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Determination of sunflower ideotype in the Gonbad region using multiple regression modelling

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Abstract

Background and objectives: Plant breeders to select their breeding objectives through the physiological and morphological characteristics, require classification of the limitations and capabilities which exists in plants; this issue leads to the concept of the ideotype. Achieving the best crop ideotypes requires appropriate statistical methods. The objective of this study was to introduce a method based on multiple regressions to find ideotype with a case study of sunflower in Gonbad.

Materials and methods: Data were collected by sowing 12 sunflower genotypes in four replications in a randomized block design in south of Gonbad city. Using multiple regressions in order to determine the important traits and to show the contribution of each trait in formation of yield. The method identified the relation between yield and all variables in a quantify matter. Also according to the positive or negative correlation between the variables affecting the yield, to designing ideotype, various hypotheses put forward and various aspects of them was examined.

Results: Five important traits including total dry mass production, maximum leaf number, grain weight, the percentage of empty achene and the oil percentage had high role in determining sunflower yield. Optimum amount of each variable was determined by multiple regression method. These five variables explained 57% of yield variation. The results indicate that if the correlation between some traits changed, it could be used for the yield improvement. Regarding negative correlation between oil percentage and total dry mass, several hypotheses were evaluated. If the negative correlation between max dry matter and oil content is not

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breakable, the yield of the best ideotype will increase 812 (from 2080 to 2892) Kg ha^{-1} in comparison with sunflower hybrids. If with increasing max dry mater, oil content stay at moderate level, it will increase 873 (from 2080 to 2953) Kg ha^{-1} in the best ideotype, and if correlation between max dry matter and oil content is breakable, it will increase 999 (from 2080 to 3079) Kg ha^{-1} in the best ideotype.

Conclusion: Mean seed yield of sunflower improve from 2080 Kg ha^{-1} to 2892-3079 Kg ha^{-1} in the selected ideotype. It was concluded that because of concerning the genetic differences among varieties, the method which used in this study, can be used in determining plant ideotypes in conjunction with other methods and it can guide plant breeders to move through the best crops ideotype.

Keywords: Plant breeding, Plant ideotype, Multiple regressions, Correlation

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Evaluation of carbon sequestration potential of canola fields in Khorasan Razavi province

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Abstract

Background and objectives: Nowadays, it is believed that carbon distribution and emission between different pools of soil, plant and atmosphere have an essential role in sustainability of agroecosystems, environmental challenges especially global warming and climate change. CO_2 is the most important of greenhouse gases that increasing of its concentration in the atmosphere has been caused global warming and climate change (8). Carbon sequestration is increase soil organic carbon (SOC) that improves depth distribution of SOC and stabilize SOC by encapsulating it within soil and the simplest ways to mitigation levels of this atmospheric gas (18, 52).

Materials and Methods: In order to evaluate the potential of carbon sequestration in above ground and below ground organs for canola as an important oil crop in Khorasan Razavi region, an experiment was conducted in 2013. Sampling was performed with random-systematic method by using 30 plots of 0.5 m^2 and along three transects of 50 m. Conversion coefficients of above ground and below ground organs including silique+ seed, stem, leaf and root of canola were determined with combustion method separately. Sequestration carbon potential for above ground and below ground organs of canola and soil were measured. After the calculation of emission for greenhouse gases including CO_2, N_2O and CH_4 based on emission indices, global warming potential (GPW) were calculated.

Results: The results showed that mean yields of silique + seed, stem, leaf and root were achieved with 33.46, 36.60, 17.45 and 22.91 $kg.ha^{-1}$, respectively. The mean carbon sequestration of soil for canola fields was 3.46 $t.ha^{-1}$. Conversion

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coefficients and carbon sequestration potential were significantly different between above ground and below ground organs of canola ($p \leq 0.01$). The highest conversion coefficient was observed in silique+ seed with 51.65%. Total carbon sequestration potential for above ground and below ground organs was obtained 5.12 $t.ha^{-1}$ that the maximum and the minimum were belonged for stem and leaf with 1.81 and 0.76 $t.ha^{-1}$, respectively. The highest emission of greenhouse gas was achieved for nitrogen fertilizers with 1.35 ton CO_2 and GWP was 0.688 ton CO_2 equivalent per ha.

