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Estimating Yield Gap of Wheat (*Triticum aestivum* L.) using the Comparative Performance Analysis (CPA) Method in the Bam, Narmashir and Fahraj Counties of Kerman Province

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ABSTRACT

Background: Yield gap is distance between potential yield and attainable yield (yield gap= potential yield-attainable yield) in order to increase the crop yield and the goal of sustainable agriculture.

Methods: This study was conducted in Bam, Narmashir and Fahraj counties in 219 separate farms (79 farms in Bam, 72 farms in Narmashir and 68 farms in Fahraj) during the years 2019 and 2020 to investigate the yield gap of wheat and determine the limiting factors and their contributions to yield reduction, using the Comparative Performance Analysis (CPA) method. All information related to soil factors, management factors, climatic factors and agronomic traits (53 variables) were measured and recorded. The relationship between wheat yield and all variables was examined using a stepwise multiple regression method. A production model was determined for soil and management factors.

Result: The results showed a yield gap between actual yield and potential yield in the regions of Bam, Narmashir and Fahraj, which were 1770.8, 1817.61 and 1605 kg per hectare, respectively. Since the actual yield in these regions was 4248, 4228 and 3161 kg per hectare, the yield gap was observed to be 33.6%, 30% and 29.4%, respectively. The effective factors in reducing the yield in the Bam region included water shortage (19.48%), nitrogen deficiency (16.09%), delayed planting (15.40%), soil available phosphorus deficiency (10.14%), weed density (10.8%), soil organic carbon (13.59%) and inappropriate plant density (14.47%). In the Narmashir region, water shortage (26.68%), nitrogen deficiency (18.86%), soil organic carbon (11.78%), inappropriate plant density (12.43%), wheat aphid (19.58%) and weed density (10.64%) caused yield reduction. In the Fahraj region, water shortage (20.65%), nitrogen deficiency (19.62%), delayed planting (9.44%), soil available phosphorus deficiency (8.45%), weed density (12%), soil salinity (12.80%) and black stem disease (17%) caused a decrease in wheat yield.

Key words: CPA, Wheat, Yield gap, Yield potential.

INTRODUCTION

To meet the energy need of the ever growing world's population, wheat (*Triticum aestivum* L.) is the second most widely gowned cereal after rice in the world (Gupta *et al.,* 2019). If the required water and nutrients for the plant are fully provided and the growth environment is free of any weeds, pests, or diseases, the growth rate of the product is determined by environmental factors such as the amount of solar radiation, temperature and CO_2 concentration, as well as the plant's characteristics or agricultural variety. Yield under these conditions is called potential yield. Achieving this level of yield under field conditions is difficult and requires proper management practices. "A subset of limiting factors, including improper irrigation, unsuitable variety and density, deficiency of macro and micro fertilizers, delayed planting and reducing factors such as pests, diseases and weeds, affect growth and reduce the actual yield to a much lower level than its potential. Therefore, the difference between potential yield and actual yield, which is referred to as limitation or yield gap, includes a set of factors that are the target of agricultural management and research to control them, which can increase farmers' productivity, improve their livelihoods and achieve self-sufficiency (Naghashzadeh *et al.,* 2014).

The surest and fastest way to increase farm yield is to reduce e the yield gap in order to create a more coordinated farm performance level with current capacity levels.

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The most obvious strategy for reducing the yield gap quickly is to improve agricultural management through millions of smallholder farmers with low yield. Undoubtedly, accepting new technologies (such as small-scale machinery, plant nutrition management, weather forecasting, integrated pest and disease control and breeding) and reducing the yield gap is one of the important factors in increasing farm yield in the country. The greatest opportunity to increase farm yield is to speed up the reduction of the yield gap Naghashzadeh *et al.* (2014). Various methods have been used to analyze data and identify factors contributing to yield gaps, including the Boundary Line Analysis Hajjarpour *et al.* (2017), the Analytical Hierarchy Process (AHP) and the Comparative Performance Analysis (CPA). CPA is a method used to quantify yield gaps (Soltani, 2007) by determining the primary performance limitations and quantified functions for yield gaps. With the use of multiple regression and a step-by-step approach, performance limitations are determined and, ultimately, a production model is established using the CPA method. By using the production model and parameter values, the contribution of each limitation to the yield gap is determined (Alasti, 2020).

