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ORIGINAL ARTICLE

Factors affecting Zea yield gap in Savojbolagh

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ABSTRACT
One of methods to determine the cause factors of yield gap of product in one area is using experts and farmers opinions at that region. Therefore, in order to evaluate the performance of forage maize at Savojbolagh region, an experiment was carried out as interview with questionnaires in the agricultural fields of Savojbolagh in 2014-2015. The investigation of correlation coefficients showed that the applied amount of micronutrient fertilizer and furrow lengths(0.23 and 0.67*, respectively) had positive and significant correlation with performance. Stepwise regression analysis showed that the important effective charters on the performance are included frequencies of irrigation, furrow length, depth of plough and using of leveler, and are justified about 65% of variation in performance. Path analysis showed that the greatest direct effect on performance related to the frequency of irrigation, with amount of 0.301. The following characters were the use of the Leveler (0.281) and depth of plough (0.204) had a direct positive effect on performance. Management of various factors, frequency of irrigation(45%) and length of the furrow (13%) were the most common factors caused23.77 t/ha offorage maize yield gap between different management factors in the studied area. Therefore, determining the most appropriate frequency of irrigation and length of furrow to increase performance in this area is recommended.*
***Key words**: Performance gap, Corn, Regression, Correlation*

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INTRODUCTION

Increased crop yield is an important nowadays goalto cope with the increasing world population. The world population is growing at a rate of 1.6 to 1.7 percent and, in other words, 95 million people are yearly added to the consumers of agricultural products. This condition means that it is necessary to continuously increase food production to compensate the food shortage of human in many areas of the world [1].

A major problem in the production of agricultural crops in Iran is the marked difference between the real performance of farmers and harvestable yield. To fill the void of crop yields in agricultural systems, there are three stages: determination of the difference between regional potential yield and the actual yield (yield gap), optimization of the production system in order to reduce the gap, and improvement of agricultural systems. It seems important to determine environmental and agricultural factors limiting yield in a given area in order to reduce the gap between the potential and actual yields. There are no perfect approaches for this purpose because a lot of heterogeneities and interactions are associated with agricultural environment and management, which do not allow for a complete statistical analysis [2]. However, there are several methods for the detection of these factors, each if which have their own defects and advantages. In recent years, the voided crop yield have widely been analyzed at different levels in the world. The extent of these surveys can be categorized as global [3], continental [4], national [5-7] and regional [8]. The majority of these investigations have been focused on the cereals, in particular three major cereals namely wheat, corn and rice, which supply a considerable portion of man's food. Some studies are based on surveying measurements, in which the problems of farmers are collected through questionnaires [9]. In other cases, the performance of farmers and the relevant crop management are specified and factors affecting the yield are realized by multivariate analysis and also statistical correlations between the yield and management Variables [11]. Simulation models are other among other methods for the determination of factors voiding the yield; these include both complex and simple models each with its defects and advantages [12]. The first step for reducing the yield gap is to identify the yield restrictions in a given area [13]. Agarwal *et al*. [14] used a simulation model and estimated potential wheat yield in India to be between and 2.5-7 t/h with a gap of 2-4 t/h. Bhatia *et al.* [5] evaluated potential wheat yield and the gap for rain-fed soy in 21 areas of India and reported an average potential yield in these areas of 3020 kg/ha with a mean gap of about 28 percent. Rajapaks [15] also showed that fertilizers with 33 percent, water shortage of 26 percent, late harvest of 18 percent, second-time hand weeding of 16 percent, and postponed transplantation of 6 percent accounted for the most important factors causing a gap in rice yield of 2365 kg/ha. Abledo *et al.* [10] reported a wheat yield gap of 40 to 70% in a Mediterranean area of Spain and showed that the amount of gap was a function of nitrogen and water access of farmers. As noted, a number of parameters hinder farmers to attain various harvestable products. Apparently, through determination of the impact of each management factor on the extent of the observed yield gap followed by the farmers' awareness, the space between the actual and attainable yields can be reduced to a minimum. This research, therefore, aimed to survey corn yield in Savojbolagh, Iran.