Conclusion: It is therefore concluded that reduction of chemical fertilizer and more use of above ground and below ground residues for canola seems to be a rational ecological approach for sustainable management of agroecosystem with a consequence of reduction in greenhouse gases and mitigation of climate change.

***Keywords*:** Greenhouse emission, Climate change, Ecological approach, Global warming, Oil crop

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The effect of different levels of nitrogen fertilizer on yield and fertilizer use efficiency of corn for different planting dates in Ardabil climate condition

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Abstract

Background and objectives: Since cultivation of hybrid corn is rarely possible in Ardabil region, determining the best planting date for achieving optimum performance is the first step for its cultivation. Nitrogen as the most widely used nutrient required by plants, can affect performance. Therefore, in this study, the effect of different planting dates and different amounts of nitrogen on yield, yield components and nitrogen use efficiency in corn have been investigated.

Materials and Methods: A split plot experiment was carried out at the research station of University of Mohaghegh Ardabili with four replications based on randomized complete block design in order to study the effect of different levels of nitrogen fertilizers at different planting dates on yield and fertilizer use efficiency in corn at Ardabil climate. Main plots were three planting dates (10, 20 May and 30 June) and subplots were different nitrogen levels (0, 75, 150, 225 Kg N ha^{-1}).

Results: Interaction between planting dates and nitrogen levels was significant on grain yield, and the highest yield (12.33 t ha^{-1}) was achieved in the first planting date (10 May) with 150 Kg ha^{-1} nitrogen level. The highest 1000-kernel weight (226 g) achieved in 10 and 20 May planting dates with 225 Kg ha^{-1} nitrogen and the highest biological yield (38.4 t ha^{-1}) was obtained at related to 225 Kg ha^{-1} nitrogen level in second planting date (20 May). Fertilizer use efficiency was significantly affected by nitrogen levels and interaction between planting date and nitrogen levels, while planting date had no significant effect on fertilizer use efficiency. Comparison of means indicated that the highest value for fertilizer use efficiency (36.5 Kg Kg^{-1}) was related to 75 Kg ha^{-1} nitrogen level in third planting

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date (30 June). The highest kernel no per ear (436) obtained in the third planting date (30 June) with application of 225 Kg ha^{-1} N. Also, the highest total kernel weight in ear (89.6 g) achieved in the first planting date (10 May) and application of 225 Kg ha^{-1} N.

Conclusion: In order to achieve the highest corn grain yield (12330 Kg ha^{-1}) in Ardabil climate condition 10^{th} May sowing date with 150 Kg ha^{-1} nitrogen application is recommended.

Keywords: Cob, Growth season, Nitrogen, Single cross, Yield.

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Evaluation of extinction coefficient and radiation use efficiency in different cultivars of Safflower under different levels of Nitrogen (N) fertilizer

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Abstract
Background and objectives: There is a high correlation between crop growth and the rate of radiation interception. The efficiency of radiation interception and absorption is dependent on leaf area index, light extinction coefficient and radiation use efficiency.To study extinction coefficient and radiation use efficiency in different cultivars of Safflower under different levels of N fertilizer, an experiment was carried out in the research field at the University of Valiasr in Rafsanjan during 2013-2014.

Materials and methods: Experiment was arranged in a split plot design in complete randomized block design with four replications. Experiment factors including N fertilizer were a main factor in 5 levels (control, 50, 100, 150 and 200 kg per hectare) and cultivar in 4 levels (Local Isfahan, Goldashat, Sofe and Naeen). In addition to measuring the radiation above and under the canopy, the plots were sampled 8 times during growing season and leaf area index, total dry matter and finally light extinction coefficient and radiation use efficiency (RUE) were measured.

