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Effects of flooding and application time of thiobencarb herbicide efficacy in paddy rice

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Abstract

Background and objectives: Growth irregularity and yield reduction has been reported in some transplanted rice growing area treated with thiobencarb (TB) herbicide. This experiment was carried out in order to study the effect herbicide application time and flooding time on response of rice and weeds to TB doses.

Materials and methods: The experiment was laid out as a factorial split-plot in a randomized complete block design with three replications. Treatments included factorial arrangement of time of TB application (before and after transplanting) and time of flooding (before and after TB application) as main plot and TB doses (0, 1, 1.5, 3, 4.5 and 6 Kg.ai.ha^{-1}) as subplot.

Results: TB efficacy in barnyardgrass and sedges control 4 weeks after transplanting (WAT) was similar and in 6- WAT, TB efficacy on barnyardgrass control was better. Irrespective of time of TB application, the dosage required for 50 or 90% barnyardgrass or sedges biomass reduction was less if TB was applied before flooding compared with after flooding application, but TB selectivity on rice decreased in non-flooded treatments. In waterlogged soil that the experiment was carried out, TB caused 12% and 4% mortality of transplanted rice seedlings when TB was applied before and after flooding and also 9% and 5% if applied before and after transplanting respectively, which occurred in the highest investigated dose. Increasing TB dose up to 50 percent more than the recommended dose (3 Kg.ai.ha^{-1}), increased rice leaf area and further increasing the dose of herbicide despite better control of weeds, rice leaf area was reduced indicating the phytotoxicity of TB on rice. In general, rice produced 25 and 15% more LAI and tiller, by applying

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TB at flooded plots compared with non-flooded plots, respectively. Rice plant height response to TB dose and time of application was similar to leaf area and decreased more if herbicide was applied before flooding. Also fertile (panicle-bearing) and unfertile (nonpanicle-bearing) tillers were affected by time of flooding and TB dose, if applied after and before flooding the most fertile and unfertile panicles were produced, respectively. Grain yield, biological yield and harvest index trends were presented by three parameters Gaussian model ($R^2 \geq 84\%$). Based on these models, by increasing the TB rate these traits increased and then decreased, but reduction in lower doses of TB occurred if TB was applied before flooding.

Conclusion: TB cannot be recommended in paddy waterlogging soils if they are facing flooding limitation in early season when TB is applied. Despite better weed control in non-flooded treatments is obtained, TB causes delayed growth irregularity and yield reduction if fields are treated in non-flooded condition. Continuous application of TB in successive years exacerbated TB phytotoxicity.

***Keywords*:** Dose, Herbicide, rice, Thiobencarb, Water shortage.

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Calibration and Evaluation of the CERES-Maize model in Gorgan climatic conditions

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Abstract

Background and objectives: Sowing date and irrigation are two constrain factors for maize production, thus before sowing, it is necessary to know about crop yield responses to sowing date and water stress. These factors can be simulated using CERES-Maize model. This experiment wasaimed to calibrate and evaluate the CERES-Maize model in Gorgan climatic conditions.

Materials and methods: For this purpose, two experiments (each one at two years) were carried out at agricultural research station of Gorgan, Golestan Province . SC.704 as a commercial late-maturing hybrid (MO17 ×B73), is known as the best maize hybrid is planting in different parts of Iran as well as Golestan province. The first experiment was performed within a three-replicated randomized complete block design during two years (2012 and 2013). The factors included three sowing dates (22 June, 6 July and 21 July) and four irrigation regimes based on maximum allowable depletion (MAD) of the total available soil water (TAW). Also the second experiment was conducted within a four-replicated randomized complete block design during two years (2007 and 2008). The factors included three sowing dates (7 April, 19 April, and 4 May) and two planting densities (6.5 and 8.5 plant m-^{2}). The data from 6.5 plant m^{-2} was used in this experiment. The model was calibrated using three treatments of optimum irrigation and with no-stress in 2012 and two treatments of the second experiment in 2007. Evaluation was done using planting date treatment (2008), planting date and deficit irrigation in 2012 and 2013.