MATERIALS AND METHODS

This field experiment was conducted through questionnaires in the agricultural fields (which had already been chosen by the authors) in Savojbolagh during the agronomic year 2014-15. The amount of moisture in the city is 24.54 percent. The city is geographically located in 50° 56' E and 35° 57' N.

Statistical procedures including correlation, stepwise regression to identify important traits affecting the yield, path analysis to determine the direct and indirect effects of important characters as dependent variables included in the regression model, all of which were analyzed by SAS 9.1 and Path. Then the corresponding graphs were drawn for analysis. In order to understand the correlation between variables, simple correlation can be employed, but it has flaws so that changes in one variable with another one are estimated by ignoring the effects of other variables present. To fix this flaw, path analysis was used. It should be noted that multistage sampling was applied in this study. The farmers were sampled from the city and then samples were taken from selected districts. Within each district, a list of villages was prepared, from which sampling was performed. A list of resident farms to be sampled was also obtained for each selected village.

RESULTS AND DISCUSSION

Results of correlation between the various factors studied are presented in Table 1. The length of furrow and consumption amount of seed have a positive and significant correlation with performance (0.23*) and (0.67*), respectively. Also, in the case of other factors, sowing plant with the type of prior product (-0.32*) and the type of cultivation as dry or wet (-0.26*) had a significant and negative correlation. The amount of N fertilizer at sowing date with a total nitrogen (0.42**) had a significant and positive correlation. Supply nitrogen at different times of growth and based on plant demand and increasing of its uptake can affect the speed of plant growth and yield. Therefore, the management of timing and amount application of nitrogen can be evaluated as a strategy to reduce the yield gap. It is included the relation of nitrogen with photosynthesis, nitrogen distribution between the leaves, leaf arrangement and eventually its subsequent effect on the light received by the leaves [21]. Increasing nitrogen fertilizer, usually through increasing leaf area index causes to reduce the evaporation to transpiration ratio. Nitrogen may increase the rootlet length, rooting depth and water consumption [17]. The amount of nitrogen in the second stage with total nitrogen had also a significant and positive correlation (0.74**). The third stage nitrogen content with total nitrogen had a significant and positive correlation (0.59**). Nitrogen should preferably be used in several stages to achieve better results and also decrease the leaching. Depending on the soil type and cultivation system (water or dry farming), nitrate leaching was estimated on average between 13 and 39 kg per hectare per year at Gorgan region. Phosphate fertilizer has positive and significant correlation (0.88**) with potassium fertilizers. Number of discs has a significant and positive correlation (0.18*) with the amount of seed.

