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Evaluation of wheat genotypes under tillage practices: application of technique for order preference by similarity to ideal solution method

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ABSTRACT- Adoption of conservative agriculture at farm level is associated with reducing the production costs and leads to crop yield stability. The aim of this study was to prioritize experimental treatments based on different criteria by applying "technique for order preference by similarity to ideal solution" (TOPSIS).A filed experiment was carried out at Zarghan research station, Fars province, Iran, during 2014-2016 growing seasons. Experimental treatments were three tillage practices including conventional tillage (CT), reduced tillage (RT) and no tillage (NT) that were assigned to main plots and four spring wheat genotypes (Chamran, Sirvan, Picaflor#1 and M-89-10)were randomized in subplots using split-plot arrangements in randomized complete block design with three replications. Selected criteria including two groups of economic- i.e. water cost, weed control cost, production cost and gross margin- and agronomic –i.e. grain yield and soil bulk density criteria used to prioritize the treatments. The weights of bulk density (0.040), grain yield (0.180), gross margin (0.280), water cost (0.0270), weed control cost (0.150), and production cost (0.080) was calculated. Results showed, considering all criteria to prioritize wheat genotypes under different tillage practices, that Sirvan and Picaflor#1 genotypes under RT practice could be the first treatments in 2014-15 and 2015-16 growing seasons, respectively. Therefore, the multiple criteriamethodshould be used for selection of the best tillage practices and wheat genotypes under tillage practices rather than a criterion such as grain yield or production cost.

INTRODUCTION

Conservation agriculture aims to make optimized use of agricultural resources through integrated management of soil and water combined with limited external inputs. Benefits and costs of conservation practices adoption have been evaluated by many researchers. Uri (2000) provided a detailed evaluation of costs and benefits of conservation tillage, including production costs, labor, machinery, fuel, and yield return. Some researchers compared conventional, minimum, and no tillage practices in wheat cropping systems(Gathala et al., 2011; Ghaghazardi et al., 2016; Jat et al., 2009, 2013, 2015; Saharawat et al., 2010; Su et al., 2006). Results have indicated that conservation tillage practices (minimum and no-till) were the most profitable operations due to reduction of average operational time, labor, fuel, energy and water consumption and increased yield in comparison with CTpractice.

Jin et al. (2007) and Zentner et al. (1996) reported that NT practice provided higher economic benefit in wheat production compared to CT practice. Sharma et al. (2011) showed the maximum benefits could be obtained under RT practice followed by NT practice, and the lowest under CT practice. Rabiee and Rajabian (2012) also reported that RT practice, with or without crop residue, had some advantages when compared with CT practice and justified its application. Therefore, conservation tillage (RT and NT) practices provide several advantages, including savings in labor, fuel, water and soil resources (Erfanifard et al., 2014; Jat et al., 2015) and these cost savings were more than expenditures offset by herbicides (Zentner et al., 1996). Many researchers elucidated the effects of tillage practices on weed seed bank composition and diversity (Cardina et al., 2002; Carter and Ivany, 2006; Mohler and Callaway, 1995),which was reported that tillage practices could have variable effects on weed seed bank size and composition. Lutman et al. (2002) and Hosseini et al. (2014) found that reduced level of soil disturbance, increased the proportion of weed seeds near the soil surface. Carter and Ivany, (2006) reported that weeds seed population was significantly higher under direct drilling and shallow tillage than moldboard plough in 0-20 cm of soil depth. Increased the diversity of weed seed bank spectrum under non-inversion tillage practices was mainly related to changes in the number of annual broadleaf weeds compared to perennial broadleaf and grasses.

Reduced tillage and NT practices conserved soil and water resources and also provided equal or more economical benefits than CT practices(Romero and Rehman, 1987). Most economic studies have been focused on maximizing profits and making decision to select the best treatment(s) considering a criterion by simple methods so far. While, decision making in accurate management is complicated particularly if more criteria are considered (Antucheviciene et al., 2010). Since the performance of wheat genotypes under tillage practices was affected by multiple criteria; therefore, TOPSIS was usedfor decision making to prioritize the best combination of tillage practice and wheat genotype.

MATERIALS AND METHODS

Site Description

The experiment was conducted at the Zarghan field station(29° 47′ N, 52° 43′ E, 1604m asl), Agriculture and Natural Resources Research and Education Center of Fars Province, in southern Iran.

