improve fluorescence indices and some physiological traits such as stomatal conductance, relative water content and chlorophyll index.

***Keywords*:** Chlorophyll content, Drought stress, Relative water content, Stomatal conductance

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Effects of methanol on grain yield, chlorophyll fluorescence indices and some physiological traits of wheat (*Triticum aestivum* L.) under irrigation withholding conditions

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Abstract

Background and objectives: Drought stress is the most effective factors affecting crop yield particularly in arid and semiarid regions. This stress induces various biochemical and physiological responses in plants as a survival mechanism. Drought stress limits plant production and the performance of crop plants, more than any other environmental factor. Also this stress can damage the photosynthesis of plants and reduce chlorophyll content, relative water content, stomatal conductance and quantum yield. One of the important strategies for increasing of carbon dioxide concentration in plants is using compounds such as methanol that can increase the concentration of CO_2 in a plant and help photosynthesis rate and growth under water deficit conditions. The aim of this study was to investigate the effects of methanol on yield, chlorophyll fluorescence indices and some physiological traits of wheat (*Triticum aestivum* L.) under irrigation withholding conditions**.**

Materials and methods: A factorial experiment was conducted based on randomized complete block design with three replications at the research farm, faculty of Agriculture and Natural Resources, University of Mohaghegh Ardabili during 2018-2019. Factors experiment were included irrigation at three levels (full irrigation as control, irrigation withholding in 50% of heading and booting stages as moderate and severe water limitation respectively according with 43 and 55 BBCH scale) and foliar application of methanol at four levels (foliar application with water as control, application 10, 20 and 30 volume percent).

Results: The results showed that irrigation withholding decreased quantum yield, maximum fluorescence (F_m), variable fluorescence (F_v), chlorophyll index, relative water content, stomatal conductance and grain yield, but increased electrical conductivity, electrolyte leakage and minimum fluorescence (F_0). Foliar application of 30 volume percent of methanol under full irrigation increased about 51.53, 170.75, 78.76, 55.69, 77.58, 79.4 and 46.98% maximum fluorescence (F_m), variable fluorescence (F_v), quantum yield (F_v/F_m), chlorophyll index, relative water content, stomatal conductance and grain yield respectively in comparison with no foliar application of methanol under irrigation withholding in booting stage condition. Also, foliar application of 30 volume percent of methanol under full irrigation condition decreased electrical conductivity, electrolyte leakage and minimum fluorescence (F_0 122.68, 73.07 and 42.59% respectively in comparison with no foliar application of methanol under irrigation withholding in booting stage condition.

Conclusion: Based on the results of this study, it seems that foliar application of 30 volume percent of methanol can increase grain yield of wheat under water limitation condition due to

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lowest amount with an average of 487 and 2930 Kg ha^{-1}, respectively, was related to the control treatment in the first year of the experiment.

Conclusion: Based on the result, the simultaneous use of vermicompost, bacteria, humic and mycorrhizal fungi are the best compounds.

Keywords: Biological fertilizers, Combined application of fertilizers, Purple coneflower, Total dry matter.

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Study of organic, biological and chemical fertilizers effect on vegetative traits and medical components of *Echinaceae purpurea* L.

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Abstract

Background and objectives: Today, medicinal plants are the most important economic plants that are used and exploited raw or processed in traditional and modern medicine, and method of management is very important in the production of these plants. Echinacea is one of Asteraceae plants, which is native to North America, but today it is cultivated in most parts of Europe and Asia, as well as Iran. All vegetative organs of this plant, including roots and leaves, contain valuable active ingredients. The compounds of this plant have been used in the past and present for blood purification, snakebite, respiratory disorders and viral infections. Research has shown that several factors such as climate, soil type, crop management, plant nutrition, harvesting method, environmental stresses, etc. affect the amount of active ingredient of medicinal plants. One of the effective agricultural factors in quantitative and qualitative of plant growth and yield is plant nutrition. Therefore, in this regard, a study has been conducted on the effect of organic, biological and chemical fertilizers on vegetative traits and medicinal compounds of this plant.

Materials and Methods: This experiment was carried out to investigate the effect of organic, biological and chemical fertilizers on vegetative traits and medicinal compounds of Echinacea in Agriculture farm of Azad University of Karaj in two cropping years (2018-2019). The types of biological fertilizers used in this study included: *Glomus intradices*, humic acid, growth-promoting bacteria (*Azotobacter chroococum*), vermicompost (source of cow manure) on *Echinaceae purpurea.* Treatments were in the form individual, pairwise, three to three and control.

