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Yield gap analysis related to management constraints in wheat crops in Parsabad Moghan region

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Abstract: One of the main problems in crop production in Iran is the difference between actual yield and attainable yield which is called yield gap. Thus, identifying yield constraints and yield gap are important. To do this, a study was conducted in 60 farms in Parsabad Moghan, covered by three agricultural service centers of Dasht, Savalan and Araz, during two crop years 2013-14 and 2014-15 using Comparative Performance Analysis (CPA). Sampling of wheat fields was performed randomly from 5 different points of each farm using a square meter. In this study, all of the information about management operations, soil and crop characteristics including Seedbed preparation, sowing, planting, selection of varieties, the seed, weed fight methods, the type, amount and timing of using herbicides and fungicides and harvest time were recorded and measured (including 100 variables). Then, the relationship between variables and yield were considered (using stepwise regression). The results showed that there is a 2317.42 kg/ha difference (gap) between actual yield (average farmers' yield) and attainable yield (maximum farmers' yield). It was identified that Planting time , Spike density, the number of split application of urea, the preparation of land, farming experience and repeated use of fungicides were responsible for this yield gap with contribution of about 15%, 32.7%, 20%, 4.6%, 8.6%,14.3%, and 13.4%, respectively. Data investigations revealed that most of the variables listed above can be controlled by the management of planting date. Therefore, planting time, spike density and split application of urea with the highest contribution in total are the most important factors that affect the performance in the region. By selecting suitable planting date, Spike density is created which can be led to yield increase of 2317.42 kg/ha in the region if it is used with effective management in fertilizer partitioning, the use of fungicides and reducing Total field preparation.
Keywords: Yield gap; Attainable yield; Actual yield; Wheat; CPA.

INTRODUCTION

In Iran, as in many countries, the most important daily meal is bread, so that the entire supply of bread consumption in Iranian daily calorie intake is about 40% per individual (Normohamadi et al., 2000). Assessment of future grain production, especially wheat is one of the issues that have attracted the attention of many researchers. One of the concerns of agriculture section is producing enough food to meet growing demand from increasing population of the world. Estimates indicate that the performance of this product should increase by 44 percent on a global scale to meet the needs to wheat in 2020(Nassiri mahalati and Koocheki, 2009). Therefore knowing about the crop management in order to produce food is one of the major duties of farmers and managers of this section. False management leads to considerable difference between actual yield and attainable yield which is called yield gap (Torabi ea al., 2011). Food security in the world is vulnerable due to various factors such as diet, weather conditions, destruction of arable land and growing competition for water and energy and other factors (Ray et al., 2013 ; Sharma et al., 2012). Food security has always been the most important concern of mankind on Earth. Many international organizations and governments are doing some researches to ensure human needs for future generations. In fact, for a more secure food supply, it is necessary to increase yield potential of wheat, soybeans and rice, especially for wheat for which a minimum increase in performance is strategic in order to meet the highest growth in demand (Godfray et al., 2010). There are two ways to increase agricultural production; an increase in under cultivation area which has environmental problems, and increasing the productivity of agricultural land (Lambin and Meyfroidt, 2011). Thus increasing crop yield in order to meet the need for food, fuel and fiber can be important and minimize the environmental damage (Mueller et al., 2012). However, current progress with its slow functioning cannot meet the growing demand for agricultural products for the next population (Ray et al., 2013). Potential crop yields in different parts of the worlds, and the yield gap is very different and in large amount, for example, because of the management limitations infrastructure, education and agricultural policy which often prevents increasing land productivity, the whole yield gap in developing countries is very high in comparison with developed countries (Tilman et al., 2011; Neumann et al., 2010).

One of the requirements of investigating yield gap is a better understanding of the performance, yield potential, cooperation of the agencies and appropriate way to improve performance (Fischer et al., 2009; Carberry et al., 2011). Measuring the yield gap, suitable procedure to enhance performance, increasing profits, saving time, increasing awareness and knowledge of farmers about the correct way of farming, raising target land and crop productivity and, enhancing risk farmers, and recommendations for improving limitations of management and appropriate response to natural disasters affect crop yield potential in a year.(Heidari Sharifabad, 2016). So the potential yield is subjected to weather (climate) and biophysical conditions and selection of varieties. As a result, the role of management can be tested (Ittersum et al., 2013 Lobell et al., 2009;). Testing under conditions of good management and control, eliminating the limiting factors of yield potential will result in potential performance (Ittersum et al., 2013). Iran is also one of the great wheat producing countries in the world. One of the major problems in crop production in our country is the lack of exact agricultural strategy in fertilized agricultural areas arising different biological, social, economic, and climate factors to increase the yield gap in Iran especially in Moghan. So limiting factors affecting yield and yield gap not only in the region but also in the other parts of Iran is very important. CPA (Comparative Performance Analysis) is one of the methods used to quantify the yield gap. Using this method, the main performance limitations and some quantified functions for the yield gap are determined. In the comparative analysis using multiple regression and stepwise analysis (Rezaie and Soltani, 2007) function limitations, and consequently production model will be determined. Using Production model and values of model parameters the contribution of any of the restrictions in yield gap is determined (De Bie, 2007). Rajapakse (2003) using CPA showed that Production Model explains 58 percent of the rice variety with an average yield gap of 2365 kg per hectare. In this model, the impact of functional limitations was as follows: 33% of the effect of fertilizers, 26% of water shortages, 18% of late harvesting, 16% of second hand weeding and 6 percent of delayed transplanting. This study showed that the yield gap is reduced through the provision of appropriate technology and improving agricultural management skills. Also the CPA model developed by Pradesh (Pradhan, 2004) showed the contribution of different parameters to reduce corn were 27%, of the soil texture, 30% of the area of the plots on the farm, 30 percent of the number of seeds planted in each hill and 13 percent of the lack of thinning operations. Kayranga (2006) in another study on rice using CPA showed that functional limitations related to management factors. The production model in this study estimated yield gap as 1855 kg per hectare, and 75% of the changes were justified by the model. Tungro disease at a rate of 1.64% and soil conditions at the rate of 9/35 percent were the most important causes of the yield gap. Studies show that the first step to reducing the yield gap is identifying specific functional limitations in the area. Understanding the functional limitations can help us in trying to reduce yield gap. Reducing the yield gap not only helps to increase performance and production, but also improves the working efficiency of land use, reduce production costs and increase yield stability (Torabi et al., 2011). In general, the aim of this study was to determine the yield gap, limiting factors, and to determine the contribution of each factor in wheat fields in causing yield gap using CPA is Parsabad (A city in Ardabil Province, Iran). Providing appropriate solutions to reduce yield gap through crop management strategy in the region is another aim of the present study.