Results: The results showed that light extinction coefficient was not affected by N fertilizer but comparison of extinction coefficient in difference cultivars showed that Goldasht cultivar have significant difference with Landrace of Local Isfahan and Sofe and RUE obtained for endemic cultivars of Local Isfahan, Goldasht, Naeen and Sofe were 0.46, 0.54, 0.48 and 0.46, respectively. Radiation use efficiency was influenced by N fertilizer; in this case, at fertilizer level of 150 Kg, there was a significant difference among endemic cultivars of Local Isfahan, Goldasht, Sofe with control. At 200 Kg N level, Naeen cultivar had a significant

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difference with control for RUE. There was no significant difference in obtained RUE in different cultivars and amount of RUE obtained for endemic cultivars of Local Isfahan, Goldasht, Naeen and Sofe were 4.45, 4.19, 4.62 and 4.35 g MJ^{-1}, respectively. In addition, at 100 Kg h^{-1} fertilizer level, maximum leaf area index of all cultivars had a significant difference with control level.

Conclusion: In this experimental study with increasing the level of N fertilizer, maximum leaf area index increased significantly. Increasing the leaf area index caused radiation use efficiency affected by N and in general the highest radiation use efficiency obtained at 100 to 150 Kg h^{-1} N level. It seemed that among the above cultivars, Naeen is the most suitable for radiation use efficiency.

Keywords**:** Leaf Area Index, Light extinction coefficient, Nitrogen, Radiation use efficiency, Safflower.

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The effect of different residue type, management and nitrogen on yield, quality of durum wheat (*Triticum durum* L.) and soil macronutrients

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Abstract

Background and objectives: Arid climate condition of the country, no proper crop rotation, collection, and burning of crop residue, over dose application of chemical fertilizer and not application of organic fertilizer caused to decreasing in soil organic matter that the yield and the soil fertility decreased. Crop residue is one of the most important conservation tillage factors for improving soil properties. Crop residue is the source of biofuel and industrial production. Residue removal has negative effect on crop production and environment. Result of experiment showed that residue removal affect soil organic carbon and this effect was more obvious when high amount of residue removed.

Material and Methods: In order to investigation the effect of different residue type and management and nitrogen on growth characteristics and yield of durum wheat (*Triticum durum*), an experiment was conducted at Agricultural Faculty of Shahid Chamran University of Ahvaz in 2012-2013. The experimental design was completely randomized block design, with three replications. The first factor was residue types (wheat and canola), second factor was residue management (residue burning, residue moving and 30% residue incorporated to the soil) and the third factor was different nitrogen resources (100% urea, 50% urea+Alkazotplus and sulfur seed coated urea). The measured traits were grain yield and protein and nitrogen, phosphorus and potassium of soil and plants. The Behrang cultivar was used with 350 plant m^{-2} density in 2×3 m plots. The harvest operation was on April, 2015 after ripening.

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Results: The results showed that the highest grain yield (6.92 t ha^{-1}) was achieved at 150 Kg ha^{-1} urea and canola burning residues. Also the highest grain protein (15.25%) and nitrogen (2.61%) were observed at canola residue incorporated to the soil and sulfur seed coated urea. The highest grain phosphorus and potash content obtained at biological and chemical combination fertilizers + wheat residue removing and wheat residue incorporated to the soil + sulfur seed coated urea, respectively. Also the results revealed that the residue incorporated to the soil had positive effects and caused to more availability of the soil nutrients. The highest soil nitrogen and phosphorus were obtained at canola residue incorporated to the soil+ 150 Kg ha^{-1} urea fertilizer. Also the combination of biological and chemical fertilizer + canola residue incorporated to the soil had the highest soil potash contents.

Conclusion: In general, the crop residue incorporated to the soil had positive effects on measured traits and concluded to increased soil nutrient availability. The highest soil nitrogen and phosphorus were obtained at canola residue incorporated to the soil+ 150 Kg ha^{-1} urea fertilizer. The canola residue incorporated to the soil+ combination of chemical and biological fertilizer treatments had the highest soil potassium contents. Although residue burning caused to uptake the soil nutrients in short term, but in long time, the disadvantages of this is more than advantages that it concluded to destruction the soil structure and decreasing in grain yields.

