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Quantifying dry matter production and partitioning in different parts of safflower (*Carthamus tinctorious* L.)

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Abstracts

Introduction: Simulation crop models are a robust tool to improve crop management and to study yield limiting and reducing factors. Crop parameters related to phenology, leaf area and dry matter production and partitioning are needed to simulate crop growth and yield. Therefore, the aim of present study is to quantify the dry matter production and to estimate dry matter partitioning coefficients to different crop parts (stem, leaf and grain).

Materials and Methods: A factorial experiment was conducted based on completely randomized block design with four replicates and three sowing dates (4 April, 25 April and 16 May) and four cultivars (411, Sina, Local Isfahan and Sofeh) in Research Farm of Rafsanjan Vali-e-Asr University in 2011. Sampling was done at an interval of 5-10 days from two weeks after planting and continued up to end of the growing season. On each sampling, the leaf, stem and grain dry matter weight were measured. The truncated expolinear model was fitted on total dry matter weight (w) data over the time (t). Coefficient of dry matter partitioning to different crop parts (leaf, stem and grain) was obtained by fitting the linear regression model on dry matter weight of each part versus total dry matter weight.

Results: Results showed that the model well described the trend of dry matter production versus days after planting. According to the model, the maximum dry matter accumulation in all three planting dates was obtained 972-1179, 576-611 and 191-277 gm^{-2}, respectively. Coefficient of dry matter partitioning to leaves ranged from 0.45 to 0.51 in the first planting date, 0.51 to 0.60 in the second planting date and 0.44 to 0.61 in the third planting date. There was no different between the coefficients of cultivars. Coefficient of dry matter partitioning to stem in all three planting dates were 0.35-0.49, 0.24-0.44 and 0.14-0.23, respectively. There was no significant difference among the cultivars. Partitioning coefficient to grain was between 0.16 and 0.44 for the first planting date that was lower than the second planting date. In the third planting date, the coefficient was between 0.35 and 0.76 that there was a significant difference among the cultivars.

Conclusion: It was concluded that the trend of the dry matter production and partitioning is affected by environmental condition (temperature and solar radiation) and cultivar. The results showed that with delay in planting date crop growth rate and dry matter production were decreased. In such condition, coefficient of dry matter partitioning to stem was decreased and coefficient of dry matter partitioning to leaves and grain was increased.

Keywords: Dry matter, Planting date, Quantification, Safflower

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Interaction between sulfur and zinc on cotton (*Gossypium sp.* L.) yield and some soil parameters

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Abstract

Introduction: Sulphur in plant as important as phosphorus and importance for producing protein is the same as nitrogen. But it has second position in soil and plant system, after nitrogen, phosphorus and potash. Sulphur in soil is under influence of *Thiobacillus* bacteria which convert it to sulphuric acid in the soil and this sulphuric acid can affect the soil reaction. Acidification of the soil happen temporarily and solubility of the mineral increase and plant could use them better.

Method and materials: This research was done based on interaction of sulphate, zinc and *Thiobacillus* bacteria on cotton yield and yield component and soil parameters. Factorial experiment was done based on complete randomized block design with thee replications In Hehvalat of khoasan Razavi. The factors included the using, zinc sulphate in two levels (0 and 50 Kg ha^{-1}), granular sulphate in three levels, control, 500 and 1000 Kg ha^{-1} and using *Thiobacillus* in two levels, control and application.

