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STUDY OF THE AGRO-ECONOMIC EFFECT OF EVERY- OTHER FURROW IRRIGATION AND DIFFERENT LEVELS OF NITROGEN APPLICATION ON WHEAT YIELD

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ABSTRACT:

Background/Objectives: Choosing irrigation method and nitrogen fertilizer content are highly restricted by economic issues. In this study, economic impacts of irrigation reduction in combination of nitrogen fertilizers on wheat production were investigated.

Methods/Statistical Analysis: Three methods (normal, fixed and variable) Every-Other Furrow irrigations, which is one of the recent methods of water management used in wheat production, were employed in main plots. Nitrogen fertilizers (0, 90, 180 and 270 Kg/ha) were applied to subplots. The experiment was conducted in Bajgah and Kooshkak stations. The grain yield-fertilization functions, considering the optimum values of nitrogen application, were obtained when different irrigation methods were used. The benefit to cost ratio, real and normal profit for optimum treatment in Bajgah and Koashkak were then calculated.

Findings: Our results indicated that application of 270 kg/ha nitrogen under variable E.O.F irrigation followed by 180 Kg/ha nitrogen under variable E.O.F irrigation, lead to the highest yield. Profit to cost ration, real net profit and nominal were estimated 2.52, 11337532 and 11269302 IRR for Bajgah and 2.24, 10087351 and 10087698 IRR in Kooshkak, respectively. Upon measuring environmental factors, nevertheless, application of 180 Kg/ha nitrogen under variable E.O.F irrigation is recommended.

Application/Improvements: Irrigation using this method utilizes water less than 43% compared to furrow irrigation method.

KEYWORDS: benefit to cost ratio, every-other furrow irrigation

INTRODUCTION:

When agricultural systems met water shortage due to limited precipitation, plant water requirement to gain acceptable yield has to be met through irrigation. This kind of irrigation is called "Least irrigation."[7] It is obvious that when the water availability is limited or the cost of water is high, (economically), applying the least irrigation method is preferential because with the same amount of water, more land can be cultivated. When there are some problems to get investment, energy, labor power and other resources, or when the prices of these resources are high, using the "Least irrigation method" can be useful for getting suitable benefit.

If the goal is to get maximum benefit and suitable nutrition production, least irrigation method would be considered as a valuable solution.[4] Every Other Furrow Irrigation (E.O.F.I.) is one of the new methods of surface irrigation. In this method that just a part of the field is irrigated, the evaporation level would be decreased[1]. In this method deep penetration will be limited[9] and because of that, the problem of upcoming water level would be decreased. In addition, E.O.F.I will increase the irrigation speed up to 70 %[11]. Mast[18] tested the effects of irrigation method and timing on field corn (Zea maize L.) in Denair, California. Silage tonnage, grain yield, and plant height were compared across four treatments including; every-other furrow, the grower's standard practice, deficit, and a control with three repetitions of each treatment. The experiment showed that every-other furrow irrigation does not significantly hurt corn yields compared to the control, with every furrow irrigated on the same schedule as every-other furrow. Overall, the experiment revealed that every other furrow irrigation could be utilized to speed up the irrigation schedule.

Tafteh and Sepaskhah[17] in a study aimed at investigating the effect of conventional furrow irrigation, variable alternate furrow irrigation, and fixed alternate furrow irrigation methods on maize yield and nitrogen leaching found that the interaction between irrigation treatments and nitrogen application rates was statistically significant for all irrigation treatments. Total leached nitrate decreased for variable alternate furrow irrigation and fixed alternate furrow irrigation as compared to conventional furrow irrigation respectively. The results of a study conducted by Shayannejad and Moharrery[15] showed that there was significant difference between water use efficiency under different treatments including: normal furrow irrigation, fixed every-other furrow irrigation, and alternative (variable) every-other furrow irrigation in starch and protein contents of potato. The fixed every-other furrow irrigation treatment had the most water use efficiency. This treatment also decreased the starch content and had no effect on protein content of potato in the studied area. In a study carried out by Sheinidashtegol[14], they found that variable every-other furrow irrigation treatment had the highest water use efficiency on sugarcane yield compared to fixed every-other and conventional irrigation methods. The goal of the research was to investigate the cultural and economic effect of E.O.F.I. and different levels of Nitrogen, on wheat seed yield in two regions Bajgah and Kooshkak considering both subsidized and real price of water.