***Keywords*:** Residue type, Alkazotplus, Slow release urea and Durum wheat

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Evaluation and grouping of soybean varieties and lines under normal and drought stress using multivariate statistical methods in two regions of Rasht and Gonbad Kavous

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Abstract

Background and objectives: Considering of drought stress as a major limitation in production and stable yield of crops including soybean, identification of tolerant genotypes to water deficit can be a valuable approach against the problem. Present study was designed to evaluate varieties and advanced lines of soybean based on different agronomic traits for selection of superior varieties and lines in normal and under drought stress environments in two regions of Rasht and Gonbad Kavous.

Material and methods: Plant materials including 100 advanced lines with 21 varieties of soybean were planted in two environments under water deficit and normal conditions in two regions as randomized complete block design with three replications in 2014. Twenty one traits including phenologic, morphologic, yield and yield components were measured. The combined analysis of variance, cluster analysis, discriminant function analysis and principle component analysis were done.

Results: The results of analysis of variance for all of the evaluated traits revealed that differences among genotypes and at least one of the interactions were significant at one percent probability level indicating high genetic diversity and different reaction of genotypes to different conditions for investigated traits. Therefore other analysis including cluster analysis, principle components analysis and discriminant function analysis were performed for each condition separately. The cluster analysis was classified varieties and lines to two or three groups. The superior varieties and lines were in the clusters with means and total mean for

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important traits higher than other groups. In total varieties and lines number 8, 16, 36, 37, 42, 63, 67, 72 and 86 were in the superior group in both normal and drought stress conditions of Rasht region and varieties and lines number 34, 43, 62, 66 and 70 were better than others in both normal and drought stress conditions of Gonbad Kavous. Discriminant function analysis based on groups derived from cluster analysis revealed that in the most environments total weight of plant, grain yield per plant, total pod number and seed number per plant were the most effective traits in distinguish of the groups. As the groups including better advanced lines and varieties had higher values for these traits.

Conclusion: It is expected to use the identified tolerant varieties and lines in the studied regions after verification of the results in several years. Considering the role of more efficient some traits including total weight of plant, grain yield per plant and total pod number, those should be taken priority in breeding programs such as selection and improving of genotypes.

Keywords**:** Principle component analysis, Discriminant function analysis, Cluster analysis, Water deficit, Soybean.

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The effects of salinity stress levels on quantitative and qualitative traits of different cultivars of canola under vermicompost application

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Abstract

Background and objectives: There is an increasing pressure to apply low quality brackish waters for plant irrigation in the arid and semi- arid areas of the world. Consequently, there is a demand to identify the salt tolerant of conventional crops and varieties. Vermicompost usefulness has been reported in reducing the harmful effects of salinity on some plants.

Materials and methods: In order to investigate the effects of four salinity levels (including 1.15, 4, 7 and 10 dS m^{-1}) on quantitative and qualitative traits of four cultivars of canola (Hyola 4815, 308 and 401 and RGS 003) under application of 10 t ha^{-1} vermicompost, an experiment was conducted as factorial based on randomized complete block design with three replications. Pot experiment was conducted in a semi- controlled environment. In order to avoid toxic effects of some ions, different levels of salinity were prepared with composition of four salts ($CaCl_2$, NaCl, $MgCl_2$ and $MgSO_4$) as equal weight ratio.

Results: The results showed that cultivar significantly affected the seed yield, biological yield, harvest index, oil yield, seed water use efficiency and oil water use efficiency. Means comparison test indicated that Hyola 401 cultivar had the highest value in whole traits, although this superiority was not significant in some traits. In contrast, RGS 003 cultivar had the lowest value of seed yield, harvest index and seed water use efficiency. In comparing with RGS 003 cultivar, Hyola 401 has 23% more seed yield and seed water use efficiency. Also, the results showed that the effect of salinity on seed yield, biological yield and seed water use efficiency was significant. Based on means comparison test, the lowest value of seed yield, biological yield and seed water use efficiency had been observed in

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control salinity treatment (1.15 dS m^{-1}) and the highest value of those traits observed at 7 dS m^{-1} irrigation water salinity and more increasing of the salinity had an adverse effect. Interactions of salinity and cultivar had no effects on considered traits.