Results: The results related to agronomic traits showed that the main effect of year and treatment as well as the interaction of year and fertilizer treatments on leaf area index, number of leaves per plant, leaf and stem dry weight, number of main and lateral flowering branches, number of flowers per plant, The number of petals in main flower, total dry weight of flower and total dry weight of plant except root were significant. Main effects of year and interaction effect of year and fertilizer treatments on capitol diameter traits were not significant. These traits showed a significant increase with the combined use of vermicompost, humic acid and bacterial fertilizers. Also, in some traits, the combined use of mycorrhiza + humic acid + bacteria, vermicompost + mycorrhiza + humic increased vegetative and reproductive traits in Echinacea. Based on the results of comparing the average interaction of the year in fertilizer application, the highest total dry weight of flowers and total dry weight except roots with averages of 7300 and 18567 Kg ha^{-1}, respectively, related to fertilizer treatment combined use of vermicompost, humic acid and bacteria per year The second sampling was obtained and the

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the genotypic and phenotypic variance was higher than the stress under normal conditions. According to the results, it is clear that all traits except RWL had high heritability, which shows that these traits are less affected by the environment. Due to the existence of genetic diversity and high heritability for traits, it is possible to produce desirable cultivars through selection and hybridization. Results for stomatal characteristics showed that in drought stress, stomatal frequency increases and stomatal length and stomatal width decreases.

Conclusion: Low RWL and high RWC were recognized as a mechanism of survival and high WUE was introduced as an indicator of stress tolerance. The results showed that the RWC of flag leaf was controlled by the additive effects of the gene and had a high heritability; therefore, high genetic efficiency can be expected from selection for this trait. Results for stomatal characteristics showed that in drought stress, stomatal frequency increases and stomatal length and stomatal width decreases.

***Keywords*:** Different Irrigation Regimes, Heritability, Physiological traits, Wheat.

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Effect of different irrigation regimes on heritability and some physiological characteristics of wheat genotypes (*Triticum aestivum* L.)

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Abstract

Background and objectives: Wheat (*Triticum aestivum*) is the most important crop in terms of area under cultivation and production and plays an important role in meeting human nutritional needs. In Iran, wheat is grown in different climatic conditions and is exposed to stress at different stages of growth. Water stress is the most important cause of reduced wheat yield. Improvement of drought tolerant cultivars is one of the most important strategies to deal with water shortage and has faced many problems in arid areas. In addition to morphological traits that are considered in plant breeding and adaptation to drought stress conditions, Physiological traits are vital in the survival and adaptation of plants to environmental stresses and therefore attention to physiological indicators in order to study the rate of drought resistance is one of the important aspects of drought resistance in plants and is one of the objectives of this study.

Materials and methods: In order to analyze the effects of three different humidity regimes on physiological characteristics and yield of wheat, three different experiments were carried out under without stress conditions, water-stress at meiosis stage and continuous water stress (30% of Field Capacity). Ten different wheat genotypes including Alvand, Roshan, Back cross Roshan, Ehdaei 81 ،Ehdaei 82، Ehdaei 79, Oxley ،Chinese Spring، DN11 and Line 604 were evaluated in the greenhouse of Shahrkord University in 2019. After analyzing the results of the first experiment, genetic materials were selected for the second year experiment and cultured in conditions similar to the planting conditions of the first experiment, and stomatal characteristics were measured as another group of physiological characteristics on these cultivars.

Results: The results of analysis of variance showed that there was a significant difference between genotypes in terms of most traits. The reaction of wheat cultivars was different in three experiments, but drought stress in all types of stresses reduced the evaluated traits. Oxley genotype with high water use efficiency (WUE) in different irrigation conditions compared to other genotypes had the highest and Ehdaei 82 had the lowest WUE. In normal conditions, the highest biological yield was seen in Ehdaei 81 and Ehdaei 79. It seems that this cultivar has the highest yield by increasing the weight of biomass and finally achieved highest seed yield by increasing tiller number not by seed number per spike or 100 seed weight. Oxley showed the highest relative water content (RWC) in normal irrigation conditions. In such water conditions, the highest relative water loss (RWL) was also seen in Oxley. Therefore, it can be concluded that Oxley, although it had a high RWC, was not able to maintain the relative water content. The results of the variance components of the evaluated traits show that for most of the traits,