Given the importance of wheat self-sufficiency in the Iran country, Bam county is also considered one of the wheat-producing regions, with over 3,000 hectares of land under wheat cultivation. However, no research has been conducted on the yield potential of wheat and the limiting factors in this region using the CPA (Comparative Performance Analysis) method. The aim of this study is to identify the main limiting factors of wheat production in the regions of Bam, Narmashir and Fahraj and to determine the contribution of each factor to yield gap. This will help farmers in these areas to increase wheat production by identifying and introducing these factors and addressing them. The development of this research can contribute to the increase in production of this strategic crop and the country's self-sufficiency in wheat production.

MATERIALS AND METHODS

Bam county has an area of 5175 square kilometers and is located at longitude 58,21′, 25″ and latitude 29,6′, 22″, with an elevation of 1061 meters above sea level. The average annual rainfall is 54 millimeters, the mean temperature is 23.5°C, with an absolute maximum of 47.6 and an absolute minimum of -8.6°C.

Narmashir county has an area of 2993 square kilometers and is located at longitude 58,42′,12″ and latitude 28,57′,7″, with an elevation of 757 meters above sea level. The average annual rainfall is 43 millimeters, the mean temperature is 24°C, with an absolute maximum of 47.8 and an absolute minimum of -2.8°C.

In addition, Fahraj county has an area of 4558 square kilometers and is located at longitude 58,53′,23″ and latitude 28,56′,54″, with an elevation of 670 meters above sea level. The average annual rainfall is 38 millimeters, the mean temperature is 2.25°C, with an absolute maximum of 49.2 and an absolute minimum of -6.6°C. The main water sources in these areas are seasonal rivers, including Adori and Nesa, which some of the wheat farms benefit from. Nearly 60% of the population in these areas are rural residents engaged in agriculture and animal husbandry activities. These areas have a hot and dry climate.

In this study, information related to soil factors, management factors, climatic factors and agronomic traits of 219 farms were collected. Soil information included EC, pH, organic carbon, total nitrogen, available phosphorus, available potassium, clay percentage, sand percentage, silt percentage and soil texture. This information was obtained by soil sampling from a depth of 0-30 cm and preparing a composite sample for each farm and sending them to the soil laboratory. Management information included land preparation method (plowing, harrowing, or no-till), planting time, planting method, amount and timing of nitrogen, phosphorus and potassium fertilizer use, pest type and control method, disease type and control method, weed type and control method, irrigation frequency and amount, irrigation method, harvest time and harvest method. Climatic factors information included daily minimum and maximum temperatures, sunshine hours and rainfall, which were collected from weather stations in the areas. Agronomic trait information included podding date, stem date, pollination date, ripening date, number of pods per plant, number of fertile spikes per square meter, plant height, spike length, number of grains per spike, thousand-grain weight, biological yield and grain yield. These data were measured, recorded and analyzed.

Statistical analysis

To determine the performance model (production model) based on soil and farm management factors, the relationship between all measured variables was determined. Qualitative variables were coded, such as pest control method (1= had control, 0 = did not have control) and some, such as pest type, had four categories "Without damage (0), pest age (1), bird attack (2), black disease (3) and yellow rust (4) were coded. For each region, the performance model was calculated using the stepwise regression method and then by placing the mean of each variable observed among the farms examined in the performance model, the average performance was calculated. Then, by placing the highest value of the variables in the performance model, the potential performance was calculated. The difference between these two indicates the yield gap, which is the difference obtained by multiplying the average observed value for each variable in its coefficient with the product of the highest value for the same variable in its coefficient, indicating the amount of yield gap created by that variable. The ratio of the yield gap for each variable to the total yield gap indicates the share of that variable in creating a performance decrease, which is expressed as a percentage (Soltani, 2007). SPSS software was used for data analysis and Excel software was used for plotting graphs.

RESULTS AND DICUSSION

The stepwise multiple regression analysis showed that among the independent variables entered to select the final model generated in the Bam region, seven variables, including irrigation, nitrogen fertilizer consumption, delay in planting, available soil phosphorus, weed density, soil organic carbon and plant density per square meter, are the most influential independent variables affecting changes in seed yield (Function 1)."

$$Y=1540.2+2.3x_1+1.9x_2-24.8x_3+119x_4-9.81x_5+225x_6+2.33x_7 \quad R^2= 0.71$$

In which

Y= Grain yield (kilogram per hectare).

x_1= Irrigation.

x_2= Nitrogen fertilizer consumption.

x_3= Delay in planting.

x_4= Soil-available phosphorus.

x_5= Weed density.

x_6= Soil organic carbon.

x_7= Bush density.