Results and Discussion: Results of analysis of variance data on interaction effect of sulphur with *Thiobacillus* and zinc on some agronomic and soil traits increased significant at 1% probability in comparison to treatment without Sulphur and Zinc application with producing 5208 Kg ha^{-1} cotton yield and 3622 Kg ha^{-1} cotton seed yield, and 7.88 Kg ha^{-1} boll weight. Number of the reproductive branches in this treatment was significantly increased (at 1% level). Effect of Sulphur, zinc and interaction between zinc and *Thiobacillus* on boll per plant increased significantly. Soil pH, EC, absorbable Sulphur, plant height and first boll height was significant. Application of 1000 Kg ha^{-1} Sulphur without application of *Thiobacillus* and zinc and 1000 Kg ha^{-1} Sulphur with *Thiobacillus* increased significantly seed yield and cotton yield in comparison to control. Application of 500 Kg ha^{-1} Sulphur and 500 Kg ha^{-1} Sulphur with zinc increased boll weight significantly. Application of 1000 Kg ha^{-1} Sulphur decreased soil pH (7.35) and increased soil electrical conductivity (16.5). Amount of absorbed Sulphur increased significantly at 1% and amount of absorbed zinc increased at 5%. Application of 500 Kg ha^{-1} Sulphur with *Thiobacillus* increased significantly absorbable Sulphur of the soil and absorbed Sulphur. Results of the data showed that effect of main effect on cotton seed oil content is not significant.

Conclusion: Results showed that interaction effect of sulphur, zinc and Thiobacillus on some agronomical properties and soil were significant. According to mean comparison results, treatment of 1000 Kg ha^{-1} sulphur, without *Thiobacillus* and zinc caused significant effect on cotton yield, cotton seed yield, soil EC, soil available sulphate and zinc.

Keywords: Agronomic traits, Sulphur, *Thiobacillus*,Yield

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Phosphorus fertilizer rate and inoculation by *Streptomyces* bacteria effect on phosphorus and dry matter accumulation and partitioning - wheat and barley

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Abstract

Background and objectives: Information on the concentration and accumulation of phosphorus (P) in the plant dry matter (DM) and the coefficients of its allocation to different plant parts can help improve the P nutrition management of crops and increase the efficiency of P fertilizers. In addition, this information is required in crop growth simulation models.

Materials and methods: In order to investigate the effect of inoculation with *Streptomyces* sp. bacteria and fertilizer P rates (0, 20, 40, 60 and 80 kg P ha) on the P and DM accumulation and partitioning in wheat (cultivar Morvarid) and barley (cultivar Sahra) a pot experiment was carried out in new campus of Gorgan University of Agricultural Sciences during 2015 growing season. The experimental design was completely randomized design as a factorial experiment with four replications. Soil available P was recorded 5.8 mg kg^{-1}.

Results: Results showed that the effect of fertilizer P rate on DM accumulation, P concentration and accumulation in all plant parts was significant (P = 0.01), statistically. Inoculation also influenced on the DM accumulation in all plant parts except seeds, and P accumulation in all of them except the stem, but its effect on the P concentration in different parts of plant with the exception of leaf and root was not significant. Hence, it can be deduced that the rate of fertilizer phosphorus through both DM accumulation and P concentration, and inoculation only via DM accumulation affected on the P accumulation. Also, the findings of this study showed a very high stability of allocation coefficients of DM and P to different parts of plant compared to DM and P accumulation and P concentration. In unfertilized control, the accumulated phosphorus rate in whole plant was 3.99 and 4.57 and in grain was 1.79 and 1.94 mg P $plant^{-1}$ for wheat and barley, respectively. Based on the segmented model fitted data, the accumulation of phosphorus in the whole plant increased linearly up to 51 and 59, and in their grain up to 47 and 54 Kg P ha^{-1} for wheat and barley, respectively. But after that, more fertilizer P application did not significantly change the quantity of P accumulated per plant or grain. In above mentioned fertilizer phosphorus rates, the amount of P accumulated in whole plant was 13.67 and 13.38 and in grain was 7.95 and 6.29 mg P $plant^{-1}$ for wheat and barley respectively. In both investigated crops, at all levels of fertilizer P, the order of organs based on the P accumulation was as grain > stem > leaf> root.

Conclusion: The findings indicate the increased dry matter accumulation, concentration and accumulation of phosphorus in all plant organs by increasing the amount of phosphorus fertilizer, and relative stability of allocation coefficient of dry matter and phosphorus to organs at different levels of phosphorus fertilizer. Also, inoculation increased vegetative growth and thereby increased the accumulation of phosphorus in plant. The results of this research reveals that two strategic crops of wheat and barley uptake 3.6 to 5.9 kg P per ton of grain and 1.7 to 2.9 kg P per ton of straw depending on the amount of available P in the soil.