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Results: The results of the model evaluation indicated that the model simulated phenological stages (anthesis day and maturity day) with high accuracy in different sowing dates and different irrigation regimes. The values of root mean square for anthesis and maturity dates were as 2.5 and 2.9 days, respectively. Therefore, this model could be used in field management planning. Also the results of evaluation base on spring sowing date (2008) and summer sowing dates (2012 and 2013) indicated that the model simulated dry matter and yield of maize with high accuracy. On the other hand, the model simulated dry matter and leaf area index (LAI) trend in different irrigation levels, but hadn't enough accuracy in terms of model statistical indices.

Conclusion: Referring to results of this experiment, the CERES-Maize model can be used in Gorgan climatic conditions for simulating the growing stages and grain yield of maize under favorable conditions.

***Keywords*:** Maize, Modeling, Sowing date, Low irrigation.

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Effects of irrigation and Super-absorbent hydrogels on morphological characteristics, yield and essential oil of anise (*Pimpinella anisum* L.)

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Abstract

Background and objectives: Anise (*Pimpinella anisum* L.) is an annual medicinal plant which belonged to the Apiaceace family. Grain is the most important organ to produce essential oil of anise. In order to produce medicinal plant it is necessary to determine the environmental factors under which they give higher yields and better quality. In medicinal plants, balanced fertilization using chemical and biological inputs has great effect on yield and phytochemicals related to yield production. Management practices and the use of advanced techniques for improvement in soil water-holding capacity are essential. Therefore the pot experiment was conducted to evaluate the effect of different levels of irrigation and superabsorbent hydrogel on morphological characteristics, yield and essential oil of anise.

Materials and methods: The experiments were designed as RCBD under factorial plot arrangement with three factors in Ramiyan (Golestan province) in 2013. The first factor included four irrigation levels (FC, 80%FC, 60%FC and 40%FC) and the second factor included three superabsorbent levels (0, 100 and 200 Kg ha^{-1}) on growth parameters of anise plant. The soil was Silty clay loam in texture and its chemical characteristics of the soil were EC; 0.91, pH; 8.1, %O.M; 1.04, %TNV; 17.70, B.D; 1.5, %F.C; 27.3, %N; 0.073, P_2O_5; 4.2 and some soluble cations were 200, 1, 0.5, 0.6, 0.5 meq L^{-1} for the K^+ , Fe^{2+}, Mn^{2+}, Zn^{2+} and Cu^{2+} respectively. Plant height, number of umbels, umbellets, harvest index, one thousand seed weight and plant yield were measured. After planting and harvesting operations and growth performance measurements, essential oil was dehydrated by distilled water method using Clevenger and Sodium sulfate.

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Results: The analysis of variance showed that there was significant effect of applied water and superabsorbent on all studied characteristics of anise. The interaction effects on all traits except harvest index had a significant impact. The highest plant height, number of umbels per plant, the number of umbellets, seed number, seed weight, seed yield, and oil percentage was observed in treatment with 100 Kg ha^{-1} Super-absorbent hydrogel and Field capacity (FC), and this treatment had statistically significant differences with 80% FC and 100 Kg ha^{-1} Super-absorbent hydrogel. Interaction effect of treatments on yield was not significant, but the effect of irrigation levels and superabsorbent polymer effect on seed yield was significant at 1% and 5% level, respectively.

Conclusion: The results of this test introduced the treatment, 80% of field capacity and 100 Kg of superabsorbent hydrogel as the best treatment in terms of economy because with lower consumption of water and polymer with the same amount of yield production compare with other treatment. Based on the results of this experiment and durability of hydrogel in soil could be concluded that application enough amount of hydrogel under full irrigation or drought stress condition increase income and yield.

