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Sprinkle Irrigation System, A Way to Achieve Sustainable Production of Wheat in Kermanshah Province, Iran

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ABSTRACT

Iran is located in an arid and semiarid region. Water is the main bottleneck for agricultural development. Due to this issue, increasing agricultural production through land development is limited by water supply. The purpose of this study was to evaluate the use of sprinkle irrigation system to supply water for the production of wheat in order to achieve sustainable development. Villages in Kermanshah province were chosen as the statistical community. 140 farmers using sprinkle irrigation system and 170 farmers using surface irrigation system were chosen by Cochran formulae. The statistical sampling method stratified and randomly selected. The tool was a questionnaire. To determine the validity of questionnaire, it was assessed by university professors and experts of promotes agriculture and irrigation. Cronbach's alpha reliability coefficient for the different sections of the questionnaire survey was of 0.81. The results revealed that there was a meaningful relationship between different variables of family size, annual income, cultivated area, yield, the savings in water consumption and water availability and the dependent variable i.e. yield ($P<0.01$). Furthermore, age, experience of agriculture, education and the cost of electricity had no any significant effect on the dependent variable i.e. yield ($P<0.05$). The results of logistic regression method revealed that 72.7% of the variability by the dependent variables i.e. sprinkle irrigation is justified by yield, cultivated area, the cost of planting and harvesting and water conservation, and the other independent variables had just 25%, were involved in adoption. Obvious difference between wheat farmers of two groups in the area were advised to use sprinkle irrigation increasing yield as well as to provide the conditions for achieving sustainable production of wheat in Kermanshah province. Ii is recommended to develop sprinkle irrigation in the region, to do that paying subsidy by the government is necessary.

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INTRODUCTION

Agriculture is one of the most important sectors of the economy in Iran. Agriculture has a quarter of GDP and more than a third of its exports and a quarter of the country's GDP [15]. Iran ranks 84th in the world in term of atmospheric precipitation. The total amount of annual rainfall is about 427 billion cubic meters where just 130 billion cubic meters is renewable water. However, 74 percent of Iran's total area is arid and semi-arid, the average rainfall in this area is less than 250 mm, and 13% in other areas of the country have less than 100 mm of rainfall. Furthermore, 59 percent of the lands need irrigation compared with the global average of 16 percent which is very high. 89% of food is produce in irrigated land and just 11% is produce in dry land being considerable as compared to the world average (40% in irrigated lands and 60% in dry lands) [25]. In such conditions, to address water scarcity issue in agriculture sector as the biggest water consummator some recommendation can be presented such as changing cropping patterns, improving irrigation efficiency, increasing water productivity, etc. In this context, the use of more advanced irrigation techniques should be considered [11, 24]

Droughts in the country in the recent years had irreversible impacts on the structure of agriculture [20]. Poverty, rural uncontrolled immigration, and lack of access to water for agricultural irrigation are some

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unpleasant consequences of water scarcity and drought. Agricultural development planning is one of the most effective ways to control the effects of drought on water management in agriculture.

The agricultural sector consumes about 93% of water resource in Iran. The country's total area is about 165 million hectares where about 37 million hectares of land are suitable for cultivation, but because of water resource limitation just 8.7 million hectares of land are irrigated land, 6 million hectares are rainfed and 4.5 million hectares are fallow. According to FAO reports, irrigation efficiency in Iran in 2000 was about 32% being less than 38% in developing countries [17].

Sprinkle and drip irrigation being modern irrigation methods use pumps and pipeline systems to distribute water over a field. Irrigation efficiency of sprinkle and drip irrigation systems is from 70 to 95%. While in surface irrigation method, even with the high cost of land levelling, irrigation efficiency does not exceed 50% where irrigation efficiency in traditional field is less than 32% [1, 8].

Sustainable agricultural system should supply the needs of the present generation without compromising the needs of the future generations; furthermore this type of agriculture should be economically sustainable for farmers and society in general [2]. Kaveh *et al*. [13] compared furrow and sprinkle irrigation method for soybean. Grain yield was of 3572 and 2942 kg/ha with sprinkle and furrow irrigation methods, respectively. Furthermore, the farmer income was of 439 and 265 $/ha with sprinkle and furrow irrigation methods, respectively showing that sprinkle irrigation was more cost-effective.