Experimental Procedure

The experiment was designed as split plot arrangement in randomized complete block design with three replications and conducted during 2014-2016 growing seasons. Experimental treatments included; three tillage practices including conventional tillage (CT), reduced tillage (RT), and no-tillage (NT)as main plots and four spring wheat genotypes, Chamran, Sirvan, Picaflor#1, and M-89-10, which received by Seed and Plant Improvement Institute (SPII),as subplots. In CT practice, land was prepared using mouldboard plough followed by two perpendicular harrow disking and land leveler. In RT practice, land was prepared with a composite tiller. Seed were directly sown in NT plots without any seedbed preparation. The main plots had 25 m length and 27 m width where as subplots were 25× 6 m. Seeding rate for what genotypes was 180 kg ha^{-1} in all plots. All fertilizers including phosphorous (P), and one third of total nitrogen (N) were applied at seeding, and the remaining N was top dressed in two equal splits in tillering and flowering growth stages, based on soil test and research recommendations. Soil test showed high level of potassium (K), therefore, no potassium was applied. Weed and pest were controlled by appropriate herbicides and pesticides. No symptom of diseases observed. Gated pipe was used for surface irrigation. In the second year, wheat genotypes were planted exactly with similar protocols as the first year and on the same plots.

Decision Analysis

In this research, six characteristicsincludingsoil bulk density (an indicator of soil compaction), water cost (calculated as: applied irrigation water × water price), weed control cost (an indicator of weed density), and production cost, grain yield and gross margin were considered to prioritize treatment(s), according to researchers'views who were experts in agronomy and machinery.These views were collected for this study by 15 questionnaires. Selected criteria were ranked based on mean of scores that allocated by researchers.

Multiple criteria decision-making (MCDM) technique was used to select the best treatment. According to Hajkowicz and Collins (2007), this technique consists of:

- -A set of decision options ranked by decision makers.
- -A set of criteria measured in different units, and
- -Evaluation of performance by using raw scores of each decision option against each criterion.

A standard feature of MCDM is decision matrix (Table 1)in which the rows and columns describe criteria and alternatives. Each score (r_{ij}) described performance of alternative (A_i) against criterion (C_j).

Table 1. Decision matrix

	W_1	W_2	W_3	...	W_m
	C_1	C_2	C_3	...	C_m
A_1	r_{11}	r_{12}	r_{13}	...	r_{1m}
...	r_{21}	r_{22}	r_{23}	...	r_{2m}
A_n	r_{n1}	r_{n2}	r_{n3}	...	r_{nm}

As shown in the decision matrix (Table 1), weights were assigned only to criteria that usually determined by subjective basis. They were representative of a single decision maker's opinion or a group of researchers' opinions that mixed by using group decision technique (Fulop, 2005). Frequently, importance of criteria were not similar for decision makers. Therefore, weighted criteria should be considered. Several methods are available to determine weights of cardinal or ordinal measurements. Analytic Hierarchy Process (AHP) method was used (Saaty, 1987).The AHP incorporates a useful technique for checking the consistency of the decision maker's evaluations, thus reducing the bias in the decision making process.

In order to compute the weights for the different criteria, the AHP starts creating a pairwise comparison matrix A. The matrix A is a m×m real matrix, where m is the number of evaluation criteria considered. Each entry a_{jk} of the matrix A represents the importance of the jth criterion relative to the kth criterion. If $a_{jk}> 1$, then the jth criterion is more important than the kth criterion, while if $a_{jk}< 1$, then the jth criterion is less important than the kth criterion. If two criteria have the same importance, then the entry a_{jk} is 1.

$$a_{jk}.a_{kj}=1 \quad (1)$$

Obviously, a_{jj} = 1 for all j. The relative importance between two criteria is measured according to a numerical scale from 1 to 9, as shown in Table 2, where it is assumed that the jth criterion is equally or more important than the kth criterion.