Keywords: Anise, Essence, Irrigation levels, Super-absorbent hydrogel

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Effect of planting date on yield and yield components of *Silybum marianum* under Golestan climatic conditions

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Abstract

Background and objectives: Milk thistle (*Silybum marianum*), a medicinal plant of the Asteraceae family that have been used long time ago, in the treatment of liver disease. Sowing date of this plant has not been determined, therefore, this study was necessary. This plant was identified as a weed, while silymarin in the seeds are used in the anti-hepatitis and it is an important medicinal plant today. Silymarin, derived from the milk thistle plant, *Silybum marianum*, has been used for centuries as a natural remedy for diseases of the liver. The aim of this study was to determine the suitable sowing date for seed production of milk thistle as a medicinal plant in Golestan province.

Materials and methods: In order to determine the effect of sowing date on seed yield of *Silybum marianum* as a medicinal plant, two experiments were carried out based on a randomized complete block design with four replications in the experimental field of plant production College of Agricultural and Natural Resources of Gorgan University and a farmer field in Aliabad in 2012-2013. In order to record different stages of development 10 plants were selected in each plot. Seed yield was measured after ripening with Capitol harvesting. Capitol number per plant, number of seeds in the Capitol, plant height at harvest, sowing to harvesting time and 1000 seed weight were measured at each location. Analysis of variance was done using combined analysis method and mean comparisons were made along with slicing when interactions were significant.

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Results: Results showed that sowing dates effect were significant on measured traits. Location effect was also significant on capitol (head) number per plant, seed number per capitol, days to the flowering, days to harvesting and seed yield. Also, results revealed that effect of sowing date × location was significant on capitols number per plant, seed number per capitols, days to the flowering time, days to harvesting and seed yield at 1% probability level and plant height at 5% probability level. The regression results showed that 93% of seed yield is dependent to capitol number per plant and number of seeds per capitol. The highest average of seed yield in Gorgan and Aliabad was recorded 1634.9 Kg ha^{-1} and 1920.2 Kg ha^{-1} respectively.

Conclusion: Results suggested that milk thistle as a medicinal plant could be successfully grown on 1 Nov. as the best sowing time under Gorgan and Aliabad climatic conditions in the Golestan province.

Keywords: Combined Analysis, Seed yield, Traits.

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Study the effects of biological and chemical fertilizers on quantitative and qualitative characteristics of savory species (*Satureja khuzestanica* Jamzad)

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Abstract

Background and objectives: *Satureja khuzestanica* is valuable and endemic medicinal specie that growing widely in southwest parts of Iran. This specie is rich of phenolic compound carvacrol, therefore have considerable biological activities. *Satureja khuzestanica* is a new medicinal plant in Iran, and little research has been done on. Thus, the present study with the aim of evaluating the response of plant to the application of biological and chemical manure was carried out.

Materials and Methods: Pot experiment was carried out in field conditions as factorial layout based on a completely randomized design with three replications in Andimeshk in 2013. Biological fertilizer as first factor in four levels (1: control, 2: mycorrhiza, 3: mixture of *Azotobacter*, *Pseudomonas* and *Azospirillum*, 4: mixture of mycorrizha, *Azotobacter*, *Pseudomonas* and *Azospirillum*), and chemical fertilizer as second factor in three levels (1: control, 2:50-30 Kg ha^{-1} N-P, 3: 100-60 Kg ha^{-1} N-P) was applied. The characteristics measured were dry weight, plant height, number of branches, leaf and stem ratio, essential oil content, essential oil yield, essential oil compositions. The essential oil content was extracted using Clevenger apparatus (Water distillation). The amount and type of oil compositions were measured by gas chromatography (GC) and gas chromatography connected to

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a mass spectrometer (GC-MS) respectively. Analysis of variance was performed by software SAS (9.1). For comparison of means, least significant difference (LSD) test (At the level of 5% probability) were used.