Boujelben and M'Barek [6] carried out a field trial on potato with surface irrigation (end-closed furrow) and drip irrigation in a randomized complete block design with three replications using an irrigation water volume of 4,000 m^3/ha. Statistical analysis showed that irrigation had no significant effect on the number of stem per plant; however, the difference in yield per plant was significant being of 1.16 kg with drip irrigation and 0.836 kg with furrow irrigation.

Sadreghayen *et al*. [19] examined the sprinkle and furrow irrigation methods on sugar beet yield and its quality as well as water use efficiency. The results showed that sprinkle irrigation due to a lower water use during the growing season, has led to a significantly higher irrigation water productivity based on root yield and sugar yield as compared with furrow irrigation. Rodrigues *et al*. [18] had done a study on the energy use and water productivity of sprinkle irrigation system with corn, wheat and sunflower. The results showed that using sprinkle irrigation resulted in water productivity improvement as well as energy use mitigation.

Soleimanipour *et al*. [23] evaluated the impact of three irrigation methods including drip irrigation with tape, sprinkle and furrow irrigation methods on the water productivity of potato in Isfahan province in the center of Iran. The average of yields in furrow, sprinkle and drip irrigation methods were 21332, 25877 and 25139 kg/ha, respectively. Hanson and May [9] reported that tomato yield was increased with drip irrigation compared to furrow and sprinkle methods using saline water.

Kahlown *et al*. [12] evaluated the economic potential and water productivity of sprinkle irrigation and flooded irrigation methods for both rice and wheat in Pakistan. Results showed that using sprinkle irrigation system increased crop production by 18%, while reduced the amount of water used by 35% as compared with flooded irrigation method. Economical evaluation showed that the use of sprinkle irrigation system for wheat and rice was much more appropriate as compared to traditional method of irrigation i.e. flooded irrigation.

The goal of the present study was to assess the use of sprinkle irrigation system to supply water for the production of wheat in order to achieve sustainable development in the studied area. Our results could be useful to highlight important variables which encourage or discourage farmers to use sprinkle irrigation.

MATERIALS AND METHODS

The research was conducted using a questionnaire. Heads of households using sprinkle and surface irrigation methods were the population in this study. Statistical sample volume was of 310 people which were determined using Cochran formulae. For selecting a sample, the random stratified sampling method was used. Farmers were identified according to the geographical location of Kangavar and Sahneh cities having 13 villages, furthermore another part of the farmers were in the suburbs. 140 people in the sample were farmers using sprinkle irrigation and 170 people were farmers who did not use sprinkle irrigation.

Questionnaire was divided in four parts i.e. demographic, agronomic and economic characteristics as well as barriers and restrictions to adopt sprinkle irrigation method and factors to increase wheat production. The questionnaire was made by the researcher. To determine the validity of the questionnaire, a pretest was done with 12 faculty members and experts to promote agriculture and irrigation. To test the reliability of the questionnaire, 30 questionnaires were completed outside the study area and the value of Cronbach's alpha coefficient for different parts of the questionnaire was of 0.81. Data analysis was performed using SPSS software.

Descriptive statistics was used to evaluate different variables and further assessments were done using t-test and Pearson correlation coefficient. Since depended variable i.e. increasing wheat production using surface

irrigation or sprinkle irrigation, is a bilateral variable, so several methods of analysis can be used among them logistic regression being a powerful method of analysis can be considered.

This method is similar to conventional regression, but there is only one difference. In this method, instead of minimizing the squared error in ordinary regression, the probability of event occurrence is maximized. Furthermore, in this method both chi-square (X2) and Wald coefficients are used. Chi-square coefficient is used for the dependent variable and determines the overall effectiveness of the entire model being comparable to the F index in ordinary regression analysis. Logistic regression is calculated based on the equation (1), which is known as the logit model.

$$ln(\frac{P_1}{1-P_2}) = \beta_1 + \beta_2 \quad (1)$$

In order to analyze the data in this study the backward stepwise logistic regression was used to evaluate the effect of sprinkle and surface irrigation methods on wheat yield. In this method, first, all independent variables having a significant relationship with the dependent variable are introduced in the equation, and then after few steps the variable or variables showed non significant effect or no effect in the presence of other variables on the dependent variable should be set outside. This process should be continued until just the variables that affect significantly the dependent variable remains in the equation. In other words, remove variables from the equation, the other can continue to place and remove, leaving a variable the significant level of the variables in the equation reduced. Thus, in the last step, the variables that have the most significant effect on the dependent variable in the presence of other variables remain in the equation and the rest are out of the equation.