Table 2. Relative scores

Value of a_{jk}	Interpretation
1	j and k are equally important
3	j is slightly more important than k
5	j is more important than k
7	j is strongly more important than k
9	j is absolutely more important than k

Once the matrix A is built, it is possible to derive from A the normalized pairwise comparison matrix A_{norm} by making equal to 1 the sum of the entries on each column.

$$\overline{a_{jk}} = \frac{a_{jk}}{\sum_{l=1}^{m} a_{lk}} \quad (2)$$

Finally, the criteria weight wascomputed by averaging the entries on each row of $A_{norm.}$

$$w_j = \frac{\sum_{l=1}^{m} \overline{a}_{jl}}{m} \quad (3)$$

Decision matrix contained a combination of data in various scales. Therefore, the first step of MCDM method was to come up with a normalized decision matrix. This step transformed various attributes dimensions to non-dimensional attributes which allowed comparison between criteria. The following scale-up approach was used to normalize the data (Table 3).

$$h_{ij} = \frac{r_{ij}}{\sum_{i=1}^{n} \sqrt{r_{ij}}} \quad (4)$$

Where:

i=1,…,n and, j=1,…,m

The normalized decision matrix (Table 3)can be resolved using some methods of MCDM. TOPSIS method was used, which has been developed by Tzeng and Huang (2011). TOPSIS evaluates normalized decision matrix in several steps.

Table 3. Normalized decision matrix

	C_1	C_2	C_3	...	C_m
A_1	h_{11}	h_{12}	h_{13}	...	h_{1m}
...	h_{21}	h_{22}	h_{23}	...	h_{2m}
A_n	H_{n1}	H_{n2}	H_{n3}	...	r_{nm}

The first step was to multiply each column of the normalized decision matrix (Table 3) by corresponding criterion's weight.

$$V_i = h_{ij} \times W_j \quad (5)$$

The second step was to identify the highest and lowest value of each column and create two sets of these values across all rows named positive ideal solution and negative ideal solution, respectively (Srdjevic et al., 2004).

The positive ideal solution is:

$$V_i(max) = \{(maxV_{ji}|i \,\varepsilon\, \mathrm{I}) \text{and} (minV_{ji}|i \,\varepsilon\, \mathrm{I}')\} \quad (6)$$
$$= \{V^+{}_1 . V^+{}_2 . \cdots V^+{}_n\}$$

The negative ideal solution is:

$$V_i(min) = \{(minV_{ji}|i \,\varepsilon\, \mathrm{I}) \text{and} (maxV_{ji}|i \,\varepsilon\, \mathrm{I}')\} \quad (7)$$
$$= \{V^-{}_1 . V^-{}_2 . \cdots V^-{}_n\}$$

$(j = 1.2.3 \dots m)$

(j=1.2.3…m)

(i=1.2.3…n)

I is the set of criteria to maximize, and I'is the set of criteria to minimize.

The third step was to calculate separation measures for each alternative, which were computed based on their Euclidean distances from the positive ideal and negative ideal solutions (across all criteria).

The separation from positive ideal alternative (Fisher, 2008) is:

$$S_j(max) = \sqrt{\sum_{i=1}^{m} [V_{ji} - V_i(max)]^2} \quad (8)$$

The separation from negative ideal alternative is:

$$S_j(min) = \sqrt{\sum_{i=1}^{m} [V_{ji} - V_i(min)]^2} \quad (9)$$

The sixth step of TOPSIS method was to calculate relative closeness to the ideal solution which was calculated for each alternative, and alternatives were appropriately ranked. Top-ranked alternative was with the shortest distance from positive ideal solution and TOPSIS guarantees that it had the longest distance from negative ideal solution too:

$$C_j = \frac{S_j(min)}{S_j(min)+S_j(max)} \quad (10)$$

$0<C_j< 1$ then select the option of $C_j$which was closest to 1.

Selected criteria were quantitative and these measures were involved in the primary decision matrix directly. Two groups of economic- i.e. water cost, weed control cost, production cost and gross margin- and agronomic –i.e. grain yield and soil bulk density criteria used to prioritize the treatments.

Grain yield was measured by harvesting whole plot for each treatment (Pask, 2012). Soil bulk density was measured using standard core samplers (4-cmlong and 8-cm in diameter) and drying samples at 105°C for 48 hours. The following equation was used to calculate soil bulk density(Blake and Hartge, 1986):

$$D = {}^{W_d}/_{V} \quad (11)$$

where:

BD = soil bulk density (g cm^{-3}),

W_d = sample dry weight (g), and

V = sample total volume (cm^3).