In the Narmashir region, six variables including irrigation, nitrogen fertilizer consumption, soil organic carbon, bush density, wheat pest and weed density were the most influential independent variables affecting grain yield changes (Function 2).

$$Y=1836.2+2.88x_1+3.1x_2+340x_3+2.4x_4-20.7x_5-9x_6 \quad R^2= 0.68$$

In which

Y= Grain yield (kilogram per hectare).

x_1= Irrigation.

x_2= Nitrogen fertilizer consumption.

x_3= Soil organic carbon.

x_4= Bush density.

x_5= Wheat pest.

x_6= Weed density.

In the Fahraj region, seven variables including irrigation, nitrogen fertilizer consumption, delay in planting, soil-available phosphorus, weed density, soil salinity and black rust disease were the most influential independent variables affecting grain yield changes (Function 3).

$$Y= 2743.58+1.5x_1+2.1x_2-10.83x_3+73x_4-11.2x_5-180.3x_6-14x_7 \quad R^2= 0.65$$

In this equation,

Y= Represents the grain yield (kilograms per hectare).

x_1= Irrigation amount.

x_2= Amount of nitrogen fertilizer used.

x_3= Delay in planting.

x_4= Available soil phosphorus.

x_5= Weed density.

x_6= Soil salinity.

x_7= Damage caused by the black stem disease.

Yield gap and percentage share of each constraint

Bam region

The results shows the estimated yield gap and the percentage share of each constraint in creating the yield gap in the Bam region (Table 2). Using the production equation and variable data (Function 1), the average and best values for each variable were obtained. The estimated yield gap was based on comparing the average yield level with the best yield obtained from the desired farms. According to Table 1, the estimated average grain yield by

Table 1: Average monthly minimum, maximum, sunny hours and rainfall in studied region.

City	Month	Min temp (°C)	Max temp (°C)	Rainfall (mm)	Sunny hours
Bam	November	15.8	28.4	0	8.9
	December	7.9	19.4	0	7.2
	January	8.5	21.6	1	7.7
	February	8.8	20.7	1.3	7.1
	March	15.4	27.3	10.8	7.7
	April	19.3	31.5	9.8	8.2
	May	22.4	34.5	1	9.1
Narmashir	November	12.6	30	0	9
	December	4.3	20.8	0	7.5
	January	4	23	0.1	8
	February	5.3	22.3	0	7.6
	March	12.2	28.8	1.8	7.9
	April	16.9	33.1	3.3	8.6
	May	20.8	36.1	0	9.5
Fahraj	November	13.3	30.2	0	9.2
	December	4.5	20.6	0.2	7.5
	January	4.3	22.5	0	8
	February	5.6	22.6	0	7.8
	March	12.6	29.2	1.4	8.1
	April	17.4	33.3	5.2	8.9
	May	21.6	36.7	0	10

this model is 4248.91 kilograms per hectare, while the best estimated yield is 6019.75 kilograms per hectare.

The estimated yield gap is 1770.80 kilograms per hectare and the percentage share of each factor contributing to this reduction is as follows:

Irrigation water shortage (19.48%), decrease in nitrogen use (16.09%), delay in planting (15.40%), insufficient available soil phosphorus (10.14%), weed density (10.8%), soil organic carbon (13.59%) and inappropriate plant density 14.47% (Table 2).

Narmashir region

The estimated average grain yield by the production function (Function 2) in Narmashir Region was 4228.82 kilograms per hectare and the best estimated grain yield was 6046.43 kilograms per hectare (Table 3). The predicted yield gap was 1817.61 kilograms per hectare and the contribution of each factor causing this reduction is as follows:

Irrigation water shortage (26.68%), Decreased nitrogen consumption (18.86%), Soil organic carbon (11.78%), Inappropriate plant density (12.43%), Wheat stem pests (19.58%) and Weed density 10.64% (Table 3).