MATERIALS AND METHODS

The research was conducted in Parsabad at the area between 39 to 41 latitude, 47 to 32 degrees longitude, and 45 to 50 meters above sea level. The area is semi-arid with mild winters and hot summers. The maximum and minimum temperature was 37 ° C in June and 13 ° C in January. The average rainfall was 317 mm and relative humidity was 76% according to the meteorological information during these two years of experiments. 60 farms were selected for two consecutive years and all necessary information to the survey were collected from the farms. Selected farm management practices, including seed bed preparation, operation (including planting, irrigation and weed fight ...) and harvested were done under the supervision of experts for wheat. Despite, conditions of the farms were diverse in operation management. Information on physical and chemical properties of soil, data management, including the preparation of planting bed (type, number and timing of plowing, etc.), the use and location of formulated packages, planting, fertilizer (type of fertilizer nitrogen rate and the number of using fertilizer), weed fight, pests and diseases, including type of toxin and the toxin intake, number and timing of irrigation, harvest time, information on crops including registration and performance measurement and yield components, the stem elongation, heading, pollination and grain filling, and the leaf area index of selected plants from each field (10 plants randomly) were calculate and recorded. To determine the yield, the relationship between all variables (qualitative and quantitative, qualitative variables were coded as zero and one) were measured and performance through stepwise regression method (Torabi ea al., 2011) were examined. The final model was determined by the controlled trial and error method, which could quantify the functional limitations. By putting the average observed variable (Xs) in 60 farms of the study, the model calculated the average performance. Then by putting the observed value of the variables in the model, the maximum attainable yield was calculated. The difference between the two was considered as the yield gap. Yield gap ratio for each variable represents the contribution of each variable's performance to total yield gap which is shown in percent in table1. SPSS software was used to analyze the data.

RESULTS AND DISCUSSION

Results of stepwise regression to determine the most important variables affecting the performance management and performance models are given in Table 3. In this Regression, the performance of the yield per unit area was considered as the dependent variable and other variables such as planting date, spike density, using urea, preparation of the land, the farmer's experience and the number of repetitions of fungicides were used as independent variables. The results can be seen in equation (1). Finally, using this equation, the actual yield, the attainable yield and the contribution of each variable to reduce performance were determined.
Y (kg/ha) = 7254.22 -17.98 (PD) +3.8 (SD) + 422.21 (NSF) – 268.43 (NOP) – 21.39 (FEP) +182.68 (NRF)
Where,
Y is performance, **PD**: planting date, **SD**: spike density, **NUU**: The number of split fertilizer or urea, **NOP**: The number of operations to prepare the land **FEP**: Farmer's experience and **NRF** is the number of repetitions fungicides.

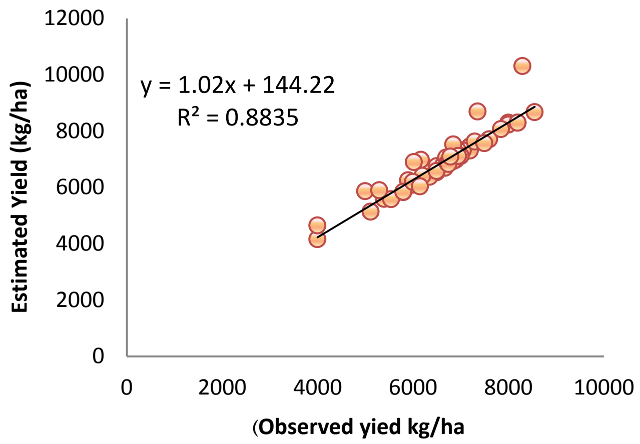

Figure 1. The relationship between the observed and estimated by the model

Table 1. Regression analysis of various factors on crop yield gap.

variables	ratio	The variables in the model		The obtained yield through the model		Gap	
		average	selected amount	average	selected amount	amount)Kg/ha(	%
Yield	7254.22	1	1	7254.22	7254.22	0	0
Planting date	-17.98	69.22	50	- 1244.57	-899	-345.57	15
Spike density	3.8	470.6	670	1788.28	2546	757.72	32.7
Number of split fertilizer or Urea	422.21	1.95	3	862.31	1326.63	464.32	20
The number of operations to prepare the land	268.43	5.43	5	- 1449.52	- 1342.15	-107.37	4.6
Farmer's experience	-21.39	47.52	32	- 1016.45	-684.48	-331.97	14.3
number of repetitions fungicides	182.68	1.3	3	237.48	548.04	310.57	13.4
Average yield	-	-	-	6431.85	8749.27		-
Yield gap estimated by the model	-	-	-	-	-	2317.42	100

Figure 1 shows the relationship between actual yield and estimated attainable yield through model with a correlation coefficient of 0.94. SD of estimate model is 371.7 kg. Based on these criteria, the model is applicable for determining the efficiency of the use of yield gap and contribution of each of its functional limitations.