The volume of water needed for irrigation was determined according to Michael and Ojha (1987) as follows:

$$V_w = {(D_n \times A)}/_{IE} \quad (12)$$

where:

V_w: water volume (m^3)

D_n: depthof irrigation (cm),

A: irrigated area (m^2)

IE: irrigation efficiency (%)

The following equation was used to evaluate depth of irrigation:

$$D_n = {[(FC - \theta_m) \times SPG \times D]}/_{100} \quad (12.1)$$

where:

FC: soil field capacity (%),

Θ_m: gravimetric water content before irrigation (%),

SPG: specific gravity, and

D: depth of soil samples (cm).

Θ_m was calculated using the following formula:

$$\theta_m = (W_s - W_d/W_d) \times 100 \quad (12.2)$$

where:

W_s: weight of wet sample (g)

W_d: weight of dry sample (g)

The fallowing equation was used to calculate gross margin:

$$GM = (TR - TVS) \quad (13)$$

Where:

GM: Gross margin

TR: Total Revenue

TGS:Total Variable Cost of goods Sold.

The selected criteria were analyzed using two methods**:**

Prioritizing Treatments Based on Tillage Practices

Tillage practices were considered in the decision making process.

Prioritizing Treatments Based on Interaction Between Wheat Genotypes And Tillage Practices

Wheat genotypes under three tillage practices were considered in the decision making.

RESULTS AND DISCUSSION

Prioritizing Treatments Based on Tillage Practices

The experimental treatments including alternatives (tillage practices) and characteristics (bulk density, water, weeds control and production costs, grain yield and gross margin) for 2014-15 and 2015-16 growing seasons were used as the criteria in the decision matrix (Table 4).

First, we considered each character for selecting the best tillage practice. The highest soil bulk density was obtained under NT practice in both years(Table 4). It was mainly due to minimum soil disturbance that led to soil compaction and associated with low residual crop retention (Fabrizzi et al., 2005; Gathala et al 2011; Taser and Metinoglu, 2005).Water cost under CT practice was the highest followed by RT and NT practices (Table 4). No- tillage practice required lower amount of water. These results are generally in agreement with findings of Bhushan et al. (2007), Jat et al. (2009, 2013).Cost of weeds control under CT practice was the lowest followed by RT practice and the highest under NT practice in 2014-15 and 2015-16 growing seasons (Table 4).The highestweeds control cost under NT practice could be associated to higher weeds seed bank near the soil surface (Conn, 2006; Carter and Ivany, 2006), and maximized germination potential of fresh weed seed due to residual burying, which is in agreement with the results reported by Mohler et al. (2006).Production cost followed the trend of CT>NT>RT in both years. Greater production cost under CT practice was due to higher water cost (Table 4).Water used under CT practice was 27%and 10% higher than NT and RT practices, respectively (data not shown). The highest and lowest wheat grain yield was achieved under RT and NT practices, respectively in 2014-15 and 2015-16(Table 4). Grain yield was consistently lower under NT than RT by 50 and 23% in the first and second year, respectively. The lower grain yield under NT practice could be related to higher soil bulk density (Chen et al., 2014; Kuncoro et al., 2014), which can limit root growth (Mosaddeghi et al., 2009), water uptake (Jin et al., 2013). These results are in agreement with findings of Alijani et al. (2012), Ghaghazardi et al. (2016) and Hemmat and Eskandari (2004a).In grain yield, costs were not elliptical. To overcome this weakness, gross margin was calculated. No tillage and RT practices resulted in the lowest and highest gross margin per hectare in both years, respectively (Table 4).

Considering each of above-mentioned characters, it was not clearly possible to determine effective criteria to select the best tillage practice. Therefore, the weights of each character as criterion considered by pair wise comparison (Table 5), and then TOPSIS method was used to prioritize the best tillage practice by using criteria. The separation of each tillage practice from positive and negative ideal solution was calculated by means the Euclidean distance.

Then, the relative closeness to ideal solution as a preference index was calculated. Top-ranked tillage practice was with the shortest distance from positive ideal solution and TOPSIS method guarantee that it had the longest distance from negative ideal solution too (Table 6). Additionally, calculated compatibility rate of pair comparison (0.07) showed they were compatible.

The pair wise comparison indicated that the effective criteria to prioritize the best tillage practice were gross margin (0.280) followed by water cost (0.270) in both years (Table 5). Averaged over relative closeness to the ideal criteria, the first preference of tillage practice was RT practice (0.812) followed by CT (0.651) and NT (0.314) practices in both years (Table 6). The results indicated that the most effective criteria to select the best tillage practice in two growing seasons was constant.Although, the financial profitability of conservation tillage (RT and NT) practices is uncertain in a short-term study.