Table1. Correlation between the factors studied

Variables	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}	X_{19}	X_{20}	X_{21}	X_{22}	X_{23}	X_{24}	X_{25}	X_{26}
y)Yield	-0.1	0.02	0.32	-0.59	-0.16	-0.11	-0.07	-0.03	-0.11	0.02	-0.01	-0.04	-0.02	0.11	0.23*	0.08	-0.02	0.01	0.01	-0.005	-0.01	-0.6	-0.03	0.67*	0.09	-0.11
X_1)Planting date	-	-0.08	-0.32*	0.11	0.002	0.05	0.07	0.05	0.1	-0.1	-0.07	-0.24*	-0.25*	0.08	0.15	0.03	-0.12	0.09	0.04	-0.09	0.06	0.22*	0.11	-0.1*	-0.17	0.14
X_2)Soil tests done or not done		-	-0.18	0.21	0.09	-0.03	0.07	0.14	0.05	-0.07	0.01-	0.01	0.18	-0.08	0.05	-0.16	0.03	-0.11	-0.14	0.05	-0.09	-0.07	-0.18	-0.07	-.003	-0.09
X_3)Priorproduct type			-	-0.23	-0.01	0.17	-0.009	0.01	0.07	0.02	-0.02	0.14	0.05	-0.11	-0.1	0.06	0.034	0.1	0.03	0.06	-0.01	0.006	0.01	0.12	0.12	0.09
X_4)Depth of plough				-	0.17	-0.07	0.12	0.07	0.09	0.0002	0.05	0.006	0.07	-0.01	-0.08	-0.14	-0.035	-0.15	-0.12	0.02	-0.017	0.45*	-0.08	-0.5	-0.02	0.07
X_5)Planting depth					-	-0.06	0.02	0.11	0.05	-0.03	-0.05	-0.06	0.000	-0.07	-0.07	-0.005	0.038	0.007	-0.33	0.02	0.02	0.16	-0.14	-0.2	-0.04	-0.02
X6)The amount of nitrogen at planting stage							0.12	0.11	0.42**	0.07	0.11	0.12	0.1	0.02	0.08	0.1	0.13	0.007	0.12	0.13	0.15	0.08	0.03	0.01	0.08	0.041
X_7)The amount of nitrogen in the second stage							-	0.09	0.74**	0.11	0.13	-0.1	0.11	-0.01	-0.11	0.04	0.06	-0.16	-0.35	0.06	-0.08	0.05	-0.0003	-0.14	-0.01	0.27*
X_8)The amount of nitrogen in the third stage								-	0.59**	-0.21*	0.19	0.1	-0.12	-0.08	-0.06	-0.03	0.15	0.02	-0.38	0.02	-0.05	-0.08	-0.03	-0.1	-0.19	0.09
X_9)Total nitrogen									-	-0.02	0.016	-0.05	-0.04	-0.04	-0.14	0.05	0.07	-0.09	-0.13	0.1	-0.14	0.01	-0.02	-0.12	-0.15	0.24*
X_{10})The amount of phosphate fertilizer										-	0.88**	-0.12	0.11	-0.08	-0.04	-0.08	-0.035	-0.14	-0.33	-0.01	0.01	-0.18	-0.07	0.02	0.07	-0.07
X_{11})The amount of potassium fertilizer											-	-0.17	0.07	-0.19	0.002	-0.1	-0.06	-0.08	-0.35	-0.02	0.03	-0.12	-0.11	0.04	0.04	-0.06

Variables	X_1	X_2	X_3	X_4	X_5	X6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}	X_{19}	X_{20}	X_{21}	X_{22}	X_{23}	X_{24}	X_{25}	X_{26}
X_{12}) Iranian or foreign seed												-	-0.07	0.09	-0.11	0.003	-0.05	0.01	-0.01	0.17	-.19	-0.09	0.14	0.13	0.18	0.05
X_{13}) Type of cultivation (water or dry farming)													-	-0.08	-0.08	0.02	0.06	-0.15	0.02	0.06	-0.08	-0.07	-0.24*	-0.06	-0.07	0.12
X_{14}) Date of first irrigation after water-soil														-	-0.06	-0.002	-0.07	0.14	-0.03	-0.18	0.18	0.001	0.23*	-0.06	0.06	-0.09
X_{15}) Length of furrow															-	0.08	0.01	-0.05	0.05	-0.04	0.08	-0.003	0.02	-0.04	-0.08	-0.05
X_{16}) Cultivation area																-	0.1	0.21*	0.88*	0.07	-0.05	0.12	0.06	-0.011	-0.01	0.11
X_{17}) Irrigation frequency																	-	0.02	0.19	-0.04	0.02	0.08	-0.1	-0.03	-0.003	-0.04
X_{18}) Harvest date (days from planting to harvesting)																		-	0.19	-0.02	0.04	-0.03	0.08	0.05	-0.16	-0.14
X_{19}) Iranian or foreign seed																			-	0.1	-0.1	0.1	-0.04	-0.02	0.09	0.02
X_{20}) Number of Discs																				-	-0.95**	-0.007	-0.16	0.18*	0.15	**0.15**
X_{21})The use of the Leveler																					-	0.04	0.2*	-0.19*	-0.15	-0.16
X_{22}) Seed type (public-private)																						-	-0.1	0.04-	-0.08	0.13*
X_{23})Type cultivars of seeds																							-	-0.14	-0.03	0.05
X_{24}) The amount application of seeds																								-	0.1*	0.08
X_{25}) The amount application of micronutrient fertilizers																									-	-0.06
X_{26}The height of crop harvest																										-