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decrease of 2004.3 Kg ha^{-1} and 1000-grain weight loss was related to Zarfam genotype with a decrease of 1.39 g. In contrast, the highest increase in grain yield due to inoculation of seeds with *P. indica* and *A. siccitolerans*, related to the Okapi genotype with an increase of 332.08 and 436.25 Kg ha^{-1}, respectively, and the highest increase in biological yield related to the Modena genotype with an increase 1239.41 was under inoculation with *A. siccitolerans* and an increase of 1205.58 was under inoculation with *P. indica*. In general, drought stress reduced grain yield and biological yield by 24 and 20.5%, respectively, but inoculation with *P. indica* and *A. siccitolerans* improved grain yield under drought stress conditions by 7 and 10, respectively. Percentage and improvement of biological yield were 12.6% and 11%, respectively. Also, under conditions of drought stress, inoculation of seeds with *P. indica* and *A. siccitolerans* improved grain yield by 10.5% and 11% and biological yield increased 15% and 16%, respectively. The results also showed high correlation between grain yield and all measured traits and biological yield with all measured traits except harvest index.

Conclusion: The results showed that inoculation of rapeseed cultivars had a positive and significant effect on yield and yield components under both stress and full irrigation conditions and among cultivars Talayeh cultivar had the highest yield and yield components compared to other cultivars.

***Keywords*:** Biological yield, Grain yield, Irrigation cut, Podding.

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Evaluation of yield and yield components of some rapeseed cultivars with endophyte *P. indica* and *A. siccitolerans* under drought stress

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Abstract
Background and Objectives: One of the global and national problems for the production of agricultural products is drought stress that the encounter with at least one of the important stages of the plant life cycle. Therefore, the development of drought-resistant cultivars and more food production from less water in a situation where the development of agricultural land is not possible, led to more attention to increase yield per unit area. One of the basic components of increasing crop yield is the consumption of more inputs, especially chemical fertilizers, the use of which creates problems for humans, soil and the environment, and the solution to overcome these problems is the use of biofertilizers. Therefore, according to the country's need to increase oilseed production, this study was aimed to investigate the evaluate the yield and yield components of inoculation of different rapeseed cultivars with mycorrhiza-like fungi (*Piriformospora indica*) and growth-promoting bacterium (*Arthrobacter siccitolerans*) on growth, yield and yield components of canola under normal and water stressed conditions.

Materials and Methods: This experiment was performed in field conditions at the Agricultural Research Center of Mohaghegh Ardabili University located on 10 km from Ardabil, in the form of split-split plots based on a randomized complete block design with three repetitions in 2016-17 and 2017-2018. Experimental treatments included two levels of irrigation as the main factor (including normal irrigation based on 80 mm evaporation from pan class A (control) and the other drought stress in the form of interruption of irrigation in the reproductive growth stage (from the podding stage, code No. 5.5 from Sylvester-Bradley table) to physiological maturation stage (code No. 9.9)) and three levels of microbial inoculation (without inoculation, *P. indica* inoculation and *Arthrobacter siccitolerans* inoculation as a sub-factor and 10 cultivars of winter rapeseed (Karaj 1, Karaj 2, Karaj 3, Talayeh, Zarfam, Licord, SLM-046, Modena, Opera, Okapi) as a sub-factor totally consists of 60 treatments.

Results: The results of combined analysis of simple effects showed that irrigation cut off, significantly reduced grain yield, biological yield, leaf area index, number of seeds per pod, pod length, pod per plant, 1000-seed weight and plant height, but there was no significant effect on the number of main stems and harvest index. The results of comparing the mean interactions of drought stress and genotype showed that the highest grain and biological yields related to Talayeh genotype with 3323.5 and 9745 Kg ha^{-1} yield under drought stress conditions, respectively, and also the highest 1000-grain weight related to Opera genotype (4.9 g). The highest decrease in grain yield as a result of drought stress was related to Karaj-2 genotype with a decrease of 693.2 and the decrease in biological yield was related to Modena genotype with a

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Growth and fruit yield response of khatoni melon to nitrogen application rates

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Abstract

Background and objectives: Melons are vegetable crops belonging to the family Cucurbitaceae, which consists of about 118 genera and 825 species. Persian melon is one of the most important melons with high economical and nutritional values and widely cultivated in Khorasan Razavi province. Nitrogen is the main plant nutrient resources with a structural and functional roles that affect growth and yield of melon production. Regarding to the importance of melon production in Khorasan Razavi province, this study aimed to determine the required amount of nitrogen fertilizer to reach maximum melon yield and to reduce excessive nitrogen application by farmers.