Table (1) shows the yield gap and contribution of each yield limiting factor. The model estimated maximum and average yield as 8749.27 and 6431.85 kg per hectare respectively which are comparable with the maximum and average performance observed in the field. The yield gap estimated as 2316.42 kg per hectare. This indicates that there was a difference of 2316.42 kg between actual yields and attainable yield which can be get to zero by selecting optimal management.

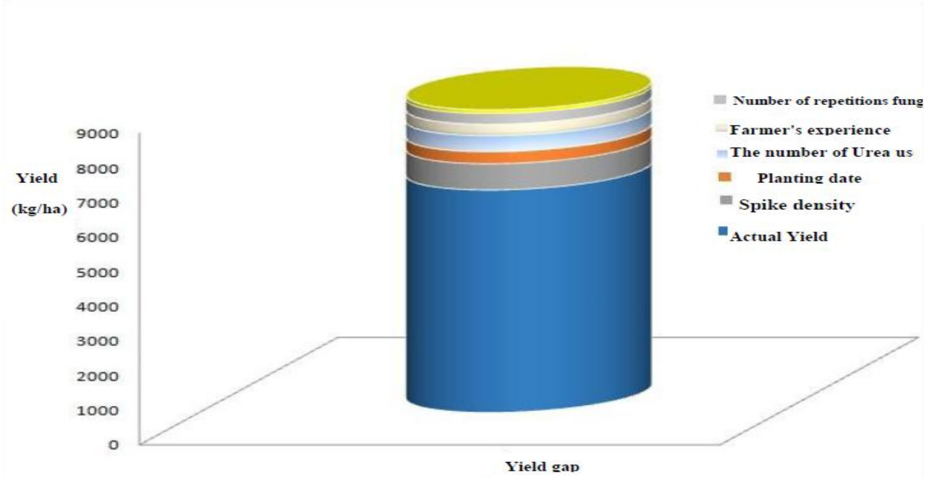

Figure 2. The contribution of the major limiting factors to wheat yield gap

The results presented in Table 1 show that planting date with 15% yield gap is one of the factors that create a gap between actual yield and attainable yield (Table 1). Performance model output suggests that if farmers cultivate on 20 November (50 days after the September, their performance increases at a rate of 345.57 kg per hectare. Farmers in the region plant autumn wheat late and in a bad weather conditions due to poor crop rotation (corn as second crop) leading to late harvesting of maize (late December). These conditions, in turn, increases density and the number of operations required to produce the crop. In Moghan, wheat is mainly planted on 38 to 100 days after the first of October. As it can be seen in Figure 3 by increasing the number of days from the beginning of October, the yield is dropped significantly ($p<0.01$). Therefore, late planting date is one of the major factors in creating yield gap. Kiani et al., (2012) introduced planting dates as a factor affecting the vegetative and reproductive growth, the balance between them and ultimately the yield. Mahlooji et al., (2000) also investigated the effect of two planting date (7th of May and the 7th of July) and water stress on yield and yield components of bean in Isfahan stated that the delay shortens the development phases and also accelerates the ripening time and flowering (vegetative period) resulting in a 29.6 percent yield loss. Flowers et al (2006) stated that planting date had a great effect on wheat yield and decreased yield up to 24 percent.

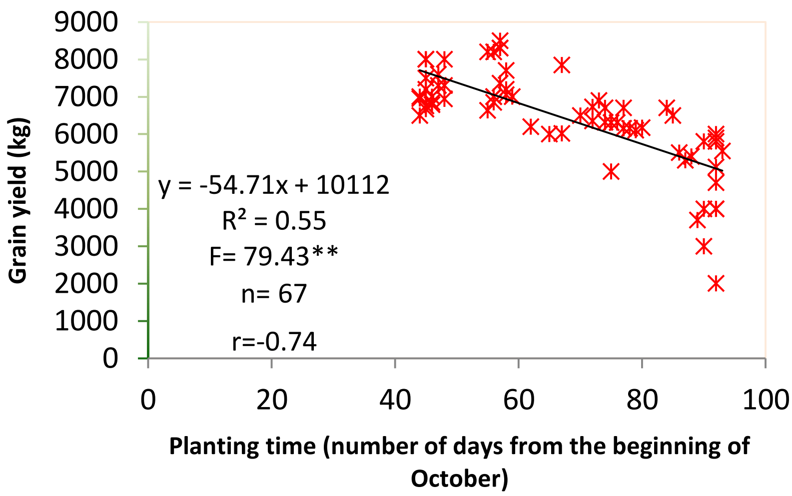

Figure 3. Regression Relationship of planting date and yield in the farmers' fields

Delayed planting reduces the yield of wheat varieties (4-5% for delay per week). According to the researchers yield loss from planting date can be due to shortened grain filling period, a rise in temperature during grain filling, reducing the number of seeds, seed weight, density and other factors contributing to yield (Kumar et al., 2013; Cassim, 2008; Zia et al., 2014; Ibrahim et al., 1995); Kerr et al., 1992; Subdi, 1997. In most cases, the delay from optimum planting date can be caused by changes in environmental conditions during grain filling with water stress and temperature rise (Ferrise et al., 2010), the weakness and vulnerability of root system (Waines and Ehdaie, 2001), shortening the period before pollination, beginning early reproductive stage, lack of photosynthetic resources (Foulkes et al., 2004) and changes in dry matter content in the pollination stage (Waines and Ehdaie, 2001). Spike density per unit area is one of the of the factors affecting grain yield. The results show that by increasing the density of wheat spikes per square meter, yield increases significantly and linearly ($p<0.01$). Among the variables examined in the table (1), removable spike density had the highest proportion (32.7%) in creating the gap between the actual yield and attainable yield. Spike Density in wheat is mainly affected by planting date. The data obtained in the field survey showed that wheat farmers who planted on an optimal date (from 15 November to 15 December) had more spike density and greater yield. Performance model output suggests that if farmers planted on 20th of November (50 days after September, the yield would increase 345.57 kg per hectare. low density of plants is responsible for 32.7 per cent of the yield gap from the whole yield gap 757.52 kg per ha). According to Figure 4 spike density significantly affected yield, so that 56 percent of the variation in performance among farmers is explained. The average removable spike density in land was examined as 470.6 plants per square meter. If by using appropriate methods for the preparation of litter, planting timely and optimal weather conditions and soil density removable spikes to more than 650 plants per square meter increase. If by using appropriate methods for the preparation of plant, optimal planting time , suitable weather conditions and soil , removable spike density increases to more than 650 plants per square meter, yield will increase 757.72 kg per hectare.