In this study, a questionnaire was used to identify important variable which affect on the adoption of sprinkle irrigation. In the next section, the results will be analysed.

RESULT AND DISCUSSION

Descriptive results are presented in Table 1 indicating that the average age of the population was of 48 and 46 years for sprinkle and surface irrigation methods users. Therefore, users of sprinkle irrigation system were older than surface irrigation method users. Regarding the level of education, the highest frequency in the group of sprinkle irrigation users belongs to high school diploma, where the highest frequency in the group of surface irrigation users belongs to literacy, representing that sprinkle irrigation users had a higher level of education.

According to Table 1, the highest number of households in sprinkle irrigation users group was of 3 or 4 people and 1 or 2 in the surface irrigation users group indicating that sprinkle irrigation users family were more crowded. The average of yield was of eight Mg/ha with sprinkle irrigation whereas it was 6.5 Mg/ha with surface irrigation method, indicating that crop production was higher with sprinkle irrigation method than surface irrigation method. The averages of farmer income were 8300 $/ha with sprinkle irrigation and 5400 $/ha with surface irrigation method.

The results in Table 1 show that the average costs of planting to harvesting were 2600 and 1600 $/ha with sprinkle and surface irrigation methods, respectively. Thus, sprinkle irrigation method was more cost-effective. The averages cost of electricity were 78 and 100 $/ha with sprinkle and surface irrigation methods, respectively. Surprisingly, the averages of work experiences were 26 and 20 in sprinkle and surface irrigation users groups, respectively, normally younger people accept more easily the modern technique. Farmer's averages farm was 21 and 14 ha with sprinkle irrigation and surface irrigation, respectively. Shrestha and Gopalakristhnan [21] reported that the increase in production, income, saving water and labour are the factors affecting the adoption of modern irrigation technique. Factors such as water consumption, yield, land slope, soil quality and farm size have been more effective in the adoption of modern sprinkle irrigation system and also stated that the increase in operation costs results in decreasing the application of modern irrigation systems with farmers.

According to Table 2, there was a significant and positive impact of farmer's age on the adoption of sprinkle irrigation so that the probability of sprinkle irrigation adoption increases with age of farmers. That is because of more experience and probable facing with the problem of water scarcity, whereas Kohansal *et al.* [14] found that the effect of the age variable is negative and so the probability of sprinkle irrigation adoption decreases with increase in age of farmers. Farmer's literacy variable had not a significant effect in adoption of sprinkle irrigation because of low level of education in studied farmers which is not in agreement with Jahannama [11] and Kohansal *et al.* [14]. Other studied variable was the family size having a positive and significant impact on the adoption of sprinkle irrigation ($P<0.05$), in other words the probability of sprinkle irrigation adoption with bigger family was higher. Among these families, there were people knowing sprinkle irrigation system to inform farmers about the system and encourage them to use the system. In contrast, Bagheri and Malek-Mohammadi [5] found a significant difference between the groups in the number of household members ($P<0.05$) where sprinkle irrigation users have had fewer family members.

Table 1: Descriptive characteristics of wheat farmers**.**

Independent variables	sprinkle irrigation users			surface irrigation users		
	Average	Maximum	Minimum	Average	Maximum	Minimum
Age (years)	48	75	23	46	80	22
Household size (people)	4	11	0	4	10	4
Yield (Mg/ha)	8	9	7	7	8.5	6
Annual revenue ($/ha)	8330	35000	1500	5417	25000	1400
The cost of planting to harvest ($/ha)	2600	3000	1600	1800	2800	800
Electricity costs($/ha)	500	2000	100	300	2000	780
Farmer experience (years)	26.5	60	15	20	50	10
Farm size (ha)	21.33	70	3	14.88	52	2

Table 2: Results of t-test for comparison between sprinkle and surface irrigation users.