Materials and Methods: A field experiment was conducted at Torbat-e Jam in 2019. The effect of five levels of nitrogen fertilizer (0, 70, 140, 210 and 280 Kg ha^{-1}) was evaluated in a randomized complete block design with three replications. The size of each individual plot was 6 by 8 m and the melon row spacing was 2 m. Melon seedlings at three-leaf stage were planted about 75 cm apart in rows, on 23 June 2019. The studied traits in the experiment included leaf chlorophyll and leaf area at fruiting stage, number of fruits per plant, average fruit weight per plant, fruit yield, percentage of soluble solids and total dry matter.

Results: Analysis of variance showed that nitrogen fertilizer application had a significant effect on all measured traits, except soluble solids of fruits. The results also showed that nitrogen fertilizer application increased leaf area index and leaf chlorophyll content by 37 and 22%, respectively. The highest leaf chlorophyll content and leaf area index was obtained from 210 and 140 Kg nitrogen fertilizer application, respectively; and increasing nitrogen application did not have a significant increase in leaf area and chlorophyll content. The melon dry matter production increased with nitrogen fertilizer application compared to non-nitrogen fertilizer application and the highest dry matter production was obtained from 210 Kg N ha^{-1}, and more nitrogen application was not a significant increase in dry matter production. The highest amount of the produced fruit per plant and fruit weight was obtained from 280 and 140 Kg N ha^{-1}, respectively. Fruit yield of melon at 70, 140, 210 and 280 Kg N ha^{-1} increased by 39, 57, 41 and 28%, respectively. The highest fruit yield (33 t ha^{-1}) obtained at 140 Kg N ha^{-1}, and increasing nitrogen application significantly reduced melon yield.

Conclusion: Nitrogen application improved growth and fruit yield of melon plants. The highest quality and quantity of melon yield was achieved with application rate of 140 Kg N ha^{-1}, and application of excess nitrogen would reduce fruit yield. Nitrogen agronomic efficiency showed that fruit yield increased by 87 Kg ha^{-1} for each unite of N application rate under the optimum nitrogen fertilizer treatment. The study of the net economic income from the use of nitrogen fertilizer showed that the growers can experience up to 50% more economic profit with the optimal application of nitrogen fertilizer.

***Keywords*:** Agronomic nitrogen use efficiency, Fruit yield, Leaf area index, Regression analysis, Total soluble solids.

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Comparison of quantity and quality of sunflower yield in sole and intercropping with bean-soybean in Hamedan climate condition

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Abstract

Background and objectives: One of the key strategies in sustainable agriculture is diversity restoration to agricultural environments and its effective management. Intercropping is an effective way of sustainable agriculture. Intercropping, which is defined as growing two or more species simultaneously in the same field during a growing season, is considered as one important strategy in developing sustainable production systems, particularly systems that aim to limit external inputs such as chemical fertilizer and herbicide. Compared to sole crops, intercropping system have higher utilization of resource i.e., nutrient use efficiency, water use efficiency, and land use efficiency.

Materials and methods: In order to comparison of quantity and quality of sunflower yield in sole cropping and intercropping with bean-soybean, an experiment was conducted at the Agricultural Research Station, Faculty of Agriculture, University of Bu-Ali Sina, during 2013 and 2014 growing seasons. Experiment was conducted as randomized complete block design with three replications. Experimental treatment were different planting patterns including sunflower, bean and soybean sole cropping with and without weeding, additive intercropping of 30, 60 and 90% bean, as well as 30, 60 and 90% soybean with sunflower. Evaluated traits of crops including grain yield, protein and oil percent and yield and grain phosphor and potassium. Intercropping systems was evaluated by using land equivalent ratio (LER) index.