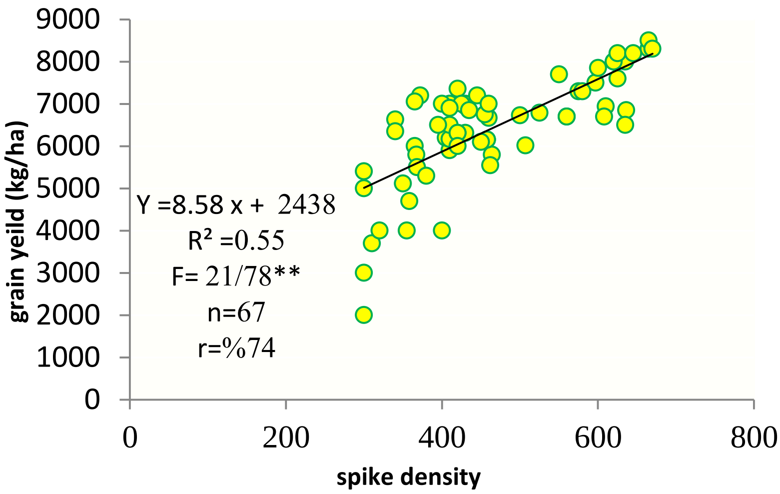

Figure 4. Spike density regression relationship with grain yield in agricultural farms

Bed unfit seed sowing, increasing the number of operations to prepare the land, unfavorable weather conditions in December, including lowering the temperature, increasing the length of time which takes to germinate due to delayed planting and adverse weather conditions leads to smaller and weaker tillers in the fall. Tillers created in the spring have smaller share on their performance compared to a loss of tillers in the winter. Many researchers agreed on this. Late planting and unfavorable weather conditions, flowers and land compaction, reduces wheat density (Singh et al., 2011). Tenyokago and Gardner (quoted by Tahernia, 2009) stated that since the high density of plants better covers the field and make up closed vegetation , the plants can use the maximum environmental resource and contributors. As a result, they produce more index leaf area per unit followed by absorption of photosynthetically active radiation in the vegetation dense and photosynthesis rate increases. Zhou et al., (2012) introduced the corn remains as the main cause of inappropriate bed preparing for wheat. Failure to use appropriate technology (Erenstein, 2012) In these circumstances, poorly controlled irrigation due to failure of infrastructure (Liang et al, 2011), reduces germination which ultimately reduces the optimum density of plants (Singh et al., 2011). Delayed wheat planting increases the number of days for germination from 7 days to 13 days under normal conditions (Hongyong et al., 2007) and by reducing the temperature necessary for the completion of plant growth (Wysocki and Cro, 2006) affect the potential wheat yield. Nitrogen use efficiency is one of the breeding objectives for sustainable agriculture. From the agricultural perspective, nitrogen use efficiency is the increase in the yield per unit of nitrogen fertilizer (Hirel et al., 2007). Simultaneity of plant need and urea consumption increases nitrogen use efficiency which can be done in different ways. Split application of urea fertilizer in wheat production has an important role in plant nutrition management strategy. High-performance, profitability and sustainability are the important effects of split application of urea fertilizer. Using urea in two or three phases, helps producers increase productivity of plants, increase yield and reduces wasting urea by leaching, volatilization and denitrification. According to figure (5 and 6) the range of nitrogen fertilizer use was 550 kg the fields. The region farmers have an average consumption of 356 kg urea fertilizer. According to the third quartile, 75 percent of farms had urea consumption of 450 kg. However, the harvest index of nitrogen on farms is low, and a significant portion of the nitrogen is lost. So split use of nitrogen fertilizer is an effective way to increase the efficiency of urea use which will significantly be effective in Disease Control and Prevention of water waste in irrigation of wheat, reducing the risk of freezing and ultimately increasing wheat yield.

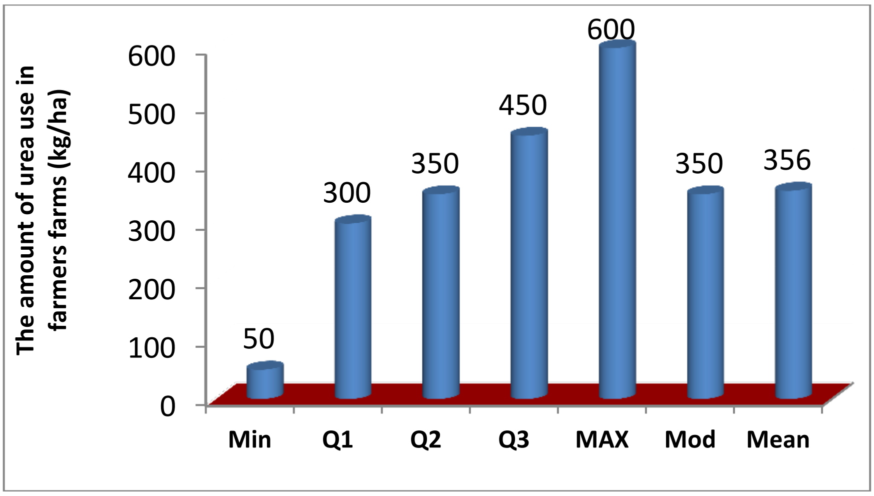

Figure 5. Consumption of urea fertilizer in the fields of selected farmers

Regression relationship of split urea fertilizer after planting reveals significant relationship between independent variable and yield in farmers' fields. Farms in which used urea fertilizer at right time and replications, had a higher yield (Figure 6).