MATERIALS AND METHODS:

The research was conducted in two locations, Bajgah and Koshkak. Both locations belong to faculty of Agriculture, Shiraz University. The geographical and meteorlogical parameters for the two stations are bringing in Table 1. According to the soil analysis, the former location had sandy clay and the later sandy loamy soils (Table 1). The water for irrigation in Bajgah and Koshkak was supplied from wells and Doroudzan dam, respectively. The most important soil volumetric parameters for both regions are listed in Table 2.

The experiment was arranged in a split plot arrangement on a complete randomized blocks design with three replications. The main plots were composed of irrigation mode including three levels, as original (conventional) irrigation, fixed Every Other Furrow Irrigation (E.O.F.I.) irrigation , and variable E.O.F.I. Subplots were four different nitrogen levels including 0-90- 180 and 270 kg/ha. Each subplot included three rows with (1.8m ×30m) cm apart. On each row, plants were spaced 30×9 cm. Amount of the water reached to the plots was controlled using a contour.

Irrigation time was determined according to soil moisture content and evapotranspiration. Soil moisture content was measured in depth of 30, 60, and 90 cm under the soil surface. In each position, soil was taken using auger and after packing in plastic bags, transferred to lab. Weight of the soil samples was measured and the samples were incubated for 24 h at 105°C.

The evapotranspiration from reference plant surface was measured by Penman FAO2. Daily meteorological data, containing daily minimum and maximum of ambient temperature, mean of relative humidity, daily sunshine hours and daily average of wind speed, were taken from synoptic stations in Bajgah and Kooshkak.

Wheat harvest index was calculated according to the following formula:

$$HI\% = \frac{Ys}{Yt}$$

Where Ys and Yt are stand for grain yield and total dried biomass of the plant, respectively.

For each treatment, weights of 1000 seeds and number of spike/m2 were measured, as well. Cost for agricultural activities, from swing to harvesting, are listed in Table 4.

In this survey, cost variables including costs of sowing and harvesting, cost of nitrogen fertilizer, and transporting the harvested crop to silo were considered to be the same for all treatments in both stations. In the course of economic analysis, costs and incomes variables were estimated for different treatments (see following). Dividing profit to cost components, the most economically suitable treatment was determined.

The economic analysis was conducted under two constrains: "with limitation of water consuming reduction" or "without limitation of water consuming reduction". In the method of " without limitation of water consuming reduction " in both stations , using low-irrigation, where only59% of the water in full- irrigation was applied, the opportunity cost of water and real and nominal net profit was calculated. In this method using low-irrigation, 0.7 ha more land could be used for cultivation compared to full irrigation condition.

In the case of "with limitation of water consuming reduction", a total of 1.7 ha land was considered in such a way that 1 ha as one full irrigated and 0.7 h as rain fed. This was compared with the case of 1.7 ha full irrigated land and respective real and nominal net profit were calculated.

In these calculations, nitrogen level of zero (N= 0 kgha-1)) in full irrigation was considered to as check. Considering the inflation rate of 17% in 1376 (data from Central Bank if Iran) and the annual inflation rate of 20% for the years 1377 to 1382, the cost of per cubic meter of water was calculated to be 227.1 Tomans.

RESULTS AND DISCUSSION:

The Interaction of Irrigation Methods and Nitrogen Levels:

Analysis of variance performed on the data collected at both locations is presented in Table 1 and 2. Mean comparison was subsequently performed.

Also, different levels of nitrogen had significant effects ($\alpha \leq 0.05$) on total biomass and 1000 seed weight. In the treatments of N=0, N= 90 and N=180 kg/ha, the yield and number of spike/m2 was 270 and 180 kg/ha nitrogen, these agricultural characters didn't show significantly different at 5%. Biological yield in original furrow irrigation and variable and fixed every other one under application of N=270 kg/ha and N=180 kg/ha didn't show significant difference at 5%. In original furrow irrigation variable and fixed every other one in N= 270 kg/ha and N= 180 kg/ha treatments, seed yield and number of spike/m2 were not significantly different at 5%. But these traits appeared as significant ($\alpha \leq 0.05$) under in N=0, N=90, and N=180 kg/ha. Thus for, in all irrigation treatments, 180 kg/ha nitrogen application appeared to has the highest effect on seed yield. (Table 1and 2).