Table 4. Primary matrix of criteria for tillage practices in 2014-15 and 2015-16 growing seasons

Type	Negative**	Negative	Negative	Negative	Positive*	Positive
Criterion	Bulk Density ($g\ cm^{-3}$)	Water Cost (000 IRR↓ ha^{-1})	Weeds Control Cost (000 IRR ha^{-1})	Production Cost (000 IRR ha^{-1})	Grain Yield ($t\ ha^{-1}$)	Gross Margin (000 IRR ha^{-1})
			2014-2015			
Tillage practice						
Conventional	1.247	5232	1700	24547	3.480	15647
Reduced	1.196	4999	1700	22856	3.600	18726
No tillage	1.386	3673	3400	24306	2.400	3414
			2015-2016			
Conventional	1.304	5185	1800	27295	2.972	12826
Reduced	1.359	4962	1800	25096	3.256	18859
No tillage	1.396	3589	3600	26146	2.635	9425

Table 5. Weight of criteria to prioritize the best tillage practices in 2014-15 and 2015-16 growing seasons

Criterion	Bulk density	Water Cost	Weeds Control Cost	Production Cost	Grain Yield	Gross Margin
Weight	0.040	0.270	0.150	0.080	0.180	0.280

Table 6. Prioritize the best tillage practices by TOPSIS method in 2014 -15 and 2-15-16 growing seasons

Treatments	Separation from positive ideal solution	Separation from negative ideal solution	Relative closeness to ideal solution	Treatment preference
Tillage practices	2014-2015			
Conventional	0.063	0.156	0.711	2
Reduced	0.044	0.189	0.811	1
No tillage	0.189	0.052	0.223	3
	2015-2016			
Conventional	0.087	0.123	0.591	2
Reduced	0.045	0.187	0.813	1
No tillage	0.130	0.088	0.404	3

Prioritizing Treatments Based on Wheat Genotype× Tillage Practice Interaction

The experimental treatments including alternatives (wheat genotypes under tillage practices) and characters (bulk density, water, weeds control and production costs, grain yield and gross margin) for 2014-15 and 2015-16 growing seasons were used as criteria in the decision matrixto prioritize treatment based on wheat genotype × tillage practice interaction (Tables7 and8).

First, each character was used to select the best genotype(s) under tillage practice. The lowest soil bulk density of four wheat genotypes (Chamran, Sirvan, M-89-10 and picaflor#1) was obtained under CT practice in 2014-15 and 2015-16 growing seasons (Tables7and 8).

Therefore, wheat genotypes had not affected on soil bulk density and responded similarly under each tillage practices. Weed control and water costs of wheat genotypes under each tillage practice were similar in the first and second years (Tables7 and 8), which was related to equal amount of herbicides and irrigation water applied for each genotype. Wheat genotypes under tillage practices showed equal production cost in both years, which was mainly due to same weeds control and water costs (Tables7 and 8).

The highest and lowest grain yield were obtained in Picaflor#1 genotype under CT and Chamran genotype under NT practices, respectively in the first year (Table 7). Whereas,Picaflor#1 genotype under RT and M-89-10 genotype under NT practices produced the highest and lowest grain yield, respectively in the second year(Table 8).Gross margin was the highest and lowest in Sirvan genotype under RT practice and Chamran genotype under NT practice in 2014-15 growing season (Tables 7), while it was the highest and lowest in Picaflor#1 genotype under RT practice and M-89-10 genotype under NT practice in 2015-16 growing season, respectively (Table 8).

Since the used criteria could not determine the effective criterion to prioritize the best wheat genotype under each tillage practice; therefore, TOPSIS method was applied using all criteria.