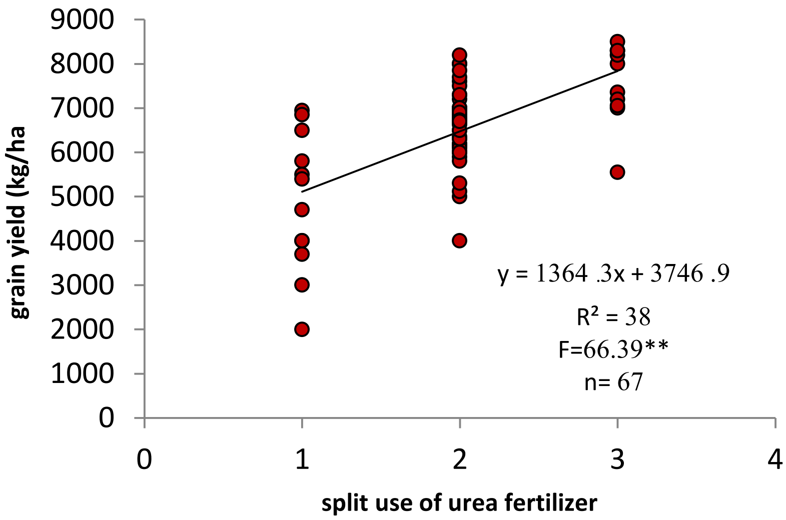

Figure 6. Regression relationship between split urea use and grain yield

Based on comparative analysis, the factors affecting the preparation of land were identified considering the estimated yield gap. Operations management of agricultural land (Chen et al., 2008), which in turn affects the management of water, machinery, density and row spacing is the result of inappropriate economic strategy in the implementation of incorrect crop rotation imposing the late planting of wheat in a bad weather conditions and low temperature to the farmers of the region. This increases in land preparation operations, especially secondary instruments traffic over the time of land preparation for wheat. In this case, not only planting operation in seed bed becomes difficult, but also reduces the number of germinated seeds, the number of tillers, the number of removable spikes, and ultimately the yield. Some researchers noted heavy traffic, increase the intensity of the physical structure of the soil, unsuitable and improper soil conditioning agent l, culture conditions as the factors affecting root growth and plant tissues (kay et al., 2006).

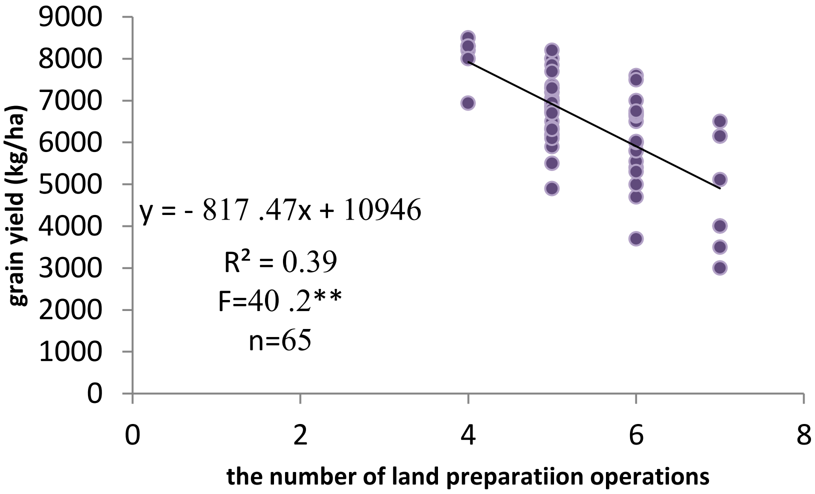

Figure 7. Regression relationship of the number of operation for preparation and grain yield of farmers' farms

Early Planting, suitable farm management (Anderson, 2010), results in reducing the number of operations for providing land, improved physical and chemical properties (Arvidsson et al., 2014; Romaneckas et al., 2012) of soil (Morris, et al., 2011; Rahman et al., 2008) and biological properties (Melero et al., 2009; Morris et al., 2010), environmental regulations and maintaining the optimum rate of nitrogen (Carver, 2010) . Besides improving soil structure, air and water infiltration and biological and microbial activities (Soane et al., 2012), reduces mineralization and increase soil organic carbon in the long-term which has impact on the activity of soil microbial biomass (Alvaro-Fuentes et al., 2013; Melero et al., 2011; et al., 2013 Swedrzynska et al., 2013; Carver, 2010). Timely planting wheat showed an increase of 30 percent compared to untimely planting. Figure (7) shows the regression relationship between land preparations and planting time which indicates the significant relationship between this independent variable and yield in agricultural fields. By increasing the number of operations, the yield is decreased. In this study, there was an inversely significant relationship between the farmer's experience and crop yield, which was probably due to the lack of updated information among experienced farmers. . It seems that the old farmers are more willing to traditional agriculture compared to farmers with less work experience. The average age of farmers was 47.52. Young farmers with a college education had more yield than old ones. According to Figure 8, product performance significantly decreased with increasing farmers' age and experience. Older farmers are more likely to use traditional methods and show less interest in application of new findings. If we assume that the age of a farmer is 32 years, probably the yield increases 97/331 kg ha due to the use of more scientific methods in production. Based on the variable of farmer's experience, wheat yield gap was 3.14 percent in this study. Nekahi and colleagues (2015) found similar results in Bandar Gaz in Golestan Province.