The Cost of Different Ttoman Treatments:

According to Table 4, the cost of twice ploughs of one hectare per year is 70,000 Tomans. The cost of land levelering per hectare is 70,000 Tomans, superphosphatefertilizer150 kg/ha, every 50 kg bag, 25000 Tomans and Urea fertilizer each bag of 50 kg, was 22500 Tomans. The quantity of seed used in each hecta rwas 25 kg and with 2100 Tomans per kg seed.

During growing period, only part of urea fertilizer was applied. Harvesting by combine machine costs 225000 Tomans per ha, and transferring harvested crops to silo needs 25000 Tomans per ton. So the total fixed expenses have been estimated 152000 Tomans.

In Kooshkak, Water supplied by Doroudzandam was used for irrigation of the farm. According to responsible statements about fixed and variable investments, for each cubic meter of water, the minimum price in year 1376 are estimated 100 Tomans. Considering the average annual inflation rate as 20% for six years, the cost of getting one cubic meter of water in 1382 in Kooshkak area, was calculated 298.6 Tomans. Of course every cubic meter of water was sold to farmers in Kooshkak 25 Tomans and in Bajgah 21 Rilas. This price is less than one eleventh real price of water. According to responsible statements, the price of one Kg wheat, 1720 Rilas and irrigation labor wage, for eight hours work in year 1382 for Bajgah has been recognized 5000 Tomans and for Kooshkak 7000 Tomans.

In Bajgah, the water used for irrigation was supplied from wells. Costs of extracting water from the wells is divided into two groups: fixed and current cost;the fixed costs are included initial investments such as drilling wells, buying and installing the pump motor, power supply and operational, and the current cost covers power or gasoline consumption, repair and maintenance. Cost for production per cubic meter of water extracted from wells can be estimated considering annual costs and average volume of water supplied from the wells.

These parameter are combined into the equation presented by AbdollahiEzatAbadi[8] to estimate total cost required for a cubic meter of water in Toman, providing the hydrant depth is assumed equal to the well depth.

$$Yt = 8.39 + 0.455\ D$$

Where, D is depth of wells in meter and Yt is the total costs of a cubic meter of water. Assuming a well depth of 127 meters, the total cost required for access to cubic meters of water in Bajgah is to be estimated about 65 Tomans in 1375.

Net profit and benefit ratio to cost ratio:

While in the case of limitation of decrease in water consumption in Bajgah, the highest real and nominal net benefit obtained from variable E.O.I treatment with N= 270 kgha-1 were calculated to be 11338 and 11269 thousand Tomans, respectively. In Kooshkak where the highest real and nominal net gain was 10087 and 10088 thousand Tomans, respectively (Table 5). In the case of without limitation of decrease in water consumption in Bajgah the E.O.I treatment with N= 270kgha-1 real and nominal net profit was estimated to be 11083 and 11110 thousand Tomans, respectively. Interestingly, in Kooshkak the same treatment showed the highest profit. Thus forall the treatments, N= 270 kgha-1, in variable E.O.I was recognized the most economic treatment followed byN= 180 kgha-1Table 5however, from environment point of view, N= 180 kgha-1 is recommended to preventing more underground water and soil pollution.

In the method of limitation of decrease in water consumption for economical calculations, the rent price of the land is added to fixed costs (4 Million tomans ha-1).

Economical interpretation was conducted by the sub budget method. In these calculations, the check was the treatment of N= 0 kgha-1 in conventional irrigation but in second strategy 0.7 hectare did not take in consideration, because regarding the rent and the volume of crop harvested it was not economic. Again it is clear that the variable every other irrigation is most economic and the treatment of N= 180 kgha-1 in every other irrigation is in second priority. Of course the treatment of N= 180 kgha-1 is recommended to prevent the environment and underground pollution.