The first hypothesis		Average	tests	The first hypothesis
Age (years)	Sprinkler irrigation	48	t=2.018	0.04
	Surface irrigation	46		
Education	Sprinkler irrigation	4.4	z= 0.338	0.07
	Surface irrigation	4.3		
Family size	Sprinkler irrigation	28.3	t= - 1.109	0.45
	Surface irrigation	48.3		
Farmer's experience (years)	Sprinkler irrigation	27.75	t= 1.052	0.02
	Surface irrigation	99.25		
Annual revenue ($)	Sprinkler irrigation	8333	T= 4.59	0.00
	Surface irrigation	5472		
Yield per unit area (ha)	Sprinkler irrigation	5.8		0.00
	Surface irrigation	5.4	t=17.48	
Area planted (ha)	Sprinkler irrigation	15.3		0.00
	Surface irrigation	10.3	t=3.99	
Planting to harvesting cost ($)	Sprinkler irrigation	2652	t=1.97	0.04
	Surface irrigation	1896		
Electricity cost ($)	Sprinkler irrigation	78	t=0.24	0.00
	Surface irrigation	100		
Saving water	Sprinkler irrigation	1.6	z=-17.43	0.00
	Surface irrigation	4.44		
The amount of available water (l/s)	Sprinkler irrigation	9.9	t=3.47	0.001

The results in Table 2 show that the mean difference between the previous experience in agriculture of irrigation methods was significant (P<0.01). Some other researchers' findings indicated a significant relationship between experience and innovation adoption in agriculture i.e. sprinkle irrigation [10, 22]. Annual income is one the other variable influencing the adoption of sprinkle irrigation. In a way that increases in annual income results in having enough funds to pay necessary cost to adopt sprinkle irrigation system. Norozi and Chizari [16] stated that sprinkle irrigation technique is effective in increasing income. According to Table 2, the yield variable had a positive and significant effect (P<0.05) on the adoption of sprinkle irrigation. This means that increases in crop production in a unit area encourages more and more farmers to adopt sprinkle irrigation resulting in wheat production increase which is a way to achieve sustainable development.

Siddighi and Farzand-Vahi [22] in their study, represented sprinkle irrigation method as a relevant technique to increase crop production. The surface area under cultivation is one of the variables having both positive and significant effects (P<0.01) on the probability of sprinkle irrigation adoption by farmers. In other words, farmers having larger farms use normally more sprinkle irrigation system. This is mostly due to the fact that the efficiency and performance of sprinkle irrigation system are better in large and medium farms. Since small farms are not appropriate technically and economically for sprinkle irrigation system, so the behavior of farmers regarding farm size variable is perfectly rational. Albrecht and Ladewing [3] represented the farm size as the most important factor in the adoption of modern irrigation technology.

Planting to harvesting costs had a negative effect on the probability of sprinkle irrigation adoption by farmers, which was not expected. There was a significant difference between the cost of electricity and sprinkle irrigation adoption (P<0.05). Farmers using sprinkle irrigation method gave a lower electricity cost. Thus the universal adoption of sprinkle irrigation can have other benefits as part of the cost of planting to harvesting and in this way increase cost efficiency.

Saving water is one of the variables with positive and significant effect (P<0.01) encouraging more farmers to adopt sprinkle irrigation system. In other words, as sprinkle irrigation methods are more efficient, farmers will replace it instead of the traditional irrigation methods. In this way farmers can bring more land under cultivation by saved water. Caswell and Zilberman [7] have pointed out, one of the major benefits of sprinkle irrigation is to save water and use it to irrigate rainfed lands. Access to water is a variable expected to have a positive impact on sprinkle irrigation adoption. In this study access to water was significant (P<0.01) on the

adoption of sprinkle irrigation method. In fact, farmers who are faced to water scarcity tend more and meaningful to benefit from sprinkle irrigation system than the other farmers.

Kohansal *et al*. [14] reported that access to water has a significant effect on the adoption of sprinkle irrigation which is in agreement with the results of present study. Results are shown separately in Table 2.

Correlation:

The correlation of household size (r=-0.96), annual income (r=0.411) and the cost of planting to harvesting (r=-0.597) were significant with yield. The results are presented in Table 3. On the basis of these results, with increasing annual income and decreasing planting to harvesting costs and smaller family size, the yield increases and farmers have the ability to buy more inputs which increase more and more the yield.

Table 3: Correlation results of the independent variables with the dependent variable.