Conclusion: It seems that increasing in seed yield, biological yield and seed water use efficiency in salinity levelof 7 $dS.m^{-1}$is due to the increasing absorption of nutrients from the soil, less leaching of nutrients from the soil because of reduced water solubility and stimulates the plant to cope with the stress led to an increase in those attributes. Also, application of vermicompost led to increasing salinity threshold of canola cultivars because it improves the soil physical and chemical condition.

Keywords**:** Gorgan, Hyola, RGS, Water salinity.

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Effects of Irrigation regime based on field capacity percent and Humic acid on morphophysiological traits of medicinal plant (*Portulaca oleracea* L.)

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Abstract

Background and objectives: Drought stress is major constrain for crop production worldwide and is the common stress. Natural fertilizer and humic acide application causes consume less water, lower water evaporation from soil surface and water storage in soil. So, because of importance of portulaca for hailing of cardiovascular disease, cancer, asthma, Diabaties and infectious diseases an experiment conducted for evaluation of Humic acid on some of morphological and physiological charactristics of *portulaca oleracea* under water stress.

Materials and Methods: In order to investigate the effects of Irrigation regims and Humic acid levels on morphophysiological traits on portulaca (*Portulaca oleracea* L.), as a medicinal plant a pot experiment was conducted as factorial based on completely randomized design with three replications at Gorgan University of Agricultural Sciences and Natural Resources in 2014. Treatments included irrigation regimes in four levels (100, 75, 50 and 25% FC) and humid acid in four levels (0, 200, 400 and 600 mg L^{-1}). Studied traits included the water stress reduced shoot length, number of stem, root diameter, root length, stem wet and dry weight, leaf wet and dry weight, leaf area index, proline, leaf water ratio and a, b and total chlorophyll content. Chlorophyll and Proline were measured with Arnon and Bates method.

Results: The results showed that by increasing drought stress, shoot length, number of stem, root length, stem wet and dry weight, leaf wet and dry weight, leaf area index were decreased. Also, with increasing drought stress, leaf water ratio and a, b and total chlorophyll content decreased and proline were increased in

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comparison with control. Choloropyll a, b and total decreased with irrigation regimes and at the lowest rate at 25% FC was 0.40, 0.25 and 0.66 mg g^{-1}, respectively. Humic acid had significant effects on all of morphological and physiological characteristic except of stem wet and dry weight and the highest rate was observed at 200 mg L^{-1}. Humic acide effect on proline and relative water content was significant but on cholorophyll a, b and total was not significant. Intraction effects of Irrigation regime and humic acid had significant effects on all of morphological and physiological characteristic except of stem wet and dry weight, leaf area index and b chlorophyll content. Proline increased compared to control (1.72%) in 600 mg L^{-1} humic acid. The highest value of a and total chlorophyll content was obtained in 100% FC and 200 mg L^{-1} humic acid. The most value of LWR was meatured in 100% FC and 400 mg L^{-1} humic acid.

Conclusion: The results showed that by increasing drought stress, all of the measured traits were decreased, In spite of that, humic acid protected purslane against drought and decreased drought damages. The best treatment was 75% FC and 200 mg L^{-1} humic acid in terms of economic benefit, Because of consuming less water and humic acide produce more yield. In general, with supplemental experiment humic acid could be applied for reducing adverse effect of irrigation regime.

Keywords: Chlorophyll, Medicinal plant, Organic acid, Prolin, Water difiicit stress.