According to Table 7 the ratio of benefit to cost in all cases for variable every other irrigation (with N= 270 kgha-1) in both two regions was maximum, so that the ratio for this treatment in Bajgah was calculated as 2.52 and in Kooshkak 2.24 unit. This function shows that every one toman investment in this treatment in Bjgah and Kooshkak regions will bring 2.52 and 2.24 rilas benefit to the farmers, accordingly. So in drought conditions, farmers can continue to cultivate using variable every other irrigation with more confidence. The treatment of N= 270 kgha-1 in every other irrigation method having 5.09 tonha-1, has been the optimum one. The volume of water used in this treatment was 3988 cubic meter in hectare and nominal cost of water was calculated 9057 and 837 thousand tomans accordingly.

Fertilizer utilization-yield function:

The functions of fertilizer application and yield in Bajgah region are briefly as below:

Y = 1653 + 34 N – 7.87 ×10-2 N2	R^2=0.9224	Original irrigation
Y = 1996 + 20 N – 5.09 ×10-2 N2	R^2=0.9554	Variable every other irrigation
Y = 1653 + 14 N – 4.65 ×10-2 N2	R^2=0.905	Fixed every other irrigation

The functions of fertilizer utilization-yield in Kooshkak region are as below:

Y = 1649 + 31 N – 7.191 ×10-2 N2	R^2=0.9395	Original irrigation
Y = 1760 + 18 N – 4.4 ×10-2 N2	R^2=0.9894	Variable every other irrigation
Y = 1565 + 20 N – 6.23 ×10-2 N2	R^2=0.9693	Fixed every other irrigation

Then, the cost equation is presented as a function of nitrogen level is written as below:

C (N) = 6 × 106 + 980 N

The optimum level of nitrogen application in conventional furrow irrigation was estimated to be 212 kgha-1 but it's level was not significantly different comparing with the dosage needed for every other variable irrigation (191-198 kgha-1). The optimum level of Nitrogen in fixed every other irrigation method is significantly less (145-156 kgha-1).

CONCLUSION:

This study shows that in every other furrow irrigation treatment, compared with conventional furrow irrigation, less water has been delivered to soil without a significant decrease in the crop yield. Decrease in using water of irrigation and no decrease in yield of E.O.F.I. system; indicate that these kinds of irrigation are more economic. The results of this survey also, shows that the treatment 270 $kg.ha^{-1}$ Nitrogen in variable every other furrow irrigation (E.O.F.I.) is the most economic treatment, and the second economic treatment has been 180 $kg.ha^{-1}$ Nitrogen. Of course to prevent the pollution of underground water and other elements, the second treatment N= 180 $kg.ha^{-1}$ in E.O.F.I. has been recommended.

The ratio of maximum profit to cost in all cases for variable E.O.F.I. with the treatment N= 270 kgha-1 has been observed. The tables show that the profit has a reverse relation with the price of water. According to the results in conventional fixed and variable every other irrigation, the most harvest index has been for N= 90 $kg.ha^{-1}$ and N= 180 $kg.ha^{-1}$, because of Nitrogen shortage in the soil and plant growth decrease in treatment N= 0 $kg.ha^{-1}$. The best mean ratio of seed yield to biological yield in different furrow irrigation methods has been for this treatment.

The ratio of income to costs and real and nominal net profit for the suitable treatment in Bajgah was 2.52, 11337532 and 11269302 Tomans, for Kooshkak 2.24, 10087251 and 10087698 Tomans accordingly.

For better water usage, and to decrease the waste, different solutions as increasing the price of water and delivering the water to farmers in volume are suggested. This research recommends the E.O.F.I. to farmers for getting the highest profit and to prevent the environment pollution it is emphasized not to use too much Nitrogen, because accordingly to this study, increasing the Nitrogen usage more than necessary limit, doesn't bring any more benefit to farmer, but may pollute the underground water. So that the treatment N= 180 $kg.ha^{-1}$ is recommended.

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Table 1. Analysis of variance on data collected at Bajgah station

n	P value	F	SE	R^2	Traits	Furrow irrigation method	Order
36	0.050	18.593	0.010	0.903	Fresh plant total weight	*Original	1
36	0.000	30.420	0.005	0.920	Seed yield	*Original	2
36	0.000	41.480	0.014	0.960	Seed yield	**Variable	3
36	0.000	30.340	0.002	0.910	Seed yield	***Fixed	4
36	0.048	19.272	0.521	0.906	No. plants/m2	*Original	5
36	0.026	37.227	0.013	0.949	No. plants/m2	**Variable	6
36	0.004	29.594	0.031	0.991	No. plants/m2	***Fixed	7
36	0.040	25.562	0.493	0.976	No. spikes/m2	*Original	8
36	0.024	39.510	0.006	0.952	No. spikes/m2	**Variable	9
36	0.038	24.766	0.194	0.925	No. spikes/m2	***Fixed	10

*, **, and *** (original, variable, and fixed) are introduced as materials and methods section.