Keywords: Grain, Leaf, Phosphorus concentration, Root, stem

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Effects of different levels of vermicompost on morphophysiological and essential oil characteristics of Peppermint (*Mentha piperita* L.) under water deficit regimes

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Abstract

Background and objectives: Drought is one of the most important factors limiting plant growth around the world. So it can be used minimum water with using natural fertilizer such as vermicompost and can be caused to reduce water evaporation from soil, protect and storage water in the soil. The interest in plant products has increased considerably all over the world because many herbal medicines are free from side effects since most medicinal plants are consumed raw, proper management of crop production is needed to achieve high quality plants. So in this regard, experiment was done to study the effect of different levels of vermicompost on morphophysiological and essential oil characteristics of Peppermint (*Mentha piperita* L.) under water deficit regimes.

Materials and methods: A pot experiment was conducted as factorial based on completely randomized design with three replications at Gorgan University of Agricultural Sciences and Natural Resources greenhouse during 2016. Treatments were included Irrigation regimes in three levels (100 percent FC, control, 75percent FC and 50percent FC) and vermicompost in three levels (0, 20 and 40percent volumetric). Studied traits were included plant height, internodes distance, fresh and dry weight, number of tillers, leaf water ratio, proline, soluble sugar and essential oil percent. After planting, harvesting and growth characteristics, essential oil, soluble sugar and proline were evaluated with Clevenger, the method of Omokolo and the method of Bates, respectively.

Results: The results showed that internodes distance, fresh and dry weight of shoot, number of tiller and leaf water ratio, were decreased by increasing drought stress. Also, with increasing drought stress, leaf water ratio decreased (2.13 percent) and proline, soluble sugar and essential oil percent were increased 0.72, 10, 14 and 0.13 percent, respectively. Vermicompost had significant effects on all of morphological and physiological characteristic and this effect was the highest in 40 percent volumetric. Interaction effects of Irrigation regime and vermicompost had significant effects on all of morphological and physiological characteristic except of fresh weight of shoot and number of tillers. Essential oil (0.33 percent) and leaf water ratio (23.71 percent) increased in 40 percent volumetric in 50 percent FC.

Conclusion: Due to the results, it be expressed that vermicompost application could reduce chemical fertilities requirement and achieve to sustainable agriculture then eliminated part of the drought stress effects on Peppermint. Generally, the results showed that by vermicompost application (40 percent volumetric) reduced drought damage on growth characteristics and the most essential oil.

Keywords: Essential oil, Lamiaceae, Proline, Vermicompost, Water deficit stress

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Sprouting, plant establishment, and yield improvement of potato (*Solanum tuberosum* L.) minituber cultivars by foliar application of benzylaminopurine and abscisic acid

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Abstract

Backgrounds and objectives: Potato is the fourth important crop worldwide. Since potato is mainly propagated vegetative via tubers, increasing production of high quality and virus free seed potato is very important. Phyto-hormones regulate a wide range of processes and tuberization in potato. Due to small size and weakness of minitubers and some difficulties in plantlets establishment in the field, more studies are needed to improve plant establishment and productivity of minitubers under such conditions. Therefore, this study was carried out in order to evaluate the possibility of improving sprouting and plantlet establishment of potato minituber cultivars (Agria and Fontane) using plant growth regulators (6-benzylaminopurine- BAP, and abscisic acid- ABA).

Materials and Methods: A two-step experiment was carried out at the Ferdowsi University of Mashhad, during 2014-15. In the first experiment, foliar treatment of mother plants at stolonization or tuberization stages using plant growth regulators (BAP, ABA, and BAP+ABA, 50 µM) under controlled conditions was performed. In the second experiment, progeny minitubers were compared in terms of sprouting, plantlets establishment, and yield under field conditions. Factorial arrangement based on completely randomized design and complete block design were used for the first and second experiments, respectively. Number of sprouts per minituber, length of sprouts, day to emergence, emergence percentage, number of stems per plant, morphological traits, yield, and yield component were evaluated.