Fahraj region

The yield gap in the Fahraj region was calculated to be 1605.08 kilograms per hectare (Table 4). Based on the production function (Function 3), the average and maximum wheat yield in this region were estimated to be 3198.98 and 4767.06 kilograms per hectare, respectively. The results indicated that the share of each of the limiting factors in this region included irrigation water (20.65%), nitrogen deficiency (19.62%), delayed planting (9.44%), insufficient available phosphorus (8.45%), weed density (12%), soil salinity (12.80%) and black rust disease (17%) (Table 4).

Water shortage was one of the important and influential factors on wheat grain yield in this experiment. The average contribution of water shortage to yield gaps was estimated at 21.67% in the three regions under study. Hajapour *et al.* (2017) reported that in the Golestan region, 27% of the yield gap in wheat yield was attributed to irrigation in irrigated areas using the Comparative Performance Analysis (CPA) method. Koocheki *et al.* (2017) also stated that irrigation with a regression coefficient of 0.98 and chemical fertilizers with a regression coefficient of 0.49 had the greatest effect on reducing wheat yield gaps.

Table 2: Quantification of wheat yield gap in Bam region.

Variables	Coefficient	Variable value				Yield calculated by model		Yield gap	
		Min	Max	Average	Optimum amount	Average	Optimum amount	Amount (kg/ha)	%
Intercept	1540.2			1	1	1540.2	1540.2		
Water deficiency	2.3	340	580	430	580	989	1334	345	19.48
Nitrogen deficiency	1.9	45	300	150	300	285	570	285	16.09
Delay planting	-24.8	0	25	11	0	-272.8	0	272.8	15.40
Lack of absorbable phosphorus	119	4.23	8.45	6.94	8.45	828.86	1005.5	179.69	10.14
Weed	-9.81	0	50	19.5	0	-191.295	0	191.30	10.80
Organic carbon	225	0.16	1.8	0.73	1.8	164.25	405	240.75	13.60
Improper plant density	2.33	350	500	390	500	908.7	1165	256.3	14.47
Actual yield (kg/ha)				3550	6272				
Estimated yields (kg/ha)						4248.91	6019.75		
Estimated yield gap (kg/ha)								1770.83	100

Table 3: Quantification of the yield gap in wheat production in Narmashir region.

Variables	Coefficient	Variable value				Yield calculated by model		Yield gap	
		Min	Max	Average	Optimum amount	Average	Optimum amount	Amount (kg/ha)	%
Intercept	1836.2			1	1	1836.2	1836.2		
Water deficiency	2.88	356	564.04	395.6	564.04	1139.3	1624.43	485.10	29.67
Nitrogen deficiency	3.1	50	300	189.4	300	587.2	930	342.83	18.86
Organic carbon	340	0.23	1.51	0.88	1.51	299.2	513.4	214.2	11.78
Improper plant density	2.4	324	476	381.8	476	916.46	1142.4	225.93	12.43
Sunn pest	-20.7	0	50	17.2	0	-356.04	0	356.04	19.59
Weed	-9	0	50	21.5	0	-139.5	0	193.5	10.64
Actual yield (kg/ha)				3550	6272				
Estimated yields (kg/ha)						4228.42	6046.43		
Estimated yield gap (kg/ha)								1817.61	100

Given the role and importance of water in all stages of germination, growth, photosynthesis, material transfer, chemical reactions, transpiration, *etc*., water scarcity severely affects the yield of plant grains (Noori and Safari, 2017). Therefore, ensuring the necessary water supply for agricultural plants is one of the important factors in agricultural management, which can be achieved through determining irrigation methods, determining the water needs of agricultural plants, using improved cultivars with higher water use efficiency and higher yield index, reducing or eliminating irrigation water losses, controlling runoff from fields, providing timely water supply to agricultural plants, using more effective irrigation methods, using appropriate planting dates, improving planting time and growth period of plants and improving their efficiency.