According to Table 3, comparison of full irrigation method with every other furrow irrigation, revealed that the weight of 1000 seeds, biological yield, seed yield and the number of spikes/m² were significantly different ($\alpha \leq 0.05$).

Table 2. Analysis of variance on data collected at Kooshkak station

n	P value	F	SE	R^2	Traits	Furrow irrigation method	Order
36	0.040	23.534	0.008	0.922	Fresh plant total	Original	1
36	0.000	30.422	0.004	0.939	Seed yield	Original	2
36	0.039	24.290	0.002	0.923	Seed yield	Variable	3
36	0.000	30.339	0.007	0.970	Seed yield	Fixed	4
36	0.033	29.128	0.038	0.936	No. plants/m2	Original	5
36	0.039	24.674	0.204	0.924	No. plants/m2	Variable	6
36	0.017	59.206	0.229	0.967	No. plants/m2	Fixed	7
36	0.040	26.485	0.305	0.962	No. spikes/m2	Fixed	8

Note: Original, variable, and fixed are introduced as Matetoman and method part.

Table 3. Summary of Geographical and meteorlogical parameters in Bajgah and Kooshkak regions

Location	Longitude	Latitude	Elevation	Water table (m)	Average temperature(°C)		Average rainfall (mm)		Soil texture
					Average annual temperature °C	Average temperature in 2003	Average annual rainfall	Average rainfall in 2003	
Bajgah	52° 32′	29° 36′	1810	>30	14.06	14/4	396.82	415/6	Sandy Clay
Kooshkak	52° 35′	30° 04′	1609	1-2	15.60	15/5	413.36	470/5	Loamy Clay

Table 4. Volumetric moisture parameters of soil in field capacity and permanent wilting point in different depth in Kooshkak and Badjgah regions

Kooshkak		Badjgah		
Wilting point (%)	Field capacity (%)	Wilting point (%)	Field capacity (%)	Depth (cm)
21.30	39.00	16.75	33.50	0-30
28.12	42.00	15.73	39.00	30-60
28.12	42.00	15.73	39.00	60-90
28.12	42.00	15.73	39.00	90120

Table 5. Agronomic characteristics of wheat cultivar under different irrigation treatments and nitrogen levels in two locations Bajgah and Kooshkak regions

	Nitrogen levels (kg ha-1)	Every-other furrow irrigation method							
		Original		Variable		Fixed		Mean	
Grain yield (t/ha)	0	2.073	f§	1.87	f	1.645	f	1.86	c
	90	4.455	b	3.352	d	2.774	E	3.53	b
	180	5.412	a	4.239	b c	3.716	c d	4.46	a
	270	5.353	a	4.687	b	3.742	c d	4.59	a
	Mean	4.32	a	3.54	b	2.97	b		
Total biomass(t /ha)	0	4.20	f	4.88	f	4.90	f	5.00	d
	90	11.08	c d	10.15	d e	9.67	e	10.30	c
	180	15.27	a	12.06	b c	10.45	d e	12.59	b
	270	16.11	a	12.61	b	11.30	c d	13.34	a
	Mean	11.92	a	9.93	B	9.08	b		
No. of spike/ m2	0	228	f	206	f	181	f	205	c
	90	490	b	369	d	305	e	388	b
	180	595	a	466	b c	409	c d	490	a
	270	589	a	516	b	412	c d	505	a
	Mean	476	a	389	B	327	b		
1000 SW¥	0	34.597	d	31.017	f	31.01	f	32.208	d
	90	36.347	c	32.04	e f	32.89	e	33.759	c
	180	39.343	a	37.043	b c	37.413	b c	37.933	a
	270	37.917	b	34.68	d	34.898	d	35.832	b
	Mean	37.051	a	33.695	b	34.053	b		
Harvest Index(%)	0	39.86		38.32		33.57		37.25	
	90	40.20		33.02		22.68		31.97	
	180	35.44		33.15		35.56		34.67	
	270	33.22		37.17		33.11		34.50	
	Mean	37.78		35.92		31.23		34.60	