Results: Experimental results showed that all three crops' grain yield has were affected by planting patterns. The highest sunflower, bean and soybean grain yield (3480, 3025 and 3158 Kg ha^{-1}, respectively) was achieved at sole cropping with weeding and intercropping reduced grain yield. Results also indicated that intercropping decreased grain yield. Moreover, the highest sunflower, bean and soybean protein and oil yield and grain phosphor and potassium were belonged to sole cropping with weeding of this crops. However, land equivalent ratio at intercropping patterns with 60 and 90% bean and soybean were more than 1 that showed advantage of intercropping. Totally, the findings of this study demonstrated that according to land equivalent ratio index, intercropping of sunflower and legumes (bean and soybean) in most treatments were more beneficial than sole cropping.

Conclusion: The results of this study showed that, intercropping systems decreased sunflower, bean and soybean grain yield in comparison with sole cropping with weeding treatment but, in general, in the most of the treatments, sunflower-legume (bean and soybean) intercropping was better than their sole cropping and associated with improving economic yield and land use efficiency.

***Keywords*:** Competition, Land equivalent ratio, Oil seed, Oil yield, Protein yield.

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contaminated soil can reduce toxicity by decreasing the bioavailability of metals, and increasing plant growth.

Conclusion: Biochar has been proven efficient in reducing heavy metals exposure and increasing phytostabilization, associated with maize's phytoremediation potential.

***Keywords*:** highly polluted soils, Lead, Morphological indices of maize, Walnut leaves biochar, Zinc.

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Effect of biochar on growth morphological responses of maize in a naturally contaminated soil

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Abstract

Background and objectives: The presence of heavy metals in agricultural lands inevitably poses environmental pollutions. Additionally, their exposure threatens the security of healthy and marketable products. Lead and zinc are among the most common heavy metals which are found at contaminated sites, and their toxicity has turned into one of the main environmental issues in recent decades. These hazardous metals are released into the soil due to increase in human activities, including agricultural activities (application of chemical fertilizers, pesticides and herbicides) and mining activities. They exhibit toxic effects towards creatures, especially terrestrial organisms. Therefore, it is necessary to reduce metals pollution in agricultural lands. Biochar is a carbon-rich organic compound which is produced by the thermal decomposition of waste residues in an oxygen-limited environment. Showing more active functional groups, higher porous structure, and alkaline pH, biochar can reduce the risk contamination of heavy metals in the soil and, consequently retard their entry into the food chain.

Materials and methods: This paper aims to investigate the effects of Walnut leaves and their biochars produced at different temperatures of 200, 400 and 600 °C on the bioavailability of zinc (Zn) and lead (Pb), as well as morphological characteristics of maize (*Zea mays* L. Cv. Single cross 704) grown in a highly polluted calcareous soil adjacent the Zn and Pb Bama mines. An experiment was conducted by planting maize in untreated soil (control) and soil treated with three rates (0.5, 1, and 2% w/w) of Walnut leaves and biochars. In order to equilibrate soil and biochars mixtures, pots were incubated for 45 days. After the incubation period, macro- and micro-nutrients were added to all treatments according to the soil test. In each pot, 3 seeds of maize were sown, and plants were grown for 8 weeks. Plants were harvested, and roots were separated from soils. The maize morphological indices were determined. Some chemical properties of soils (pH, EC, and DTPA-extractable of Pb and Zn) were analyzed after planting.

Results: This study demonstrated that different pyrolysis temperatures and rates of biochar had a significant effect on the bioavailability of Pb and Zn in a highly polluted soil. Bioavailable Pb and Zn (DTPA-TEA extraction) decreased with increment in amendments rates and pyrolysis temperatures. In comparison with the control, the 2% biochar produced at 600 °C, significantly ($p<0.05$) decreased the DTPA-extractable Pb and Zn by 49.1 and 34.9 %, respectively. Morphological responses showed that biochar increased the ratio of shoot to root growth significantly compared to control. Biochar also had a significant effect on leaves, stems, and roots growth. Thus, findings illustrated that biochar could immobilize Pb and Zn by reducing the bioavailability to maize and promoting plant growth. Therefore, the application of biochar in

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under Scenario RCP8.5. For both scenarios RCP4.5 and RCP8.5, the highest temperature increase was observed in the climatic zones where located in south of Alborz and the east of Zagros mountain chains as well as the Central Iranian Dry Plateau and the lowest increasing was in the climatic regions located around the Caspian Sea, the Persian Gulf and the south of Iran. For the total annual precipitation over the future period (2041-2060), the highest amplification was predicted by MIROC5 to be 98.5 mm under Scenario RCP4.5 in Climatic Region 6202 (EDAREGORGAN station), and the greatest loss of precipitation was predicted by the same model to be -29.8 mm in Scenario RCP8.5 in Climatic Region 6102.