The research that was carried out by stepwise regression between performance of forage maize and the factors affecting it were determined which frequency of irrigation can explained major part of changes (45%) in yield of forage maize. The following factors are furrow length, depth of plough and the use of leveler that explained respectively 13, 4 and 3 percent of the change rates of total yield, respectively. Therefore, the four variables mentioned explained 65 percent of the total yield (Table 2). The results corresponds to Acquaah *et al*. [11] and Bacanamwo and Purcell [16].

Table2. Stepwise regression for yield of forage maize

Stages	Regression	Coefficient of determination
1	$Y = 32.48 + 2.72\ x_{17}$	$R^2 = 0.45$
2	$Y = 56.39 - 0.096\ x_{15} + 1.90\ x_{17}$	$R^2 = 0.58$
3	$Y = 67.48 - 0.35x_4 - 0.08\ x_{15} + 1.52\ x_{17}$	$R^2 = 0.62$
4	$Y = 75.41 - 0.33\ x_4 + 3.38\ x_{21} - 0.07x_{15} + 1.55\ x_{17}$	$R^2 = 0.65$

(Y: Yield of forage maize (t/ha) --x_{21} use or non-use of the Leveler (1: non-use of the Leveler, 2: Use of the leveler-- x_4 depth of plough (cm) - x_{15}length of furrow -- x_{17}frequencies of irrigation)

According to the amounts of yield recorded in the studied region, the average yield of forage maize was achieved 71 t/ha, which is the actual performance. To determine the potential performance achieved at stage 4, regression model was used. That maximum (for the factors with negative coefficients) or minimum values (for the factors with positive coefficients) of 4 variables entered in the regression model obtained from the recorded data then fitted in the regression model (step 4), yield potential (94.77 t/ha) were estimated. Therefore, the yield gap (differences between actual and potential performance) in the region was estimatedto 23.77 t/ha. It means that the amount of actual performance of forage maize in relation to the potential yield has 25 percent shortage (Figure1).