Row	Independent variables	Dependent variable	Pearson coefficient	P value
1	Age	Yield per unit area	0.37 ^{ns}	0.258
2	Education	"	0.82 ^{ns}	0.75
3	Number of households	"	0.96 ^{ns}	0.427
4	Agricultural experience	"	-0.004 *	0.04
5	Annual income	"	0.318 **	0.00
6	Cultivated area	"	0.14 **	0.00
7	The cost of planting to harvesting	"	-0.559 **	0.00
8	The cost of electricity	"	0.71 ^{ns}	0.107
9	Saving water	"	-0.265 **	0.00
10	The amount of available water	"	0.250 **	0.00

* Significant at 95% level
** Significant at 99% level
^{ns} non significant

The correlation between the area under cultivation (r=0.318), water conservation (r=-0.265) and the amount of available water (r=0.25) with the yield were significant (P<0.01), showing that with more area under cultivation the yield will increase. When more water is available and farmers attempt to save water, so they will have enough water to use when plant need water results in increasing the yield. Increase the yield increase the income, so proper conditions for sustainable development are available.

The correlation between the age of wheat producers (r=0.37), education level (r=-0.82), farming experience (r=-0.004) and the cost of electricity (r=0.071) were not significant. It is indicating that these factors had not any significant effect on increasing the yield. According to Table 3, almost all agronomic and economic variables influenced the yield which is in agreement with previous research finding in other area [10, 11, 16].

Logistic Regression:

In this study, from a total of 60 independent variables, seven variables: age, annual income, yield, cultivated area, the cost of planting to harvesting, which had a significant correlation with the dependent variable, sprinkle irrigation adoption were entered into the logistic regression and regression analysis was done until four steps. At each step the software removed independent variables with less effect according to Wald test, thus, first the farmer age and the cost of planting to harvesting were excluded. Table 4 shows that 84% of the variability of the independent variable justified with cultivated area, yield, the cost of electricity and water saving.

Table 4: Independent variables with the most significant effect on the dependent variable.

Independent variable	Differential (β)	Standard deviation (SE)	Wald test (Wald)	Degrees of freedom (df)	Significant level (p)
Yield	2.181	0.194	26.824	1	0.00
Cultivated area	0.763	0.221	18.241	1	0.00
The cost of electricity	-0.974	0.253	21.564	1	0.00
Water saving	0.4116	0.195	17.368	1	0.00

Conclusion:

The correlation between the independent variables including farming experience, yield, electricity cost, area under cultivation, annual income, saving water and the amount of available water and the dependent variable, sprinkle irrigation adoption was positive and significant (P<0.05). But education level and family size had not a significant effect. Torkamani and Gafary [24] reported that the farmer failure to pay different costs weaken the adoption of pressurized irrigation systems. In addition collective ownership of wells and land, land use restrictions such as small size land, land dispersion, physical obstacle, lack of expert in pressurized system and poor performance are other obstacle in promoting to develop sprinkle irrigation system.

Between variables, household size, annual income, the cost of planting and harvesting, cultivation, water conservation, water availability, there is no significant correlation with yield And the variables of age, education, agriculture, and the cost of electricity is not significant. There were a significant correlation between yield and family size, annual income, the costs of planting to harvest, cultivated area, water saving, available water, but the correlation between yield and farmer age, education level, farming experience and electricity cast were not significant.

Sprinkle irrigation system user harvested approximately 2 Mg/ha more compared to surface irrigation method users resulted in annual more income. Also Baghani *et al*. [4] in their study found that with changing surface irrigation system to pressurized irrigation system, the yield of all studied crops increased. The highest and lowest yield increases were obtained with corn and melon. Onions, silage maize and sugar beets yields increased 79.4, 52.4 and 35.2%, respectively.

The role of sprinkle irrigation in increasing the wheat yield in comparison to surface irrigation method to achieve self-sufficiency in the production of this strategic crop is evident. So the government should encourage farmers for sustainable use of sprinkle irrigation methods which increases farmers' income being an indicator of development. In this way the wheat production of the region will increase and achieving self-sufficiency in wheat production will be possible.

More than 80% of surface irrigation method users believe that sprinkle irrigation save water, to address water scarcity in the region as well as groundwater level decrease issues sprinkle irrigation method can be a relevant solution as compared with surface irrigation methods; especially for the farmers who have less available water and changing the irrigation system diminish water scarcity in the region.

So far, much research has been done about pressurized irrigation systems. But given the current economic conditions and particularly the governmental policy of targeted subsidies payment it is recommended to consider these new condition and new prices of electricity, water and other input variables. Furthermore, the satisfaction of farmer using sprinkle irrigation system would be evaluated after some year of use.

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