Conclusion: Given the prediction of rising average annual minimum and maximum temperature and the decline of precipitation over the future period (2041-2060) in the climatic regions leading to the arid plain of central and southern Iran, it can be concluded that the variations of meteorological parameters induced by climate change will be significant in the cotton-growing climatic regions of Iran over the future decades.

Keywords: Climate change, GCM models, RCP scenarios, Simulation.

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An assessment of LARS-WG's model to forecast meteorological parameters for climatic zones of cotton-harvested areas over Iran

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Abstract

Background and Objectives: Nowadays, climatologists and researchers are interested in the long-term forecast of climatic variables to be informed about the extent of their variations and to take measures to mitigate the adverse effects of climate change. Accordingly, general circulation models (GCMs) of atmosphere have been developed to predict climatic parameters. LARS-WG is a model to downscale the output of GCMs. It was used in the present research to generate data of daily precipitation, radiation, and minimum and maximum temperature across the cotton cultivation climatic zones (Meteorological stations) in Iran. The objective of this study is to estimate climatic factors (rainfall, radiation and minimum and maximum temperature) in the future period in major climatic cotton cultivation areas in Iran, which may be used for optimized water resource preservation and management in these regions. Also, the 5th IPCC report was used in this study, in contrast with the majority of investigations that use the 4th report.

Materials and Methods: In this research, the important areas under cotton cultivation in Iran are the target area. The data of 23 synoptic stations were used in these areas. The required meteorological data recorded in the stations were daily rainfall, minimum temperature, maximum temperature and sunshine. The present study assessed the performance of five different GCM models in simulating the data of precipitation, radiation, minimum temperature, and maximum temperature in nine synoptic stations (SABZEVAR, GHOOCHAN, GHOM, HASHMABAD, LAR, BILESOWAR, EDAREGORGAN, HASANABADEDARAB, and MASHHAD) from 2011 to 2016, firstly. Finally, two GCMs (MIROC5 and GFDL-CM3) were selected for the research purpose based on the results of t-test, F-test, and the Kolmogorov-Smirnov non-parametric test. Then, the parameters were predicted by the selected GCM models for 20 years (2041-2060) under the emission scenarios of RCP4.5 and RCP8.5.

Results: According to employing the scenarios of RCP4.5 and RCP8.5, the predicted solar radiation does not show a significant change in the future period versus the base period of 1981-2010 in all studied regions based on both GCM models. The highest change (0.249 MJ / m^2 / day) is based on the MIROC5 model and the RCP8.5 scenario in climate zone 6102 (HASHMABAD station). The predictions revealed that the parameters of maximum and minimum temperature would be ascending for all the climatic regions over the future period. The highest variations in the average long-term annual minimum and maximum temperatures versus the base period would be 2.67 and 2.75 °C happening in Climatic Region 6002 Includes stations (HASANABADEDARAB, KHAF, HAJI ABAD and GONBAD) over the 2041-2060 period

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Foliar application of Rooyesh-No fertilizer on yield and agronomic characteristics of rice *cv* Hashemi

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Abstract

Background and objectives: Foliar application of fertilizers is an effective fertilizing method for enhancing growth in plants through fast absorption and accelerate the transport of assimilates from leaves to the reproductive organs. Rice (*Oryza sativa* L.) after wheat is the most important crop in Iran and has a special place in people's food basket. Increasing rice production needs the development and release of high yielding cultivars and management of agricultural practices especially proper fertilizer application. This experiment was aimed to evaluate the effect of foliar spray of Rooyesh-No liquid fertilizer on yield, yield components and agronomic characteristics of rice *cv* 'Hashemi'.

Materials and methods: This experiment was carried out based on randomized complete block design with three replications in 2017 and 2018. Fertilizer treatments included T0: control (No fertilizers applied), T1: application of base fertilizers: (NPK), T2: one-time foliar application of fertilizer with no application of base fertilizers, T3, T4, T5, T6, T7 one, two, three, four and five times application of fertilizer +NPK, respectively. Measured parameters were panicle length, plant height, number of tillers, flag leaf area, length of flag leaf, plant dry plant weight, number of grains, percent of filled grains, yield, harvest index, total chlorophyll content, chlorophyll a and b content, carotene, SPAD value and leaf color.