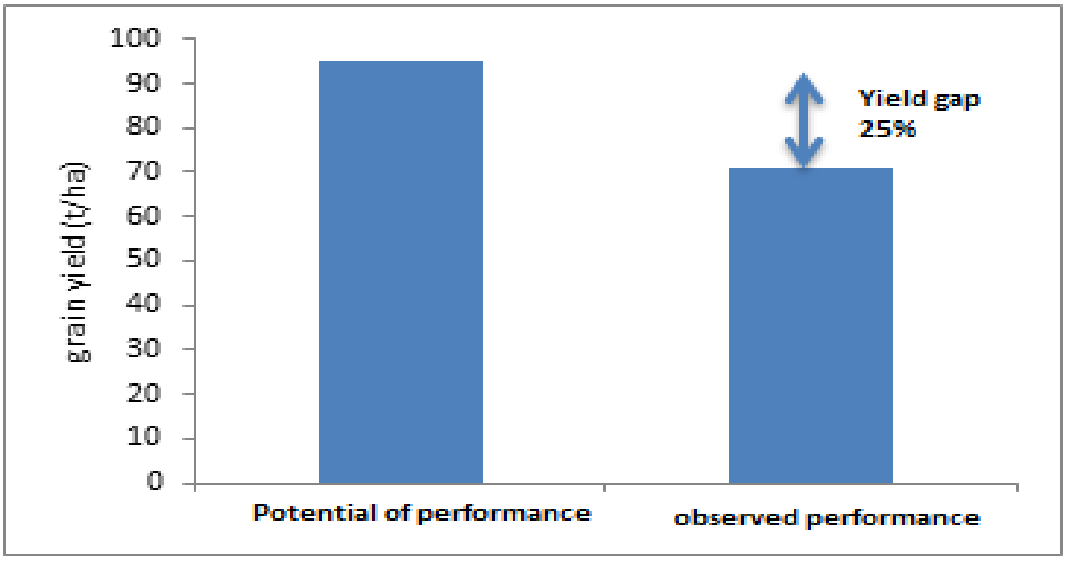

Figure1. The values of the potential performance, observedperformance and yield gap of maize

The path analysis is considered a very helpful method for the examination of genetic and phenotypic correlations and detection of both direct and indirect effects. Three traits were entered the model and explained a high percentage of the variations. Path analysis (causality) was applied to assess their direct and indirect effects on the grain yield. Path analysis is a method to study the principle of causality among a set of variables and is very useful for correlation analysis and also understanding the direct and indirect effects of traits. When referring to the concept of causality, some of the variables should be taken as the causes, and the others as the effects. Dewey and Lu [18] describing the path analysis noted that correlation between each of the parameters examined with a dependent variable in a multivariate system can be analyzed to its direct and indirect effects through the other independent variables. In such a system, the whole change in a dependent variable is divided into two justified and unjustified components with variables under consideration. What is expressed by the independent variables is the coefficient of determination in a standard multiple regression analysis. The relationship between different traits is important for increasing grain yield as a one-way choice for agronomic characteristics regardless of the effects of other traits will not provide trustable results. Hence, the correlation between traits as well as their direct and indirect effects on the yield should be taken into consideration, making the path analysis indispensable. Therefore, the path analysis is essential. The most direct effect was observed in the frequencies of irrigation (0.301).Then the use of the leveler (0.281) and depth of plough (0.204) had a direct and positive effect on performance. The frequencies of irrigation through the use of the leveler had the highest indirect and positive effect (0.21) on the performance. Also, the use of the leveler had the most direct negative effect (-0.31) through the depth of plough on performance. Length of furrow had a direct and negative effect on yield (-0.137). And this character by irrigation frequency had indirect and positive effect on yield (0.117). Furthermore, the depth of plough through the use of the leveler had an indirect negative effect on performance (-0.29). Also,the frequencies of irrigation by depth of plough had indirect negative effect on the performance (-0.18). Furrow length by the frequencies of irrigation and the use of leveler had an indirect positive (0.117) and indirect negative (-0.01) effects on yield, respectively. The frequencies of irrigation by furrow length and the use of leveler had indirect negative (-0.053) and indirect positive (0.12) effects on performance, respectively. Also, the amount of residual effects was0.31.

Table3. Path analysis of forage maize yield

Total	Direct Effect	Indirect effect by				Characters entered at model
		X_{17}	X_{15}	X_{21}	X_4	
0.714	0.204	0.19	0.03	-0.29	-	X_4
0.931	0.208	0.21	0.13	-	-0.31	X_{21}
0.323	-0.137	0.117	-	-0.01	0.059	X_{15}
0.654	0.301	-	-0.053	0.12	-0.18	X_{17}
Residual effects						0.31

(X_{21} the use of leveler, X_4 depth of plough (cm), X_{15} the length of furrow, X_{17} the frequencies of irrigation).

CONCLUSION

The investigating correlation coefficients showed that micronutrient fertilizer and furrow length had a significant positive correlation (0.23* and 0.67*) with performance, respectively. Also according to the results, it was found that most important factors of yield gap in maize are including the frequencies of irrigation, furrow length, depth of plough and the use of the leveler.

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