Results: Analysis of variance showed that the effects of biological and chemical fertilizers and biological×chemical interaction on dry weight, oil yield were significant but the effect of biological and chemical fertilizers on essential oil composition was not significant. The effect of chemical fertilizer on essential oil content was significant. Mean comparison of traits showed that the mixtures of mycorrizha+bacteria had a highest dry weight (8.4 g plant^{-1}) and control has a least dry weight (4.05 g plant^{-1}).The highest and least essential oil content (2.58, 1.76 %) and oil yield (0.25, 0.1 g plant^{-1}) were observed in the first (50-30 Kg ha^{-1} N-P) and the second (100-60 Kg ha^{-1} N-P) levels of chemical fertilizers, respectively.

Conclusions: In general, results of this study showed that plant response to use of of mycorrhizal fungi was positive. The highest dry weight was observed in pots which treated with mycorrhizal fungi. The essential oil content, dry weight and the essential oil yield were increased by Application of fertilizers up to 50-30 Kg ha^{-1} N-P.

Keywords: Dry weight**,** Essential oil composition, Essential oil content, Essential oil yield

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Effects of nitrogen and arsenic on photosynthetic pigments, antioxidant enzyme activities and nutrient elements content in safflower (*Carthamus tinctorius* L.)

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Abstract

Background and objectives: Arsenic is a toxic metalloid for plants. Arsenic is polluting the environment through the natural and artificial resources. It is harmful to human health. Arsenic in plants for the production of the reactive oxygen species (ROS) lead to destruction of nucleic acids and proteins in tissues of plants. It also reduces of photosynthesis and growth by destroy of the membranes of chloroplasts. The arsenic-contaminated soil cleanup is an important issue in the study of biology. This experiment was conducted in order to investigate the effects of different concentrations of arsenic and nitrogen fertilizer on photosynthetic pigments, antioxidant enzyme activities and nutrient concentrations in both shoot and seed of safflower plants (cv. Goldasht).

Materials and Methods: To implement of this study, a plot experiment was conducted in a factorial design as randomized complete block with three replicates in university of Zabol. Nitrogen levels including N_1=75, N_2=150 and N_3=225 Kg ha^{-1} from urea source and Arsenic treatment included: A_1= control or without application of arsenic, A_2=30, A_3=60 and A_4=90 mg Kg^{-1} soil from the Na_2HASO_4 source.

Results: The results showed that arsenic treatment had a significant effect on Catalase (CAT), Ascorbate perxidase (APX) and Guaiacol peroxidase (GPX). Among the three antioxidant enzymes, by increasing arsenic level from control (A_1) to 90 mg Kg^{-1} soils (A_4), the activity of ascorbate peroxidase (APX) decreased and the activities of gayacol peroxidase (GPX) and catalase (CAT) increased. Arsenic treatment had no significant effect on the photosynthesis pigments

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included chlorophyll a, b and cartoneid content in leaves. Among the elements content in shoot and seeds, Arsenic treatment had only significant effect on the potassium and sodium content of safflower shoot. Nitrogen and interaction between arsenic and nitrogen treatments, except on ascorbate peroxidase (APX), had significant effect on catalase (CAT) and gayacol peroxidase (GPX). The highest Gayacol peroxidase (GPX) activity was obtained at A_4N_3 treatment. However nitrogen treatment increased chlorophyll a, b and cartoneid content of leaves significantly, but by increasing nitrogen level from 75 to 225 Kg ha^{-1}, increased potassium content and decreased sodium content of the seed.

Conclusion: The results obtained from this experiment showed that, application of heavy metal element (arsenic) however adversely affect safflower plants but until to 30 mg arsenic per Kg of soil, it had not adversely affects on growth and physiological characteristics of safflower (cv. Goldasht). The adversely effect of arsenic was appeared at the higher levels of 30 mg arsenic per Kg of soil.

Keywords: Arsenic, Physiological parameters, light pigments, Oxidative enzymes, Nitrogen

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Evaluation of the seed vigour diversity of rice genotypes (*Oryza sativa* L.)

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Abstract

Background and objectives: Seed vigour is the resultant of a broad range of physiological processes which have wide genetic background. The study of genetic variation, play an important role in enhancing the ability of breeders in selection and breeding operation. This study aimed to evaluate rice genotypes with the physiological and morphological characteristics related to seed vigour and grouping them in order to achieve good parents for rice breeding and hybridization program.