Results: BAP application in tuberization stage increased sprout length in Fontane and Agria in comparison to control and the shortest day to emergence observed in this treatment in comparison to control. Significant linear relationship was observed between sprout length and day to emergence (R^2=0.88). The number of established plantlets and percentage of emergence were enhanced by treating plants using BAP or ABA compared with control plants, but the effects were different between cultivars. The greatest emergence percentage observed in ABA-treated plants at stolonization stage, which was 39% more than the control. In addition, Fontane showed 15% higher emergence rate than Agria. BAP+ABA application at tuberization stage advanced the number of sprouts in Agria, whereas, the most number of sprouts in Fontane recorded when BAP applied at tuberization stage it was 38% more than control. There is the significant linear relationship between the number of sprouts on minitubers and the number of tubers in the next generation (R^2=0.53). Regardless to the cultivar, application of BAP+ABA at tuberization stage increased the number of tubers per plant.

Conclusion: The results indicating that application of BAP caused to increase the number of sprouts and shortened the days to emergence, whereas, ABA improved emergence parentage and plantlet establishment of the both cultivars. It seems that both BAP and ABA could be effectively used for improving sink strength for better supporting the sprouts growth under field conditions. Based on our results, application of PGRs increased the number of sprouts per tuber on Fontane and Agria which result in producing higher number of stems, hence, enhance the number of tubers per plant, however, the effects are different between cultivars and Fontane produced more tuber.

Keywords: Cytokinin, Days to emergence, Sprout length, Plant Growth Regulators

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Early sowing date as a strategy for improvement of maize yield and maize physiological and phenological characteristics in climate change conditions at Kermanshah Province

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Abstract

Background and objectives: Climate change can directly effect on worldwide food security because climate change processes (such as increasing of CO_2 concentration and temperature and variability of precipitation) have directly effect on crops. Corn such as C4 plants that are sensitive to climate changes. Therefore to reduce the sensitivity of the maize in the face of climate change, we need to apply adaptation strategies. One of the effective strategies is the changes in sowing dates. Many of studies have shown that changes in sowing dates (particularly the use of early planting dates) can reduce the negative effects of climate change.

Materials and methods: This research was conducted in three locations of Kermanshah Province. Accordingly, the future climate in the study areas was generated using long-term (1980-2009) climate data of the baseline (included minimum and maximum temperatures, rainfall and global radiation) and AgMIP technique under two climate scenarios (RCP4.5 and RCP8.5) for the future period of 2040 -2069. Long-term simulation experiments consisted of five sowing dates (5st April, 20st April, 5st May, 20st May, 5st June), three locations (Kermanshah, Kangavar and Eslamabad), two future climate scenarios (RCP4.5 and RCP8.5) in 30 years. In total, around 1350 simulation experiments were carried out. In this study, APSIM crop model was used for simulation of maize growth and yield. In this study, all of the simulations were conducted in potential conditions and water- and nitrogen-limited production situations were not considered in the current study. APSIM model has previously been calibrated and evaluated for SC704 cultivar (this cultivar is the most common cultivated cultivar in the Kermanshah Province). In current research, all the output data was analyzed, graphed and mapped using the R software package (24) and OriginPro9.1 (31).

Results: Average grain yield of Kermanshah Province was 11354 Kg ha^{-1} in the baseline. Results showed that in 2050, on average grain yield was reduced 60.82 and 80.73 % (under RCP4.5 and RCP8.5, respectively) compared to baseline. In different locations, the highest and lowest grain yield in the baseline were recorded in the Kangavar with 13426 Kg ha^{-1} and Kermanshah with 7952.4 Kg ha^{-1}. When averaged across locations, the highest grain yield in the climate change conditions was obtained in an early sowing date (5st April) with 7071.2 and 4743 Kg ha^{-1} (under RCP4.5 and RCP8.5, respectively). In future on average (two scenarios) duration of growth period, vegetative and reproductive growth periods (4.7, 4 and 1.7 %, respectively) were decreased compared to the baseline. Also, in future, the number of grains and grain weight were reduced in Kermanshah Province so that under RCP4.5 were 56.5 and 31.8 %, respectively and under RCP8.5 were 78.5 and 59.3 %, respectively. However, these reductions in duration of growth period, vegetative and reproductive growth periods, the number of grains and grain weight were less in 5st April early sowing date than other sowing dates (especially late sowing dates).