Table 7. Primary matrix of criteria for wheat genotype × tillage practice interaction in 2014-15 growing season

Type		Negative**	Negative	Negative	Negative	Positive*	Positive
Criterion		Bulk Density (g cm^{-3})	Water Cost (000 IRR‡ ha^{-1})	Weeds Control Cost (000 IRR ha^{-1})	Production Cost (000 IRR ha^{-1})	Grain Yield (t ha^{-1})	Gross Margin (000 IRR ha^{-1})
Tillagepractice	Genotype						
Conventional	Chamran	1.210	5232	1700	23990	3.110	11373
	Sirvan	1.213	5232	1700	23990	3.000	10103
	M-89-10	1.031	5232	1700	23990	3.816	19528
	Picalfor#1	1.256	5232	1700	23990	4.01	21803
Reduced	Chamran	1.210	4999	1700	22280	3.420	16645
	Sirvan	1.196	4999	1700	22280	3.940	22651
	M-89-10	1.666	4999	1700	22280	3.403	16448
	Picalfor#1	1.210	4999	1700	22280	3.660	19417
No tillage	Chamran	1.416	3673	3400	24678	2.223	1370
	Sirvan	1.446	3673	3400	24678	2.266	1866
	M-89-10	1.289	3673	3400	24678	2.330	2606
	Picalfor#1	1.393	3673	3400	24678	2.770	7688

* and ** criteria which farmers wish to be maximized and minimized, respectively.‡IRR= Iranian Rials

Table 8. Primary matrix of criteria for wheat genotype × tillage practice interaction in 2015-16 growing season

Type		Negative**	Negative	Negative	Negative	Positive*	Positive
Criterion		Bulk Density (g cm^{-3})	Water Cost (000 IRR‡ ha^{-1})	Weeds Control Cost (000 IRR ha^{-1})	Production Cost (000 IRR ha^{-1})	Grain Yield (t ha^{-1})	Gross Margin (000 IRR ha^{-1})
Tillagepractice	Genotype						
Conventional	Chamran	1.347	5185	1800	27296	3.170	15499
	Sirvan	1.296	5185	1800	27296	2.783	10274
	M-89-10	1.293	5185	1800	27296	2.866	11395
	Picalfor#1	1.280	5185	1800	27296	3.070	14149
Reduced	Chamran	1.386	4962	1800	25096	3.313	19629
	Sirvan	1.333	4962	1800	25096	3.173	17739
	M-89-10	1.303	4962	1800	25096	2.923	14364
	Picalfor#1	1.413	4962	1800	25096	3.616	23719
No tillage	Chamran	1.386	3589	3600	26147	2.656	9709
	Sirvan	1.396	3589	3600	26147	2.756	11059
	M-89-10	1.376	3589	3600	26147	2.413	6428
	Picalfor#1	1.376	3589	3600	26147	2.716	10519

* and ** criteria which farmers wish to be maximized and minimized, respectively.

‡IRR= Iranian Rials

The distance of each genotypes under tillage practice from positive and negative ideal solution, and then the relative closeness to ideal solution was calculated.Top-ranked genotypes under tillage practicewas with the shortest and longest distance from positive and negative ideal solution, respectively (Tables 9 and 10). The effective criteria to select the best wheat genotypes under tillage practice were gross margin (0.280) and water cost (0.270) in 2014-15 and 2015-16 growing seasons (Table 5).

The highest relative closeness to ideal criteria was achieved in Sirvan (0.849) and Picaflor#1(0.845) genotypes under RT practice, which obtained high preferences in 2014-15 and 2015-16 growing seasons, respectively (Tables 9 and 10). Results showed that preference of the genotypes under tillage practice was different in the first and second year due to changes in all criteria, and it could be related to variable environmental conditions and crop management during years.Therefore, it is necessary to monitor the criteria for each year.Our findings indicated thatconsidering a criterion such as wheat grain yield for selecting of the best wheat genotypes under tillage practices, Picaflor#1 under CT and RTpractices was the best genotypes in 2014-15 1nd 2015-16 growing seasons, respectively. When, consider all mentioned criteria, Sirvan and Picaflor#1 genotypes under RT practice was the first priorityin the first and second year, respectively.

Table 9. Prioritizing wheat genotypes under tillage practices by TOPSIS method in 2014 -15 growing season

Criterion		* and ** criteria which farmers wish to be maximized and minimized, respectively.	* and ** criteria which farmers wish to be maximized and minimized, respectively.	* and ** criteria which farmers wish to be maximized and minimized, respectively.	* and ** criteria which farmers wish to be maximized and minimized, respectively.
Tillage practice	Genotype				
Conventional	Chamran	0.069	0.065	0.485	7
	Sirvan	0.075	0.058	0.436	8
	M-89-10	0.031	0.108	0.775	4
	Picalfor#1	0.026	0.120	0.819	2
Reduced	Chamran	0.041	0.092	0.692	5
	Sirvan	0.022	0.124	0.849	1
	M-89-10	0.042	0.090	0.682	6
	Picalfor#1	0.029	0.107	0.786	3
No tillage	Chamran	0.124	0.026	0.173	12
	Sirvan	0.122	0.026	0.177	11
	M-89-10	0.118	0.027	0.187	10
	Picalfor#1	0.090	0.044	0.330	9