Materials and methods: To study the genetic diversity of rice seed vigour, 49 rice genotypes were evaluated in a completely randomized design with three replications in Rice Research Institute of Rasht- Iran in 2013. In this study, some morphological and physiological traits related to germination and seedling growth were measured under standard germination conditions. In order to estimate the relationship between the traits, the correlation coefficients were calculated and then stepwise regression analysis were used to determine the traits that have great role in explanation of seed vigour variation. In this study, after normality test by Kolmogorov-Smirnov method, factor analysis to grouping the traits was performed by principal component analysis.

Results: The results showed that the effect of genotype was significant at 1% probability for the traits related to seed vigour such as germination rate, uniformity of germination, number of normal seedling, seedling dry weight, seedling length, conversion efficiency of depleted seed reserve, vigour index, germination index

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and energy index that reflects the diversity of seed vigour between the investigated genotype. With regard to the vigour index as the most important trait, some traits such as length of radicle, length of shoot, length of seedling and germination rate have the most significant and positive correlation coefficient to vigour index. According to the results stepwise regression, length of seedling, germination rate and dry weight of radicle had more contribution in the vigour index variations. Factor analysis determined four factors that accounted 83.83% of total variations among genotypes. Based on the trait coefficients in each factor, the first factor as germination vigour, the second factor as seedling vigour, the third factor as seed physiology and fourth factor as seed physical factor were nominated. In the first and second factors, germination index, germination uniformity, D_{05} and D_{95} (time it takes to reach germination percentage to 5 and 95 of maximun), germination rate, germination energy, vigour index, dry weight of radicle, dry weight of shoot, dry weight of seedlings and seedling length were caused 63% of the total variation. Cluster analysis based on the more important traits in the first and second factors distinct rice genotypes into three clusters.

Conclusion: In general, the present study by appropriate separation of rice genotypes based on the seed vigour in tree groups (native, improved and imported) showed that seed vigour in native genotypes was lower than improved and imported genotypes.

Keywords: Factor analysis, Genetic variation, Rice genotypes, Seed vigour.

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Evaluation of planting date and nitrogen effects on the development stages of wheat cultivars and their relationship with yield and yield components in Nishabur region

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Abstract

Background and objectives: All changes in the development stages of plants results in the change of one or more yield components and finally, the ultimate yield and manipulation of these stages means to create new possibilities for increasing yield. Accordingly, planting date has a significant impact on plant growth and development during the growth season, So that any changes in planting date may drastically change the development stages. The purpose of the current study is to explore the relationship between yield and yield components with different phonological stages of wheat cultivars in Nishabur region and examine the possibility of increased yield by changing these stages using management methods.

Materials and methods: An experiment was conducted as split-split plot with complete randomized block design and three replications at the Agricultural Research Station of Nishabur in 2013. The experimental treatments included three sowing dates (9th Oct., 8th Nov. and 8th Dec.) as the main plot, nitrogen fertilizer in three levels (75 Kg ha^{-1} as pre planting fertilizer and 150 and 300 Kg ha^{-1} urea in two times at jointing and heading stages) as the sub-plot, and six spring wheat cultivars (Bahar, Parsi, Pishtaz, Chamran, Sirvan and sivand) as sub-sub-plots.

Results: Experimental results indicated that delay in sowing date caused a decrease in the duration of developmental stages especially in the vegetative growth period. Growth period was increased by enhancing the amount of nitrogen fertilizer.

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Therefore, the thermal requirement for going through the development stages was increased. Among the numerous varieties of wheat, Syvand (2362.9 GDD) and Parsi (2299.8 GDD) cultivars had the highest and lowest required Growing Degree-Day (GDD) from sowing time to maturity, respectively. Also, the results of stepwise regression indicated that the duration of the period from sowing to double ridge emergence had the highest relationship with grain yield fluctuations compared with other development stages. Moreover, a high correlation was observed between this period and the number of spikes m^{-2}.