According to the results of stepwise regression analysis, the amount of nitrogen fertilizer consumption with an average share of 16.18% was identified as one of the important managerial factors affecting grain performance. Nitrogen is one of the major elements required by agricultural plants and its deficiency restricts the growth of roots, stems, leaves, flowers and fruits, causing stunted growth and smaller plants. (Soltani, 2007) showed, based on the CPA method and information obtained from 95 wheat farms, that the amount of nitrogen fertilizer consumption contributed to a 61% yield gap. Hajarpour *et al*. (2017) reported that in irrigated wheat cultivation in the Golestan province, suboptimal nitrogen fertilizer use was responsible for a 25% yield gap in irrigated conditions, a 9% yield gap in low-yield dryland and a 15% yield gap in high-yield dry conditions. In their analysis of limiting factors affecting wheat performance in Gorgan Torabi *et al.,* (2011) stated that the amount of nitrogen fertilizer used after planting had a significant 18% impact on yield gap. Additionally, leaf area index, chlorophyll index during pollination and the amount of total nitrogen absorbed by the plant are all influenced by nitrogen fertilizer management. Therefore, the amount of potassium consumption, nitrogen nutrition management and planting date are respectively the most important factors in creating yield vacuum, with 20%, 61% and 19% impact.

The plant's nitrogen requirements depend on the maximum weight (biomass) and critical nitrogen concentration of the plant. Most of the nitrogen consumed in plants is in the form of protein (85%), nucleic acids (5%), organic solutes (less than 5%), nitrate (less than 1%) and ammonium (less than 0.1%). Nitrogen is one of the necessary elements for the production of the enzyme Rubisco, which has a vital role in plant photosynthesis and its synthesis disruption impairs the production of dry matter in plants.

The nitrogen concentration in wheat leaf blades is 52-43 (g/kg) during tillering, 42-36 (g/kg) during stem elongation and 30-27 (g/kg) during flowering. Nitrogen forms 2 to 7% of the dry weight of plant seeds. During nitrogen deficiency, the growth ratio to tillers increases and wheat reduces its leaves. Nitrogen limitation during flowering reduces the number of seeds in wheat plants. The slow growth of plants due to nitrogen deficiency during flowering results in a lower number of grains on each wheat spike. Reducing the number of grains due to nitrogen deficiency before flowering results in a desirable ratio of source to sink during grain filling. Grain filling is dependent on carbohydrates and proteins, which are transported from the plant's vegetative organs and photosynthesis after flowering, as well as nitrogen uptake by roots. Therefore, using varieties with high nitrogen use efficiency, delaying the use of nitrogen fertilizers, applying nitrogen fertilizer based on plant requirements in several stages, using nitrogen fertilizers based on soil tests prior to planting, using animal manure, crop rotation, cover crops, preventing nitrogen loss through leaching and denitrification, timely planting, better water management in the soil, higher plant density per unit area, timely application of nitrogen fertilizer, spot application of nitrogen fertilizer and using nitrogen fertilizer based on leaf color are recommended.

The results of stepwise multiple regression analysis of soil factors and management showed that the organic carbon

Table 4: Quantifying the yield gap of wheat in the Fahraj region.

Variables	Coefficient	Variable value				Yield calculated by model		Yield gap	
		Min	Max	Average	Optimum amount	Average	Optimum amount	Amount (kg/ha)	%
Intercept	2743.85			1	1	2743.85	2743.85		
Water deficiency	1.5	383	640	419	640	628.5	960	331.5	20.65
Nitrogen deficiency	2.1	70	360	210	360	441	756	315	19.62
Delay planting	-10.83	0	30	14	0	-151.62	0	151.62	9.44
Lack of absorbable phosphorus	73	5.17	9.3	7.44	9.3	543.12	678.9	135.78	8.46
Weed	-11.2	0	50	17.2	0	-192.64	0	192.64	12
Soil salinity	-180.3	2.06	4.31	3.2	2.06	-576.96	-371.41	205.54	12.80
Common bunt disease	-14	0	50	19.5	0	-273	0	273	17
Actual yield (kg/ha)				3281	5147				
Estimated yields (kg/ha)						3161.98	4767.06		
Estimated yield gap (kg/ha)								1605.08	100

content is one of the important and effective factors on wheat yield, with an average contribution of 12.68% to yield gap in the two regions of Bam and Narmashir (Tables 2 and 3). The chemical composition of soil organic matter is approximately 50% carbon, 5% nitrogen, 0.5% phosphorus, 0.5% sulfur, 39% oxygen and 5% hydrogen. Organic matter is one of the important indicators of soil quality and is the heart of sustainable agriculture. Therefore, its management is of particular importance.

Gerke, (2022) reported a significant positive correlation between the amount of soil organic carbon and grain yield. Based on this, an increase of one gram of soil organic carbon per kilogram of soil resulted in an average increase of 286 kilograms per hectare in wheat grain yield.