Conclusion: Generally, results of the current study indicated that climate change had negative effects on maize yield and maize physiological and phenological characteristics in Kermanshah Province. However, early sowing dates might reduce these negative effects. So that in most cases, 5st April can reduce negative effects on maize yield and maize physiological and phenological characteristics in the future period.

Keywords: APSIM-Maize, Climate change, Number of grains, Maximum leaf area index

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Responses of some agronomical characteristics of faba bean (*Vicia faba* L.) to biofertilizers under water deficit stress

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Abstract

Background and objectives: Iran's climate is mostly arid and semi-arid, where water availability is a major problem in crop production. In regions where water scarcity is the principle limiting factor for crop cultivation, farmers are interested in growing crops that are able to adapt to drought conditions. Bio-fertilizer has been identified as an alternative to chemical fertilizer in sustainable farming. Organisms that are commonly used as biofertilizers component are nitrogen fixers (N-fixer), potassium solubilizer (K-solubilizer) and phosphorus solubilizer (P- solubilizer), or with the combination of molds or fungi increased soil fertility, growth and yield plants. Therefore, the aim of this study was to investigate the use of biofertilizer in drought stress on several morphological and yield characteristics of faba bean under field condition.

Materials and methods: In order to study the effects of different irrigation levels and biofertilizers on yield and yield components of faba bean, a field experiment was conducted as split plot based on a Randomized Complete Block Design with three replications at a farm located in West Azerbaijan province – city of Naqadeh, during growing season of 2013-2014. The main plots were allocated to irrigation levels (Irrigation after 50 mm (control), 100 mm (moderate water stresses) and 150 mm (severe water stresses) evaporation from class A pan) and sub-plots were allotted to biofertilizers (*Azotobacter* and Barvar Phosphate-2, *Azotobacter* + Barvar Phosphate-2 and control). The experimental units in each block included of 8 rows with 40 cm inter-raw and 7 cm intra-row spacing of 4 meters long. Different traits such as plant height, number of pods per plant, number of seeds per pod, 1000-seed weight, biological yield, seed yield and percentage of protein were recorded. Seed protein content was determined by the micro-Kjeldahl method. Seed protein content was calculated by multiplying the total N content by 6.25. The data were subjected to analysis of variance (ANOVA) using SAS statistical package. Means of each trait were compared on the bases of LSD test at $p \leq 0/05$.

Results: Results showed that factors had significant effects on plant height, number of pods per plant, number of seeds per pod, 1000-seed weight, biological yield and seed yield of faba bean but the interaction of irrigation×biofertilizer on any of the traits under study were not significant. In comparison of severe stress (lowest yield and yield components) and non-stress conditions, plant height, number of pods per plant, number of seeds per pod, 1000-seed weight, biological yield and seed yield were decreased 21.90, 39.83, 28.83, 26.15, 33 and 38%, respectively. Increasing of distance irrigation increased grain protein content. Also, the use of bio-fertilizers increased the protein content of faba bean. Generally, combined usage of biofertilizers showed the greater increasing in studied traits than individual consumption.

Conclusion: Inoculation with biofertilizers could not reduce the adverse effects of drought stress and could not effect on increasing of yield significantly. Therefore, to achieve optimal performance in arid and semi-arid areas, it's better to irrigation faba bean during different periods of growth and development. It is suggested that this research is better to be conducted on another year to get the best functioning for this area.