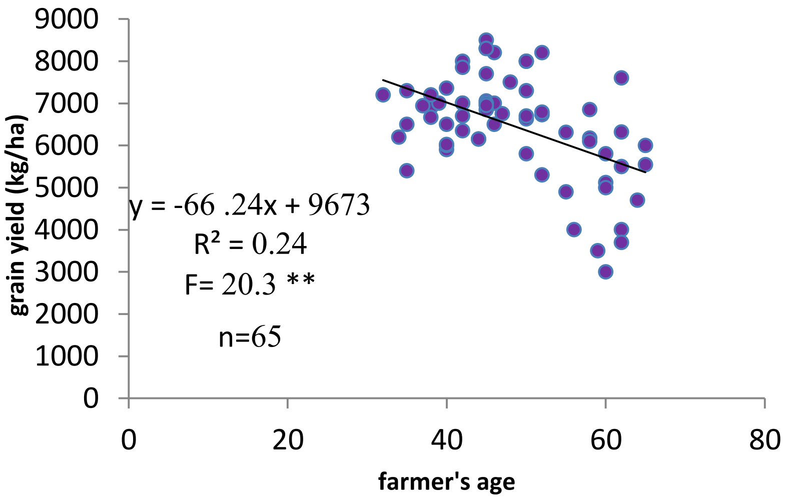

Figure 8. Regression relationship between age and experience of farmers with grain yield

Because of the sensitivity of cultivars to disease, especially Fozaryom and wheat rust in Moghan, yield is greatly affected by this variable. According to the survey on wheat and comparative analysis with stepwise regression method, frequency, type and dose of fungicides to control the disease had 13.4% rate of impact in controlling the diseases (Table 1 and Figure 9). Correlation between repeated fungicides and seed yield was 75% and farmers could successfully decrease yield gap by 311 kg by increasing the number of fungicide consumption. Figure 10 indicates a significant regression relationship between yield and grain yield and shows a growing function with the use of fungicides.

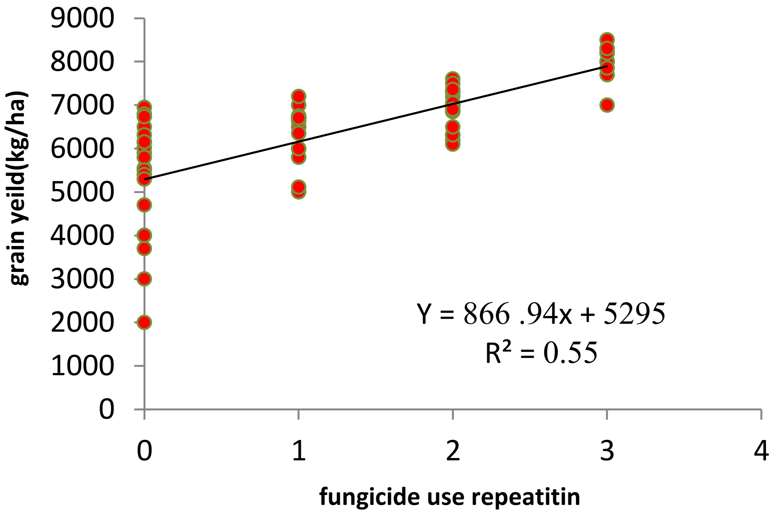

Figure 9. Regression relationship between repeatedly use of fungicides and yield in farmers' fields

CONCLUSIONS

According to the results presented above, the most important performance limiting factors can be summed up as follows:

Yield gap calculated for the selected Wheat cultivars in this project showed that there is an average yield gap of 29 percent (2300 kg) for these cultivars to which there can be a hope by Selecting the proper ways to crops production and breeding processes to fix the amount of wheat yield gap**.** Planting date is an efficiently functioning factor having impact on the other factors increasing yield gap in the area. By selecting suitable planting date, farmers can be hopeful to 15% of increase in yield per hectare. The optimum planting date in the area (Moghan) is from 15th of November to 15th of December**.** But it is better to start planting date from the first half of November and end on the first week of December. Density is one of the factors affecting the yield gap. Creating high density can be possible by planting date, genotype and seeding rate. In this way, we can create the appropriate density of 32.7 percent (757.72 kg per hectare) to reduce the yield gap in the area. Split application of urea fertilizer in wheat production has an important role in plant nutrition management strategy. High yield, profitability and sustainability are some of the important effects of split urea application. Using urea in two or three phases will help producers increase productivity of plants for nitrogen, increase yield and reduce waste in the form of urea fertilizer leaching, volatilization and denitrification. Based on production model, split use of fertilizer will increase yield by 20%, or 464.32 kg per ha. Compliance with appropriate crop rotation and diversification of cropping systems**,** Culturing conditions for preparing suitable land, reducing the number of operations prior to planting, lack of land compactness and using mechanized seeds planting in planting bed , proper depth, the percentage of high germination, density, Microbiological changes , positive reaction on root growth and disease control , controlling diseases and incompatibility between plant species especially weed control can lead to yield increase. Reducing the number of operations was effective in improving the yield gap at a rate of 4.6%. The cultivars used in Moghan are susceptible or moderately susceptible to Fusarium. The results showed that due to lack of genetic resistance to disease, by selecting suitable time, amount and type of fungicide used to control these diseases, we can be hopeful to partly chemical control methods, increase yield. Frequent use of appropriate fungicides was effective in controlling Fusarium with the rate of 13.4%. Farmers' experience is also one of the factors affecting the yield gap in Moghan. Old and experienced farmer more likely use traditional ways without regarding the recommendations of the technical experts while they should have updated information on to reduce yield gap**.**

REFERENCES

Alvaro-Fuentes, J., Morell, F. J., Madejón, E., Lampurlanés, J., Arrúe, J. L. and Cantero-Martínez, C. 2013. Soil Biochemical Properties in a Semiarid Mediterranean Agro-ecosystem as Affected by Long-term Tillage and N Fertilization. Soil. Till. Res., 129: 69-74.