Note: Original, variable, and fixed are introduced as Matetoman and method part.
In each column, means having at least one common letter do not have significant differences at α=0.05 using LSD test.
1000 SW stands for weight of 1000 seeds

Table 6. Some of the different expenses of plant production per hectare in Bajgah and Kooshkak

Explain	Cost (toman/ha)
Land rent (toman/ha)	4000000
Plowing (toman/ha)	140000
Field leveling (toman/ha)	70000
Phosphate fertilizer (toman/ha)	60000
Urea fertilizer (toman/ha)	500
Seed per ha(toman/ha)	450
Herbicide (toman/ha)	225000
Harvesting via combine (toman/ha)	225000
Transport charges to silo (toman/ha)	35000
Unexpected costs (toman/ha)	100000
Total fixed costs (toman/ha)	1520000

Location	Irrigation methods	Nitrogen Level (kg ha^{-1})	Gross Income (toman)	Real Cost (toman)	Nominal Cost (toman)	Real Net Profit (toman)	Nominal Net Profit (toman)
	Conventional	0	4368800	2957172	2596017	0	0
		90	8514000	3007172	2706517	4095200	4034700
		180	10543600	3047672	2747017	6084300	6023800
		270	10302800	3088172	2787517	5803000	5742500
Bajgah	Variable	0	6914400	4417440	4084515	1085332	1057102
		90	12108800	4598440	4305515	6098732	6030502
		180	15892800	4679440	4386515	9801732	9733502
		270	17509600	4760440	4467515	11337532	11269302
	Fixed	0	4585600	4417440	4084515	-1243468	-1271698
		90	8600000	4598440	4305515	2589932	2521702
		180	13140800	4679440	4386515	7049732	6981502
		270	13588000	4760440	4467515	7415932	7347702
	Conventional	0	2752000	3502039	2615828	0	0.5
		90	6811200	3612539	2726328	3948700	3948700.5
		180	8066800	3653039	2766828	5163800	5163800.5
		270	8118400	3693539	2807328	5174900	5174900.5

Kooshkak	Variable	0	5951200	5002888	4116330	1698351	1698698
		90	10973600	5223888	4337330	6499751	6500098
		180	13278400	5304888	4418330	8723551	8723898
		270	14723200	5385888	4499330	10087351	10087698
	Fixed	0	5332000	5002888	4116330	1079151	1079498
		90	10852000	5223888	4337330	6378151	6378498
		180	12418400	5304888	4418330	7863551	7863898
		270	12143200	5385888	4499330	7507351	7507698

Table 7. Net profit and gross income based on nominal and real price per m3 in Bajgah and Kooshkak (limitation of decreasing water use)

Note: Original, variable, and fixed are introduced as Matetoman and method part.

Nominal price of water in Kooshkakregion 25 Rilas and in Bajgah region 21 Tomans per cubic meter.

Real price of water in Kooshkak region 298.6 Tomans and in Bajgah region 227.1 Tomans per cubic meter.

Table 8. Net profit and gross income based on nominal and real price per m3in Bajgah and Kooshkak (without limitation of decreasing water use)

Location	Irrigation methods	Nitrogen Level (kg ha^{-1})	Gross Income (toman)	Real Cost(toman)	Nominal Cost(toman)	Real Net Profit(toman)	Nominal Net Profit(toman)
Bajgah	Conventional	0	4506400	2840201	2574281	-0.1556	0
		90	8651600	2884519	2675961	4100881	4043520
		180	10681200	2917387	2707641	6097613	6041440
		270	10440400	2950228	2739321	5823972	5768960
	variable	0	6914400	4417440	4084515	830761	897766
		90	12108800	4598440	4305515	5844161	5871166
		180	15892800	4679440	4386515	9547161	9574166
		270	17509600	4760440	4467515	11082961	11109966
	Fixed	0	4585600	4417440	4084515	-1498039	-1431034
		90	8600000	4598440	4305515	2335361	2362366
		180	13140800	4679440	4386515	6795161	6822166
		270	13588000	4760440	4467515	7161361	7188366
Kooshkak	Conventional	0	2889600	3363516	2594300	276123	159128
		90	6948800	3465196	2695980	4233643	4116648
		180	8204400	3496876	2727660	5457563	5340568
		270	8256000	3528556	2759340	5477483	5360488
	Variable	0	5951200	5002888	4116330	1698351	1698698
		90	10973600	5223888	4337330	6499751	6500098
		180	13278400	5304888	4418330	8723551	8723898
		270	14723200	5385888	4499330	10087351	10087698
	Fixed	0	5332000	5002888	4116330	1079151	1079498