Keywords: *Azotobacter*, Barvar Phosphate-2, Pod, Yield components, Yield

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Response of different genotypes of safflower (*Carthamus tinctoriuos* L.*)* to the foliar spraying of nano-iron oxide at the low irrigation conditions

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Abstract

Background and objectives: Among oilseeds that have a good compatibility with the climatic conditions of Iran, safflower has a special place due to the drought and salinity resistance and also because of having the different spring and autumn varieties. Environmental stresses are the main factors reducing growth and crop yield. Among the environmental stresses, water stress is the main risks for the successful production of crops in Iran and the world. One of the most important applications of nanotechnology in various agricultural fields, especially regarding to the water and soil, is the application of nano-fertilizers to nourish plants. Iron is one the micro elements in plant nutrition. In the condition of iron deficiency, the amount of photosynthetic pigments such as chlorophyll content decreases.

Materials and methods: To evaluate the effect of foliar spraying of nano-iron oxide on yield and some important agronomic traits of safflower genotypes at the low water stress conditions, an experiment was carried out in split factorial based on randomized complete block design with three replications in 2016 at the research farm of Imam Khomeini International University. The main factors include irrigation on two levels (full irrigation and water stress in the flowering stage) and nano-iron oxide spraying on two levels (application and non-application of nano-iron oxide) and sub-factor included 10 genotypes of safflower (Golmehr, Padideh, Goldasht, Sofeh, Mexican88, Sina, Mexican11, Isfahan mahali, Faraman and Kuseh).

Results: The effect of irrigation on plant height, seed number in boll, boll number in plant and seed yield were significant. The effect of fertilizer was significant only on the subsidiary branches number but genotype effect was significant on all traits. The interactions between irrigation and genotype, fertilizers and genotype and among irrigation, fertilizer and genotype were significant on all traits. The interaction between irrigation and fertilizer in most of the traits except 1000 grain weight and harvest index was significant. Mexican genotype (88) had the maximum grain yield (499.5 g m^2) in the conditions of non-stress and foliar application of nano-iron oxide. Correlation analysis revealed that harvest index in both normal and stress conditions showed the highest correlation with grain yield. Based on cluster analysis, Sina, Kuseh, Goldasht and Mexican 88 genotypes in non-stress condition and Faraman, Kuseh and Mexican 88 genotypes under stress condition had the highest yield and yield components.

Conclusion: The study showed that, regarding to the most traits, Mexican 88 and Kuseh genotypes were suitable for planting in both stress and non-stress conditions.

Keywords: Water deficit stress, Nano-iron oxide, Safflower, Yield

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Determination of optimum concentration of three antioxidant enzymes for increased drought tolerance in Mung Bean (*Vigna radiata* L.) using genetic algorithm

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Abstract

Background and objectives: The free radicals amounts are increased due to drought stress and subsequently plants have oxidative stress. The drought stress-resulted free radicals are scavenged by changing in activity of antioxidants like catalase, superoxide distmutase (SOD) and guaiacol peroxidase (GP) (regressors or independent variables; Xs). This reaction is known as resistance to (protection against) oxidative stress. This protection is reflected in traits like growth and grain production (biomass and harvest index, respectively; dependent or response variables; Ys). By maximizing Ys in relation to Xs, the combination of Xs with possible highest Ys can be obtained. This optimization comes from the relations of Ys with Xs under drought stress conditions. Due to having more than one Ys here, the relation tends to be multivariate and highly complex, especially when there is no strong positive relation (correlation greater than +0.95) between Ys variables. In such situations, the genetic algorithm can overcome the complexity. The output of mentioned algorithm can be used by plant breeders. In another words, breeders can increase drought tolerance by genetic manipulation of plant for optimum activity of Xs. This experiment was aimed to do the mentioned optimization for Mung Bean.