Anderson W.K.2010. Closing the gap between actual and potential yield of rainfed wheats. The impacts of environment, management and cultivar. Faeld Crop Research 116, 14-22.

Arvidsson, J., Etana, A. and Rydberg, T. 2014. Crop Yield in Swedish Experiments with Shallow Tillage and No-tillage 1983–2012. Europe. J. Agron., 52: 307-315.

Carberry P.S., Bruce S.E., Walcott J.J. and Keating B.A. 2011. Innovation and productivity in dryland agriculture: a return–risk analysis for Australia. Journal of Agricultural Science 149, 77–89.

Carver M.2010. United Kingdom. Pp. 503-320 in world wheat book. Volume 1, ed. By A.P. Bonjean, W.J. Angus and M. van Ginkel. Lavoisier publishing: paris.

Chen C, Neill K, Wichman D, Westcott M, 2008. Hard red spring wheat response to row spacing, seeding rate, and nitrogen. Agronomy Journal 100: 1296-1302.

De Bie, C.A.J.M., 2000. Yield gap studies through comparative performance analysis of agro- cosystems. International Institute for Aerospace and Earth Science (ITC), Enschede. The Netherlands. 234 p.

effects on the yield of winter and spring wheat varieties results from the 2005-2006 cropping year. Agri. Res. 12(2): 72-74.

Ehdaie, B. and J.G. Waines (2001): Sowing date and nitrogen rate effects on dry matter and nitrogen partitioning in bread and durum wheat. Field Crops Res., 73: 47–61.

Erenstein O. 2012. Resource scarcity dradients and agriculyural technologies: Scoping implications in the post-green revolution Indo-Gangetic plains. Outlook on Agriculture 41, 87-95.

Ferrise, R., A. Triossi, P. Stratonovitch, M. Bindi and P. Martre (2010): Sowing date and nitrogen fertilization effects on dry matter and nitrogen dynamics for durum wheat: an experimental and simulation study. Field Crop Res., 117: 245-257.

Fischer, R.A., Byerlee, D., and Edmeades, G. O. 2009. Can Technology Deliveron the Yield Challenge to 2050? Expert Meeting on How to feed the Worldin 2050. Rome: Food and Agriculture Organization of the United Nations, Economic and Social Development Department

Flowers, M., C. James, S. Petrie, S. Machado, and K. Rhinhart. 2006. Planting date and seeding rate

Foulkes, M.J., R. Sylvester - Bradley, A.J. Worland and J.W. Snape (2004): Effects of a photoperiod- response gene Ppd-D1 on yield potential and drought resistance in UK winter wheat. Euphytica., 135: 63-73.

Godfray HCJ, Beddington JR, Crute IR, Haddad L, Lawrence D, Muir JF, et al. Food security: the challenge of feeding 9 billion people. Science. 2010; 327(5967):812–818.

Heidar Sharifabad. H. 2016. Crop yiela global food security.

Hirel B[1], Le Gouis J, Ney B, Gallais A.2007. The challenge of improving nitrogen use efficiency in crop plants: towards a more central role for genetic variability and quantitative genetics within integrated approaches. J Exp Bot. 58(9):2369-2387

Hongyong, S., X. Zhang, S. Chen, D. Pei, and C. Liu. 2007. Effect of harvest and sowing time on

Ibrahim O. H. 1995. Effects of Sowing Dates on Growth and Yield of Wheat. Annual Reports 1994/1995, Hudeiba Research Station, ARC, Sudan

Ittersum van, Cassman M K, Grassini K G, Wolf P, Tittonell, P J and Hochman Z 2013 Yield gap analysis with local to lobalrelevance—a review Field Crop. Res. 143 4–17.

Kay B.D., Hajabbasi M.A., Ying J and Tollenaar M. 2006. Optimum versus non- limiting water contents for foot growth, biomass accumulation, gas exchange and the rate of development maize (zea mays l.). Soil &Tillage Research 88, 42-54.

Kayiranga, D., 2006. The effects of land factors and management practices on rice yields. nternational Institute for Geo-Information Science and Earth Observation Enschede (ITC). The Netherlands. 72 p.

Kerr N. J., K. H. Siddique and R. J. Delane. 1992. Early Sowing With Wheat Cultivars of Suitable Maturity Increases Grain Yield of Spring Wheat in a Short Season Environment. Australian Journal of Experimental Agriculture. 32: 717 – 733

Kiani, M., Badavi, A., and Movahedi Dehnavi, M. 2012. The interaction effect of planting date and weed on yield and yield components of three Varieties of white beans in Semirom. J. Crop Prod. Proc. 2: 3. 17-29.

Lambin E F and Meyfroidt P 2011 Global land use change, economic globalization, and the looming land scarcity Proc. Natl. Acad. Sci. 108 3465–72.

Liang W-L., Carberry., Wang G-Y., Lu R-H., Lu H-Z. and Xia A-H. 2011. Quantifying the yield gap in wheat-maize cropping systems of the Heberi plain. Field Crops Research 124, 180-185.

Lobell D.B., Cassman K.G. and Field C.B. 2009. Crop yield gaps: their importance, magnitudes, and causes. Annual Review of Environmental Resources 34, 179–204.

Melero, S., Panettieri, M., Madejón, E., Gómez Macpherson, H., Moreno, F. and Murillo, J. M. 2011. Implementation of Chiselling and Mouldboard Ploughing in Soil after 8 Years of No-till Management in SW, Spain: Effect on Soil Quality. Soil Till. Res., 112: 107-113.

Melero, S., Vanderlinden, K., Ruiz, J. C. and Madejón, E. 2009. Soil Biochemical Response after 23 Years of Direct Drilling under a Dryland Agriculture System in Southwest Spain. J. Agric. Sci., 147: 9-15. 29.