Results: Foliar spray of fertilizer had a significant effect on all of the studied traits except for panicle length, and plant dry weight. Foliar application resulted in darker leaves due to increase in chlorophyll content. Although application of base fertilizer could provide critical SPAD value (37), but foliar application increased the SPAD values to higher than 40. Foliar application also increased the number of filled grains. Thousand grain weight was also higher with foliar application and reached from 25.1g in T0 (no fertilizer treatment) to 29.0g in two times application treatment (T4). In this experiment foliar application had positive effects on grain yield, percent of filled grain, 1000 grain weight, SPAD number, leaf chlorophyll content, leaf color, harvest index and plant biomass. Highest grain yield (4156.0 Kg ha^{-1}) and performance were observed with two-times foliar application of fertilizer (T4).

Conclusion: Foliar application increased overall plant growth and grain yield through fast absorption of nutrients and increase of chlorophyll content. An important finding of this experiment was the confirmation of the positive effect of liquid fertilizers even in the presence of base fertilizers.

Keywords: Yield, Grain filling, Plant nutrition, Fertilizer spray

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Conclusion: In general, the use of boundary line analysis as a suitable method in this study has shown the desired effect of different factors on wheat yield gap. It seems that by modifying these limiting factors, the gap between actual yield and achievable yield can be reduced.

***Keywords*:** Achievable yield, Actual yield, Potassium, Soil absorbable phosphorus

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Evaluation and determining the share of macro chemical fertilizers and soil properties in rain-fed wheat (*Triticum aestivum* L.) yield gap using Boundary Line Analysis

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Abstract

Background and objectives: One of the main problems of wheat production, especially in Golestan province, is the yield gap, which results from a significant difference between farmers' actual yield and obtainable yield. So, the aim of this study was evaluation and determining the share of macro chemical fertilizers and soil properties in wheat (*Triticum aestivum* L.) yield gap using Boundary Line Analysis.

Materials and Methods: This study was conducted in Kalaleh and in 60 farms based on Boundary Line Analysis in 2016-17. In this study, in order to analyze and measure the physicochemical properties of soil, after harvesting of autumn products, soil samples were collected from selected fields, and electrical conductivity, acidity, organic carbon percentage, total nitrogen content, available phosphorus, available potassium, clay, silt, sand as well as the soil texture class were investigated in vitro. The amount of grain delivered to the wheat shopping centers was recorded after determining the amount of seed loss as the final yield of the farm. All information about using base fertilizers and the other field operations were recorded. Using the boundary analysis method, the relationships between yield and variables were investigated, and finally, the wheat yield gap and the contribution of each of these factors in the creation of yield gap were estimated.

Results: In the studied farms, minimum, maximum and average amount of nitrogen fertilizer were 34.5, 14.5 and 85.4 Kg ha^{-1}, respectively. Also, the minimum, maximum and average grain yield of wheat in these fields were 1950, 4890 and 3227 Kg ha^{-1}. The response of the most wheat yields in the studied farms in terms of nitrogen fertilizer consumption indicated the two-part function. So, wheat nitrogen fertilizer increased to 58.35 Kg ha^{-1} and wheat grain yield did not have a stable trend. The yield of nitrogen was limited to 4848 Kg ha^{-1} obtained by consuming at least 58.35 Kg ha^{-1} of pure nitrogen, and in 20% of the studied farms, the amount of nitrogen consumed was less than optimum, and the yield loss due to the lack of optimum use of nitrogen fertilizer in the fields was 34.4% (1671.6 Kg ha^{-1}). In other words, with the optimum use of nitrogen fertilizer, it would be possible to increase wheat yield by 1671.6 Kg ha^{-1}. The results showed that there was a difference of 4071.7 Kg ha^{-1} (56%) between the achievable (7248 Kg ha^{-1}) and actual yield (3417.4 Kg ha^{-1}). The amount of absorbable phosphorus in the soil, the amount of absorbable potassium in the soil and the amount of nitrogen consumed caused wheat yield in the studied area, which was 14.9%, 14.3%, 11.7% and 10.3% percentage respectively.

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Contents