Materials and methods: The experiment was carried out in pots located in an open filed to increase the accuracy and possibility of generalizing the results to field results. Pots had 5 kg capacity in which 5 seeds of line VC1973a were planted. For thinning, 3 seedlings were removed, and left 2 ones. The filed capacity was determined using weight method. Treatment levels were 4 levels of low irrigation including irrigation at 80% (control), 65% 50%, and 35% of field capacity. At maturity stage, the harvest index and biomass (biological yield) (Ys) were measured. The concentration of antioxidant enzymes catalase, SOD, and GP (Xs) were determined at flowering stage. For maximizing the function, first partial desirability function was determined. Then general desirability function was calculated. The value of Xs for which the highest amount of Ys is attainable was obtained on the basis of genetic algorithm and using MATLAB software.

Results: The results indicated that a function with 7 components including the main and interactive effects of Xs could predict the relation of Ys with Xs well **(**Adjusted R^2>0.97). The standardized regression coefficient was positive for catatlase which reveals that the drought resistance (harvest index and biomass) enhances with increasing the activity of this enzyme. Like catalase, the effect of GP was additive on drought tolerance, but considering its standardized regression coefficient, this enzyme had a lower effect than catalase. Due to negative standardized regression coefficient for SOD, it could be concluded that the drought tolerance doesn't enhance with increasing activity of SOD.

Conclusion: The optimized concentration of catalase, SOD, and GP was 0.956 µmol H_2O_2 g^{-1} FW, 24.23 AU g^{-1} FW, and 21.23 AU g^{-1} FW, respectively for possible maximum drought tolerance. It should be mentioned that these optimized concentrations were all among observed concentrations. Moreover, reports indicate that there is genetic diversity in activity of antioxidant enzymes (prerequisite to carry out breeding programs for attaining the optimized activity) for Mung Bean.

Keywords: Optimization, Catalase, Superoxide dismutase, Guaiacol peroxidase

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The effect of folic acid on yield and some qualitative parameters of wheat (cv. Gaskogen)

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Abstract
Background and purpose: Nowadays malnutrition due to low food diversity is a serious problem in developing countries like Iran. Due to important role of wheat in nutrition of these countries, researchers try to produce wheat grains with higher proteins, amino acids, iron and zinc content, providing essential body nutrients and as a result reduce malnutrition. Considering the role of folic acid in transfer of single carbon fragments and its effect on improvement of metabolic processes, in this research effect of external application of folic acid on the quality and yield of wheat grains were investigated.
Material and methods: Gaskogen wheat cultivar was planted in a farm experiment conducted at research farm of Maragheh University using randomized complete block design with three treatments with density of 500 seeds per m^2 in early spring of 2013. The three treatments were as follows: control (without application of folic acid), priming of seeds with 25 and 50 µM solution of folic acid for 12 h and leaf spraying of folic acid with 50 µM concentration at stem elongation, heading, milky stage and dough stage. The third one was the same as second one except leaf spraying in heading stage. Folic acid spraying is carried out in the final hours of day by a pump sprayer. 100 mL of solution was sprayed per each square meter.
Finding: Results revealed that folic acid external application had following advantages compared to control: firstly, increase the yield of grain, Secondly, protein, essential amino acids, Iron content of grain is increased meaningfully and finally cause to increase the chlorophyll content in flag leaf.
Conclusions: In this research the effects of external application of folic acid have been studied on whole grain, but part of accumulated iron along with proteins during flour preparation process have been omitted. However considering positive impact of external application of folic acid on quality of grains and on proteins, amino acids, iron content of them; we can claim that this method was a short-term solution for both improving quality and quantity of food and reducing adverse effect of malnutrition.

Keywords: Iron, Phytic acid, Protein, Malnutrition, Zinc, Zn/PA ratio

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Yield gap analysis of rice in relation to soil properties in Foumanat plain

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Abstract

Background and objectives: Nowadays, due to population growth and changes in eating habits, there is a need to increase agricultural productions to meet consumer demand all around the world. Increasing the area under cultivation is one of the solutions for this problem, which cannot be appropriate in future because this needs to use of marginal lands with low yield and stability. Hence, increased yield is an effective strategy in this regard which can resolve the problem by decreasing yield gap. Considering the fact that there is an urgent need to increase rice production in the country as well as improving the productivity of soil resources, planning for the proper use of chemical fertilizers to achieve the maximum performance seems to be required. Accordingly, the aim of this study was to evaluate rice potential yield and yield gap in Foumanat plain using boundary line analysis, moreover, to find the relationship between soil properties and rice yield.