Conclusion: wheat which have a longer period from sowing time to double ridge emergence have higher number of spikes m^{-2} and they are more likely to have higher grain yield in the climatic conditions of Nishabur. According to the results, wheat cultivation in October and application of nitrogen fertilizer can be recommended for increasing the vegetative growth period (especially from cultivation to double ridge stage that showed the highest relation with the number of spikes per square meter) and producing higher yield in the region.

Keywords: Developmental stage, Growth type, Stepwise regression

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The effect of cover crop and different tillage systems on soil physical properties and potato yield

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Abstract

Background and objectives: Suitable tillage methods and planting cover crops are such factors in sustainable agricultural systems, which play an important role in the sustainability of agricultural production systems. Minimum and no-tillage systems methods that leave instead of usually more than 30 percent of crop residue on the soil surface are used to reduce soil erosion, improve soil physical and biological characteristics, improve use efficiency and increase water infiltration. Crops residues have many benefits towards sustainable production practices, especially in conservation tillage systems. The benefits cover crop can be referred improvement of soil physical and chemical properties, maintain soil moisture, increase of soil organic matter, adjustment soil temperature, increase biodiversity and finally increasing of crop yields. This study was conducted to evaluate the effects of different tillage systems and cover crops types on soil properties, yield and yield components of potato, at the Agricultural Research Station Faculty, of Bu-Ali Sina University, during growing season of 2013.

Materials and methods: The experiment was conducted as split-plot based on a randomized complete block design with three replications. The main factor consisted three tillage systems (conventional tillage, minimum tillage and no-tillage) and three levels of cover crop (Vetch, barley and without cover crop) as subplot.

Results: Barley cover crop returned to the soil more dry matter than vetch, so that the barley biomass 1.21 times the of vetch biomass. The results showed that most soil organic matter (1.32 percent) was obtained in the no-tillage system with vetch cover crop. No tillage and minimum tillage treatments by mean of 11.75 percent of

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soil moisture caused the highest soil moisture. Cover crops increased soil moisture up to 6.26 percent in compared to control. The highest number of stems per plant and plant height were obtained by conventional tillage system. Number of stems per plant, plant height, maximum leaf area index in vetch cover crop treatments were 24.76, 17.58 and 37.79% more than control, respectively. The maximum number of tubers (48.15 Tuber per square meters) was obtained in conventional tillage system. Planting cover crops increased number of tubers to 28.79 percent in compared with the control. The maximum tuber yield was observed in conventional tillage system with cover crops vetch and barley by 48.68 and 47.95 ton per hectare, respectively.

Conclusion: It can be deduced cover crop improvement of soil organic matter, maintain of soil moisture and increased tuber yield of potato, especially under minimum and no-tillage systems.

Keywords: Crop residue, No-tillage, Soil organic matter, Tuber yield

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Using boundary line analysis in yield gap studies: Case study of wheat in Gorgan

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Abstract

Background and objectives: Due to increase in the world population and increasing concerns about the future food security, shrinking the yield gap has become a hot area of research in field crops. Estimation the amount of yield gap and determination of its causes requires using proper methods. Boundary line analysis is a statistical method that can quantify the response of yield to an environmental or management factor in a situation in which other determining factors are not constant. Indeed, with this method it is possible to determine the response of yield to a factor assuming other factors are optimal. The first objective of this study was to introduce a method of boundary line analysis as a practical analysis in yield gap studies of crops. Another one was how to use of this method to determine the best managements and estimate the potential yield and yield gap of wheat in Gorgan region which is an important wheat producing region.

Materials and methods: Yield potential, yield gap reason and factor importance in yield gap could be determined by sampling of farmer fields and this analysis method. Data were collected from 95 wheat farms during 2008 and 2009 in Gorgan. In this research soil and plant conditions were not considered and management practices were evaluated. Management factors included the amount of nitrogen fertilizer (N) (total and top dress), phosphorus (P_2O_5), potassium (K_2O), and frequency of irrigation, plant density and planting date.