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Evaluation of the integration of different clodinafop propargyl applications and wheat (*Triticum aestivum* L.) density in wild oat (*Avena ludoviciana*) control

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Abstract

Background and objectives: Considering environmental issues of herbicide applications, using of integrated weed management could reduce the amount of herbicide usage accompanied with keeping their efficacy. Farmers are always faces the weed contamination and the number of weeding labor, tillage and the amount of herbicide application shows the importance of that (Eue, 1986). However introducing the new herbicides are an important progress in agriculture (Pike and et. al.) but crop damaging and concerns about herbicides carry over to non-target areas, weed herbicide resistance, environmental consequences issues and human health, are the reasons to revise the chemical weed management (Blachshaw, 2006). Long term successful weed management needs to change the simple weed control to the system which reduce weed germination and reproduction and decrease the ability of competitiveness of weed with the crop. The purpose of this experiment was to evaluate the possibility of clodinafop application reducing in combine with different wheat densities to control *Avena loduviciana* L.

Matterials and methods: a field experiment was conducted at Hossein Abad Malek village located at 25 kilometer at east of Gorgan city. Field preparations were tillage and two vertical disc and plots making. Plots were two meter width and five meter length. A factorial field experiment was carried out based on randomized complete block design. Treatments were recommended and 150 % of recommended density of wheat and four clodinafop doses including 0, 60, 80 and

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100 % of recommended dose which every dose applied by two different application like split and single application approach. Fresh and dry weight of weeds was sampled after one month and wheat yield was obtained from 3 m^2 after removing border.

Results: Results showed that split application of clodinafop shows more control efficacy percent of *Avena ludoviciana* compared with single application. Increasing the density of wheat up to 150 % of recommended density increased the efficacy control of single application whereas at split application without any increasing in the density of wheat always shows more efficacies in comparison with single application. There was no significant difference between wheat yield at split application of 80 and 100 % recommended dose of clodinafop at both density of wheat. Also with increasing clodinafop control efficiency, wheat yield was increased as well, and this yield increasing had straight relation with both simple and split application weed control efficiency.

Conclusion: Split application approach cause increasing weed control efficacy and reducing herbicide usage up to 20 %.

Keywords: Herbicide efficacy, Integrated weed management, Split application, Single application

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Effect of auxin, cytokinin and planting pattern on grain yield and salt tolerance indicators of maize

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Abstract

Background and objectives: Salinity of soil and irrigation water is the most important factors limiting crop production in arid and semi-arid areas. Corn because of diversity, adaptation and high nutritional value is among the best crops in the world and in terms of production in the first place. Planting pattern can be effective on access to light, water and nutrients. Cytokinins by accumulation of chlorophyll and conversion of etioplast to chloroplasts and Collection of free radicals delay leaf senescence. Auxins also have a very important role in salinity tolerance. Auxin is involved in the transport of carbohydrates in their production time. Therefore, the objective of this study was to evaluate the effect of cytokinin and auxin foliar application on salt tolerance indices of maize under different planting patterns in salinity conditions.

Materials and methods: The experimental design was split plot based on randomized complete design with three replications in Bushehr Agricultural and Natural Resources Research Center in 2014. Planting patterns (ridge planting, double rows of planting on ridge in zigzag form and furrow planting) as the main factor and use or non-use growth regulators (not consumption, application of cytokinin hormone in the time of V8-V10 and application of auxin hormone at the silking stage) were investigated in sub plots. The electrical conductivity of soil and water is equal to 5.2 and 4 dS/m. Plant spacing in the ridge planting and furrow planting patterns was 17.5 cm and in the double rows planting was 35 cm and thus for all treatment plant density was 75,000 plants/ha. Benzyladenine (BA) and

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indole-3-butyric acid (IBA) were used as cytokinin and auxin hormone at a concentration of 50 and 10 mg/lit, respectively.