Table 10. Prioritizing wheat genotypes under tillage practices by TOPSIS method in 2015-16 growing season

Criterion		Separation from positiveideal solution	Separation from negative ideal solution	Relative closeness to ideal solution	Treatment preference
Tillage practice	Genotype				
Conventional	Chamran	0.049	0.084	0.633	4
	Sirvan	0.075	0.058	0.433	9
	M-89-10	0.069	0.063	0.476	7
	Picalfor#1	0.055	0.077	0.582	6
Reduced	Chamran	0.030	0.106	0.781	2
	Sirvan	0.037	0.096	0.720	3
	M-89-10	0.053	0.078	0.593	5
	Picalfor#1	0.024	0.128	0.845	1
No tillage	Chamran	0.082	0.054	0.397	11
	Sirvan	0.075	0.061	0.446	8
	M-89-10	0.099	0.039	0.286	12
	Picalfor#1	0.078	0.058	0.427	10

CONCLUSIONS

Multiple criteria decision making method was used for ranking treatments according to the relative closeness to positive ideal criteria and maximum distance from negative ideal criteria. Our finding showed that when all criteria were used, the preference of tillage practices followed the trend of RT>CT>NT in both years. However, prioritizing the best wheat genotype under tillage practices were Sirvan under RT and Picaflor#1 under RT in 2014-15 and 2015-16 growing seasons, respectively. Further research is suggested to consider multiple criteria instead of a criterion to choose the best tillage practices and genotypes under tillage practices. Therefore, application of TOPSIS method for decision making in agricultural experiments provides accurate and reasonable decisions.

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ارزیابی ژنوتیپ های گندم در سامانه های خاک ورزی:کاربرد تکنیک الویت بندی بر اساس نزدیکی به پاسخ ایده ال

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عملکرد گندم

چکیده- پذیرش سامانه‌های کشاورزی حفاظتی در سطح مزارع کشاورزان به میزان هزینه‌های تولید و پایداری بیش‌تر عملکرد بستگی دارد. هدف این پژوهش،اولویت بندی تیمارها با معیارهای انتخاب شده با استفاده از تکنیک اولویت‌بندی بر اساس نزدیکی به پاسخ ایده آل (TOPSIS)می‌باشد. این پژوهش در ایستگاه تحقیقاتی زرقان، استان فارس، ایران در طی دو سال زراعی ۹۵-۱۳۹۳ اجرا گردید.این آزمایش به صورت کرت‌های خرد شده در قالب طرح بلوک‌های کامل تصادفی در سه تکرار اجرا شد. تیمارهای آزمایشی شامل سامانه‌های مختلف خاک‌ورزی (مرسوم، کم خاک‌ورزی و بی خاک-ورزی) به عنوان کرت اصلی و ژنوتیپ‌های گندم بهاره(چمران، سیروان، پیکافلوریک و M-89-10)به عنوان کرت فرعی بودند.معیارهای انتخاب شده شامل دو گروه زراعی مانند وزن مخصوص ظاهری خاک، عملکرد دانه و گروه اقتصادی مانند درآمد ناخالص، هزینه های کنترل علف های هرز، آب و تولید بودند. وزن معیارهای وزن مخصوص ظاهری خاک (۰/۰۴۰)، عملکرد دانه (۰/۱۸۰)، بازده ناخالص (۰/۲۸۰)، هزینه آب (۰/۰۲۷۰)، هزینه کنترل علف های هرز (۰/۱۵۰) و هزینه تولید(۰/۰۸۰) بدست آمد.نتایج نشان داد که با در نظر گرفتن همه معیارها، اولین الویت متعلق به ژنوتیپ های سیروان و پیکافلوریک در سامانه کم خاک‌ورزی به ترتیب در سال‌های اول و دوم آزمایش بود. بنابراین استفاده از تکنیک های چند معیاره به جای تک معیار مانند عملکرد دانه و یا هزینه تولید، جهت انتخاب بهترین سامانه خاک‌ورزی و برترین ژنوتیپ گندم در سامانه های خاک‌ورزی توصیه می‌گردد.