Results: With plotting of yield data against management factors, the highest yield for each level of input or management factors were determined. The results show that while the average yield of farmers is 4700 Kg ha^{-1}, they can achieve up to 6200 Kg ha^{-1} by improving their cultural management. For this purpose, the following should be considered: (1) using at least 96 Kg ha^{-1} of N fertilizer so that 73 Kg ha^{-1}

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of it should be used as top dressing after sowing, (2) using at least 31 Kg ha^{-1} of P_2O_5 and 40 Kg ha^{-1} of K_2O as a base fertilizer, (3) at least two irrigations, (4) plant density of 182 to 447 in m^2, and (5) planting date before the late of November.

Conclusion: Boundary line analysis in yield gap studies can be used to evaluate response of yield to different management factors and to estimate yield potential and yield gap. Interpretation of the result is simple and obvious. This analysis reduces the common field trail and showing the clues for new field trail. If this kind of field studies were done during several years for important crops, ability of this analysis could be used for finding different ways for increasing yield. It is strongly recommended that the boundary line analysis to be used as one of a method in yield gap studies of crops.

Keywords: Food security; Environmental factors; Management factors; Proper statistical methods; Potential yield; Reasons of yield gap

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Predicting the impacts of climate change on irrigated wheat yield in Fars province using APSIM model

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Abstract

Background and objectives: Studying the impacts of climate change on crop productivity at regional scale will depend on the right estimate of future climate. This estimation is being implemented by climate models and most of them by general circulation models (GCMs). This study aims at predicting the future climate change impacts on wheat yield at six locations of Fars province (Abadeh, Darab, Eghlid, Fasa, Lar and Shiraz).

Materials and methods: The current study two general circulation models (HadCM3 and IPCM4) under three emission scenarios (B1, A1B and A2) for three periods (2011-30, 2046-65 and 2080-2099) were investigated for predicting future climate conditions in the study locations. LARS-WG software was used to generate daily climate parameters for each location. The daily climate data obtained from the outputs of LARS-WG were used as inputs for APSIM crop simulation model to simulate growth and development of wheat under future climate.

Results: The results showed that LARS-WG perfectly simulated radiation, minimum and maximum temperatures under future climate. However, the model performance was partly biased for precipitation compared with the other climate variables. According to the results obtained, the future minimum and maximum temperature in Fars will have an increasing trend. Compared to the baseline, the highest and lowest temperature rise will be occurred in Shiraz and Lar,

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respectively. In the current study, the higher grain yield during baseline period observed in Shiraz and Fasa (7753.95 and 7830.79 Kg ha^{-1}) and the lowest obtained in Lar (6810.62 Kg ha^{-1}). Compared to baseline period, the highest grain yield obtained in Eghlid and Abadeh (10761.17 and 10869.33 Kg ha^{-1}) in 2080-99 under A2 scenario. Averaging over emission scenarios, climate models and periods, the highest yield changes compared to the baseline was obtained in Eghlid (+12 to +43 percent) and Abadeh (+13 to +47 percent). In contrast, the lowest yield changes compared to the baseline was obtained in Darab (+11 to +18 percent) and Lar (+11 to +20 percent). Results of t-test also indicated that there was no significant difference between the climate models in terms of grain yield and other growth characteristics. Climate change increased grain yield and Leaf Area Index (LAI) and decreased length of growing season. Results of the current study showed that increasing of CO_2 concentration in all locations was a major reason for increasing grain yield. Generally, the highest and lowest impact of climate change on wheat growth was observed in 2080-99 under A2 and in 2011-30 under B1, respectively.

Conclusion: Generally, the results revealed that wheat grain yield will have increasing trend in the future climate of Fars Province (from 12 to 24%). The increase in yield was a result of increasing both CO_2 and temperature. However, positive effect of increasing CO_2 was eliminated in some locations mainly due to increasing temperature more than optimal temperature of wheat.

Keywords**:** Modelling, Rising temperature, General Circulation Models, LARS-WG.