Results: The results showed that double rows pattern and furrow planting pattern increased grain yield to 30.6% and 43.4% conventional planting (ridge planting), respectively. The highest chlorophyll a, b and carotenoid content of starch and potassium ions (K^+) were obtained with pattern of furrow planting, while the highest relative permeability of the membrane, proline, total soluble sugars, sodium ions ($Na^{+)}$, Chlorine ions (Cl^-) and Na^+/K^+ were devoted to the pattern of conventional planting (ridge planting). Foliar application of cytokinin and auxin increased grain yield to 34.3 % and 43.5 %, respectively. Membrane permeability and Na^+/K^+ reduced with application of regulator and the lowest amount was observed at 26.29 and 0.27 with auxin application. Cholorophyll content (a,b) and cartonoide and starch content increased with application of growth regulator and the highest amount was observed in auxin application treatment. The highest proline content (4.06 mg g^{-1} leaves FW) was observed in common planting pattern with auxin application and the lowest proline content (2.32 mg) was observed at double row planting pattern and growth regulator application. At all three cropping pattern the highest amount of soluble carbohydrates was obtained without application of growth regulator. The highest amount of Na was observed without application of growth regulator while the lowest amount of Na ions was obtained with application of auxin.

Conclusion: In general, results showed that changing planting pattern to furrow planting and foliar application of cytokinine at 8-10 leaves stage and auxin at the concentration of 50 and 10 mg L^{-1} at silking stage increase salt tolerance of maize.

***Keywords*:** Proline, Silking, Furrow Planting.

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Effect of crop rotation, *Azotobacter chroococcum* inoculation and nitrogen rate on rice (*Oryza sativa* L.) paddy yield

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Abstract
Background and objectives: A considerable portion of chemical N fertilizer in rice field is lost through denitrification, volatilization, leaching, causing environmental pollution problems. It seems that incorporation of winter legume crops in rotation with rice and using plant growth-promoting rhizobacteria can be alternative approaches in reducing N chemical fertilizer and increasing sustainable crop production in rice fields. This experiment was conducted to evaluate the effect of crop rotation, *Azotobacter chroococcum* inoculation on rice (*Oryza sativa* L. cv. Shiroudi) paddy yield at Rice Research Station of Tonekabon, Mazandaran province, during growing season of 2013-2014.

Materials and methods: The experiment was conducted as split-factorial arrangement based on a Randomized Complete Blocks with three replications. Main plots were crop rotation [berseem clover - rice, faba bean- rice, and fallow – rice (control)] and subplots were the factorial arrangement of *Azotobacter chroococcum* (inoculated and un-inoculated) and N rate (50, 75, and 100 percent of N recommended rates which were 50, 75 and 100 kg N ha^{-1}, respectively) levels.

Results: Analysis of variance showed that rice paddy yield was significantly affected by crop rotation, *Azotobacter chroococcum* and N rate. Rice paddy yield in faba bean – rice crop rotation (6174.8 kg ha^{-1}) was significantly lower than fallow – rice (7352.3 kg ha^{-1}) and berseem clover – rice (7554.8 kg ha^{-1}) crop rotations. Moreover, there was no significant difference in paddy yield between fallow – rice and berseem clover – rice crop rotations. Rice paddy yield was significantly increased by 8% after *Azotobacter chroococcum* inoculation. Rice paddy yield was significantly increased from 6628.8 to 7340 kg ha^{-1} as N rate

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increased from 50 to 75 kg ha^{-1}, but further N application (100 kg ha^{-1}) had no significant effect on paddy yield. Of the yield components, panicle number per m^2 was significantly affected by crop rotation, *Azotobacter chroococcum* inoculation and N rate, while grain number per panicle was significantly affected only by crop rotation. Moreover, 1000-grain weight was not significantly affected by any factors. The highest panicle number per m^2 was observed in berseem clover – rice crop rotation (352.1 panicles), N fertilizer at the rate of 100 kg ha^{-1} (362.0 panicles) and *Azotobacter chroococcum* inoculation (353.2 panicles). The highest grain number per panicle (105.8 grains) was observed in berseem clover– rice crop rotation, while the lowest one (96.3 grains) was observed in faba bean– rice crop rotation.

Conclusion: Based on the result of this experiment, in all crop rotations with rice, the highest paddy yield was obtained in nitrogen application at the rate of 75 kg ha^{-1} and plants inoculated with *Azotobacter chroococcum*.

Keywords: Berseem clover, Biological N_2 fixation, Crop rotation, Faba bean, Plant growth-promoting rhizobacteria