90	10852000	5223888	4337330	6378151	6378498
180	12418400	5304888	4418330	7863551	7863898
270	12143200	5385888	4499330	7507351	7507698

Note: Original, variable, and fixed are introduced as Matetoman and method part.
Nominal price of water in Kooshkakregion 25 Rilas and in Bajgah region 21 Tomans per cubic meter.
Real price of water in Kooshkak region 298.6 Tomans and in Bajgah region 227.1 Tomans per cubic meter.

Table 9. Benefit – cost ratio in different irrigation treatments based on nominal and real price of water

Location	Irrigation methods	(kg ha^{-1}) Nitrogen level (kg ha^{-1})	Profit/cost		Cost of water/ha(toman)		Water Used Volume m^3/ha	Caltivator Costs (toman)	Transport Charges (toman)	Yield (t ha^{-1})
			Real	Nominal	Nominal	Real				
Bajgah	Conventional	0	0.00	0.00	1127280	12190728	5368	1520000	88900	2.54
		90	1.36	1.49	1127280	12190728	5368	1520000	173250	4.95
		180	2.00	2.19	1127280	12190728	5368	1520000	214550	6.13
		270	1.88	2.06	1127280	12190728	5368	1520000	209650	5.99
	variable	0	0.25	0.26	837480	9056748	3988	1520000	70350	2.01
		90	1.33	1.40	837480	9056748	3988	1520000	123200	3.52
		180	2.09	2.22	837480	9056748	3988	1520000	161700	4.62
		270	2.38	2.52	837480	9056748	3988	1520000	178150	5.09
	Fixed	0	-0.28	-0.31	837480	9056748	3988	1520000	60900	1.74
		90	0.56	0.59	837480	9056748	3988	1520000	87500	2.5
		180	1.51	1.59	837480	9056748	3988	1520000	133700	3.82
		270	1.56	1.64	837480	9056748	3988	1520000	138250	3.95
Kooshkak	Conventional	0	0.00	0.00	1285175	17961606	5147	1520000	56000	1.6
		90	1.09	1.45	1285175	17961606	5147	1520000	138600	3.96
		180	1.41	1.87	1285175	17961606	5147	1520000	164150	4.69
		270	1.40	1.84	1285175	17961606	5147	1520000	165200	4.72
	Variable	0	0.34	0.41	960175	13419406	3847	1520000	60550	1.73
		90	1.24	1.50	960175	13419406	3847	1520000	111650	3.19

	180	1.64	1.97	960175	13419406	3847	1520000	135100	3.86
	270	1.87	2.24	960175	13419406	3847	1520000	149800	4.28
Fixed	0	0.22	0.26	960175	13419406	3847	1520000	54250	1.55
	90	1.22	1.47	960175	13419406	3847	1520000	106750	3.05
	180	1.48	1.78	960175	13419406	3847	1520000	126350	3.61
	270	1.39	1.67	960175	13419406	3847	1520000	123550	3.53

Note: Original, variable, and fixed are introduced as Matetoman and method part.
Nominal price of water in Kooshkakregion 25 Tomans and in Bajgah region 21 Tomans per cubic meter.
Real price of water in Kooshkak region 298.6 Tomans and in Bajgah region 227.1 Tomans per cubic meter.

Table 10. Optimum level of nitrogen application (kg ha-1)

Irrigation methods	Optimum level of nitrogen application(kg ha^{-1})	
	Kooshkak	Bajgah
Original irrigation	211	212
Variable every other irrigation	198	191
Fixed every other irrigation	156	145

Note: Original, variable, and fixed are introduced as material and method section.