Delay in planting was among other effective factors in yield reduction. The results showed that 15.40% and 9.44% of the yield reduction were due to inappropriate and delayed planting dates in Bam and Fahraj regions, respectively (Table 2 and 4). Yield reduction due to delay in wheat planting has been reported in many studies. (Sarlak and Alavi, 2021) reported in their study on the effects of planting date on wheat yield that delayed planting reduced the length of spike, number of spikelets per spike, number of grains per spike and thousand-grain weight. It seems that delay in planting reduces the growth period and causes the product to face unfavorable conditions at the end of the season, resulting in a decrease in yield. Therefore, determining and adjusting the appropriate planting date, especially in the Bam and Fahraj regions, can have a significant impact on improving yield by more than 12%.

Weeds were among the effective factors in reducing wheat yield. The results showed that in all three examined regions, weeds created an average of 6.10% yield loss (Table 2 and 3 and 4). Competition between weeds and crop plants for water, nutrients and light is one of the major reasons for the reduction of wheat performance. In addition to competition, the allelopathic effects of some weeds on seed germination of crop plants have also been reported Alipour *et al.* (2019). Studies have shown that significant damage from weeds can be prevented by implementing integrated management Khakzad *et al*. (2020). In this regard, the use of cover crops, changing planting patterns, using mulch and adjusting planting dates are recommended to reduce weed damage.

Improper plant density, especially in Bam and Narmashiraz regions, was another influential factor in yield loss, accounting for 14.47% and 12.43% yield loss in these areas, respectively (Table 2 and 3). Low density, especially, leads to inefficient use of radiation energy and other production factors such as water and soil minerals, ultimately resulting in reduced yield.

Reducing wheat plant density results in decreased competition power of the crop with weeds (Banisaeidi, 2020). Although wheat is capable of compensating for plant density reduction through tillering, it is recommended to determine the appropriate plant density at the time of planting for optimal use of production resources Rahnama *et al*. (2000). This is because the risk of not producing tillers or producing weaker tillers, which will result in unsatisfactory outcomes if tillering is postponed to achieve the appropriate plant density.

The factors of water shortage, nitrogen consumption, delayed planting, inappropriate plant density and soil organic carbon level were found to be effective in reducing the effective yield in all three examined regions. Some factors, such as soil salinity and Common Bunt disease (in the Fahraj region) and Sunn pest (in the Narmashir region), particularly affected the yield of the examined regions.

Based on the results obtained in the Fahraj region, one of the influential factors in the yield gap was the high concentration of soluble soil salts. This factor caused a 12.8% yield gap in this area (Table 4).

The composition of the parent rock, low rainfall and high evaporation and transpiration rates are effective in the high amount of soil salt (Omrani *et al*., 2022). Also, soil and groundwater salinization, caused by human activities such as deforestation, irrigation with un-drained saline water and insufficient flushing, can contribute to the problem. The main cations that cause salinity include sodium, calcium and magnesium and the anions include chloride, sulfate and bicarbonate (Hussain *et al.,* 2015). In order to reduce the adverse effects of soil salinity in the region, proper irrigation management with high-salt water, improving drainage conditions, pre-planting seed treatments, the use of osmolytes and protectants, hormones, fertilizer management and the use of resistant varieties are recommended.

Common Bunt” disease, with a 17% reduction in yield under water and nitrogen deficiency, was the most effective factor in reducing wheat production in the Fahraj region (Table 4). Although the prevalence and spread of a specific disease in a particular area with specific climatic and agricultural management conditions are closely related, measurements during two years of testing showed that Common Bunt disease had a significant impact on wheat production reduction in the Fahraj region. The use of resistant varieties, seed treatment with fungicides and proper agricultural management are recommended to reduce the effect of this disease.

One of the important pests that had a significant impact on wheat yield reduction in the Narmashir region was the Sun pest. Data analysis showed that this pest caused a 19.58% yield loss in the Narmashir region (Table 3). Common Sun pest varieties have a high density and wide distribution on wheat fields in Iran Ma’mani *et al*. (2022). Based on surveys, it appears that high weed density, late planting and lack of crop rotation are among the main reasons for the significant damage caused by Sun pest in the region.

CONCLUSION

One of the ways to increase the yield crops is to calculate the yield gap, which with proper management and proper training can lead to global food security.

Conflict of interest

All authors declared that there is no conflict of interest.

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