001	0.16	0.03	0.01	15918	22185
2002	0.17	-0.06	-0.01	-29778	-41504
2003	0.18	-0.09	-0.02	-71584	-99770
2004	0.19	-0.05	-0.01	-32231	-44921
2005	0.17	-0.04	-0.01	-31846	-44385
2006	0.18	-0.03	0.00	-27221	-37940
2007	0.17	0.08	0.01	88069	122746
2008	0.17	0.08	0.01	84744	118112
2009	0.17	0.03	0.01	37482	52240
2010	0.16	0.02	0.00	27148	37838
2010	0.16	0.03	0.00	28870	40238
2012	0.15	0.03	0.00	26453	36868
2013	0.16	0.03	0.01	35196	49054
2014	0.16	0.04	0.01	39813	55489
2015	0.15	0.05	0.01	22653	31573
2016	0.15	0.05	0.01	21505	29972
2017	0.15	0.05	0.01	20882	29104
2018	0.15	0.07	0.01	29600	41254
2019	0.15	0.09	0.01	30676	42755

* The supply elasticity was estimated from the questionnaire data and demand elasticity extracted from Russo and *et al.* (2008) that are 0.67 and -0.48, respectively.
** 10000 Iran rial ≈ 1 US dollar

Table 6: Changes in producers and consumers surpluses with CSAC in Iran

year	East Azerbaijan province production proportion	Shift parameter	Weighted shift parameter	Producer surplus change* (US dollars)**	Consumer surplus change (US dollars)
1995	0.31	8.54	2.68	1278775	1782292
1996	0.32	8.54	2.73	1353728	1886758
1997	0.32	8.54	2.74	1260942	1757438
1998	0.33	8.54	2.80	810242	1129274
1999	0.33	8.54	2.80	688240	959235
2000	0.17	3.52	0.61	1531871	2135045
2001	0.16	3.20	0.53	1682786	2345383
2002	0.17	3.15	0.54	1720571	2398046
2003	0.18	3.22	0.57	2874190	4005903
2004	0.19	3.43	0.64	2410935	3360241
2005	0.17	3.33	0.58	2968401	4137209
2006	0.18	3.39	0.60	3626926	5055028
2007	0.17	3.42	0.59	3985441	5554709
2008	0.17	3.41	0.59	3844490	5358258
2009	0.17	3.17	0.55	4037168	5626803
2010	0.16	2.87	0.45	3374289	4702915
2010	0.16	2.85	0.45	3232624	4505470
2012	0.15	2.85	0.44	3202880	4464014
2013	0.16	2.85	0.44	3173358	4422868
2014	0.16	2.88	0.45	2913506	4060700
2015	0.15	2.95	0.45	1478906	2061226
2016	0.15	2.96	0.45	1463197	2039330
2017	0.15	2.96	0.46	1441671	2009329
2018	0.15	2.96	0.45	1398773	1949540
2019	0.15	2.94	0.45	1088550	1517167

estimated to be 0.8 and 1.1 million US dollars that would decrease to 0.4 and 0.6 million US dollars with reduction in chilling probability to once a two year, respectively. So the distribution of benefits between producers and consumers were 42 and 58 percent, respectively. The results identifies that the investment in ALFC is more consumers oriented. To analyses the condition when some completely successful almond cultivars (CSAC) would develop that could make the almond supply curve unchanged in chilling situation, in this study such successful condition was examined. Table 6, presents the results.

Table 6, identifies that the producers and consumes surpluses could decrease less with CSAC about 7 million US dollars in chilling condition annually. The total decrease in producers and consumers surpluses was estimated to be about 179 million dollars. The distribution of the chilling economic loss is the same as before. The investment cost in R&E was needed to calculate IRR and NPV for ALFC project. Table 7, summaries the cost had been invested in almond R&E during 1968 to 2002.

IRR and NPV of ALFC and CSAC were calculated using information from tables 5, 6 and 7. the results showed that IRR for *ex ante* and *ex post* scenarios were 15 and 36 percent which would decrease to 11 and 33 percent when the chilling was once two year, respectively. The results identify producer and consumer surplus decrease 2000 us dollars per hectares in chilling situation. The distribution of chilling loss between producers and consumers is 1200 and 800 us dollars respectively. Developing and introducing ALFC could decease the loss 75 us dollars which is only 3.75 percent of the total loss per hectare.

Table 7: Research and extension cost of ALFC

Year	Real R&E cost (US dollars)	year	Real R&E cost (US dollars)
1968	359	1986	1126
1969	590	1987	922
1970	820	1988	753
1971	1050	1989	10526
1972	1174	1990	9677
1973	1278	1991	8036
1974	1277	1992	6452
1975	1355	1993	5248
1976	1275	1994	9719
1977	1115	1995	6503
1978	1126	1996	5282
1979	1097	1997	4500
1980	1198	1998	3810
1981	1677	1999	4231
1982	1488	2000	3757
1983	1399	2001	3373
1984	1328	2002	2913
1985	1325		

CONCLUSION

The current study analyzed the economic impacts of R&E in developing and introducing ALFC to decrease chilling loss in almond orchards. The results showed investment in R&E of almond could make supply curve shift less in chilling situation because of decrease in cultivation cost, so it is necessary to work on yield enhance too. The findings identify that the absolute amount of chilling loss is high per hectare and will increase if all almond orchards area in the country is considered which shows the importance of R&E economic impacts that poetically exist but the calculated efficiency for current system of R&E in Iran is low. So it is a necessity to find ways for make better the R&E performance in Iran which it is showed clearly in this study existence potentially some available return in R&E investments does not support the acceptance efficiency.

This study considered the closed economy with parallel shift induced by R&E and supposed no shift in almond demand curve. To get more clear results, the study should be expended to analyze trade situation and demand shifts with nonparallel supply shifts too. As the ALFC are regionally depended, so R&E can change regional income distribution which did not take to account here and may go to consideration in future studies.

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