Morris, N. L., Miller, P. C. H., Orson, J. H. and Froud-Williams, R. J. 2010. The Adoption of Non-inversion Tillage Systems in the United Kingdom and the Agronomic Impact on Soil, Crops and the Environment: A Review. Soil Till. Res., 108: 1-15.

Mueller ND, Gerber JS, Johnston M, Ray DK, Ramankutty N, Foley JA. Closing yield gaps through nutrient and water management. Nature. 2012; 490(7419):254–257.

Nassiri mahalati, M., and A. Koocheki. 2009. Agroecological zoning of wheat in Khorasan provinces: Estimating yield potential and yield gap. Iran. J. Field Crop Res. 7: 695-709.

Nekahi.M.Z., Soltani. A., Siahmargoie. A., Bagerani. N. 2015. Yield gap associated with crop management in wheat (Case study: Golestan province-Bandar-gaz). EJCP., Vol. 7 (2): 135-156

Neumann K, Verburg PH, Stehfest E, Müller C. The yield gap of global grain production: A spatial analysis.Agr Syst. 2010; 103(5):316–326

Normohamadi, Gh., Siyadat, A., and Kashani, A. 2001. Agriculture, Volume 1(Grain). hahid Chamran University Press. 446p.

Pradhan, R., 2004. The effect of land and management aspects on maize yield. International Institute for Geo-Information Science and Earth Observation Enschede (ITC). The Netherlands. 52 p.

Rahman, M. H., Okubo, A., Sugiyama, S. and Mayland, H. F. 2008. Physical, Chemical and Microbiological Properties of an Andisol as Related to Land Use and Tillage Practice. Soil Till. Res., 101: 10-19.

Rajapakse, D.C. 2003. Biophysical factors defining rice yield gaps. International Institute for Geo-Information Science and Earth Observation Enschede (ITC). The Netherlands. 80p.

Ray D.K., N.D. Mueller, P.C. West, J.A. Foley 2013. Yield Trends Are Insufficient to Double Global Crop Production by 2050. PLoS ONE 8(6): e66428. doi:10.1371/ journal.pone.0066428.

Rezaie, A., and Soltani, A. 2007. An Introduction to Applied Regression Analysis. Isfahan University of Technology Press. Isfahan. Iran. P: 294. (In Persian)16.

Romaneckas, K., Avižienyte, D., Šarauskis, E., Martinkus, M., Pilipavicius, V., damaviciene, A. and Sakalauskas, A. 2012. Impact of Ploughless Tillage on Soil Physical Properties and Winter Wheat Productivity. J. Food Agric. Environ., 10: 501-504.

Sharma R.C., Crossa J., Velu G., Hueta-Espinoza J., Vargas M., Payne T.S. 2012. Genetic gains for grain yield in CIMMYT spring bread wheats across international environments. Crop Science 52, 1522–1533.

Singh R.P., Hodson D.P., Huerta-Espino J., Jin Y., Bhavani S., Njau P., Herrera-Foessel S.et al.2011. The emergenc of Ug99 races of the stem rust fungus is a threat to world wheat production. Annual Review of phytopathology49, 465-481.

Soane, B. D., Ball, B. C., Arvidsson, J., Basch, G., Moreno, F. and Roger-Estrade, J. 2012. No-till in Northern, Western, and South-western Europe: A Review of Problems and Opportunities for Crop Production and the Environment. Soil Till.Res., 118: 66-87.

Subdi K. D., C. B. Budhathoki, M. Subedi, and D. G. C. Yubak. 1997. Response of Wheat Genotypes to Sowing Date and Boron Fertilization Aimed at Controlling Sterility in Rice – Wheat Rotation. Nepal Kluwer Journals, Plant and Soil. 188 (2): 249 -256.

Swedrzynska, D., Małecka, I., Blecharczyk, A., Swedrzynski, A. and Starzyk, J. 2013. The Effect of Various Long-term Tillage Systems on Some Chemical and Biological Properties of Soil. Pol. J. Environ. Stud., 22: 1835-1844.

Taherniaie Mojdehi, S. 2009. The effect of planting date and plant density on yield and quality of effective materials of Silybum marianum. M.Sc. Thesis, Faculty of Agriculture, Gilan University. 107p.

the performance of the rotation of winter wheat – summer maize in the North China Plain.Industrial Crops and Products. 25: 239-247.

Tilman D, Balzer C, Hill J, Befort BL. Global food demand and the sustainable intensification of agriculture.Proc Natl Acad Sci USA. 2011; 108(50):20260–20264.

Torabi, B., Soltani, A., Galeshi, S., and Zeinali, E. 2011. Analyzing wheat yield constraints in Gorgan. EJCP. 4: 1-17.

Trethowan R.M., Morguonove A., He Z-H., De Pauw R., Crossa J., Warburton M. et al.2006. The global adaption of bread wheat at high latitudes. Erphytica 152, 303-316.

van Ittersum M K, Cassman K G. 2013. Yield gap analysis—Rationale, methods and applications—Introduction to the Special Issue. Field Crops Research, 143, pp.1-3.

winter wheat seeding rates. Pages 103-110 in Oregon Agricultural Experiment Station Special. Report 1068.

Wysocki, D and M. Cro. 2006. Using seed size, planting date, and expected yield to adjust dryland

Zhou Y., Zhu H.Z., Cai S.B., He Z-R., Zhang X.K., Xia X.C. et al. 2007. Genetic improvement og grain yield and associated trait in southern Chain winterwheat region: 1949 to 2000.

Zia – ul – Hassan M., A. J. Wahla, M. Q. Waqar and A. Ali. 2014. Influence of Sowing Date on the Growth and Grain Yield Performance of Wheat Varieties under Rainfed Condition. Sci. Tech. and Dev.33(1): 22- 25.