Materials and methods: In order to investigate the yield gap (YG) of rice (cv. 'Tarom Hashemi') related to soil properties, a field experiment was carried out in Foumanat plain during two cropping seasons: 2012-13 and 2013-14. We recorded the information of 53 fields as soil samples were taken and geographic coordinates were recorded. Some soil characteristics such as total nitrogen, potassium, phosphorus, organic matter and cation-exchange capacity were measured. At the end of growing season (harvesting time) grain yield was calculated in each field (1 m^{-2}). The boundary line method was used to calculate yield gap, optimum yield and optimum amount of soil properties for each field. Data analysis done by nonlinear regression of quadratic function, dent-like and segmented models based on PROC NLIN procedures.

Results: Segmented functions were well able to describe the trend of pH and electrical conductivity of soil. In addition, dent-like function used to describe the process of changes in available phosphorus, available potassium, organic matter and cation exchange capacity. Also, a quadratic function was used to describe the trend of total nitrogen. The average of optimum yield and actual yield were 7.67 and 4.81 t ha^{-1}, respectively, in Foumanat plain with an YG of 2.86 ton ha^{-1} (37.3 percent). The optimum concentration of total nitrogen, phosphorus, potassium, organic matter, cation exchange capacity, pH and electrical conductivity were 0.266 percent, 13.49-30.35 mg Kg^{-1}, 102.2-173.4 mg Kg^{-1}, 2.7-3.2 percent, 25.43-30.8 meq 100 g^{-1}, 6.36 and 1.92 dS m^{-1}, respectively.

Conclusion: Based on the results of this study, some of the main factors for rice YG in this area could be inappropriate management of chemical fertilizer usage (nitrogen, phosphorus and potassium) as well as ignored role of organic matter and cation exchange capacity in providing essential nutrients for rice. Boundary line analysis method could clearly calculate the soil properties potential in response to yield. In general, the results of this study can help to conclude a good strategy for achieving optimal production and gap reduction due to fertility situation of the area.

Keywords: Boundary line, Yield gap, Non-linear regression, Optimum yield, Soil resources

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Study the effect of growth stimulator and chemichal fertilizer application on growth and yield of *Solanum tuberosum*

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Abstract

Background and objectives: Potato is the fourth most important food crop in the world that plays an important role in people feeding. This crop is a source of carbohydrates, protein and essential amino acids for human being and it is one of the important tuber plants. Low yield of crops in many countries often related to the deficiency of soil nutrients. Chemical fertilizers have an important role in improving yield and quality of potatoes. However, excessive use of chemical fertilizers is associated with many health and environmental problems and pollution in water and soil. This study was conducted to evaluate the effect of fertilizers and growth promoters on potato (cultivar Milva) yield.

Materials and methods: Experiment was conducted at the Agricultural Research Station of Gonbad Kavous University in a randomized complete block design with three replications in 2016. Treatments included the use of nitrogen, phosphorus and potassium to amount of common use of region (100 NPK), 100 NPK + Humic acid (HMC), 100 NPK + Equilibrate vegetative organic (EVEO), the use of nitrogen, phosphorus and potassium at a rate of half of the region convention (50 NPK) + HMC, 50 NPK + EVEO, application of EVEO and HMC alone. Traits of tuber number plant^{-1}, fresh and dry weight of tubers plant^{-1}, plant fresh weight ha^{-1}, biological yield, tuber yield, and harvest index were measured.

Results: Results indicated that application of HMC and EVEO with chemical fertilizers significantly increased tuber number plant^{-1}, tuber weight plant^{-1}, biological yield, tuber yield, and harvest index; but they had no significant effect on plant weight. The highest tuber number plant^{-1}, dry weight of tuber plant^{-1}, biological yield, tuber yield, and harvest index were obtained in 100 NPK + EVEO; although there was no significant difference with treatments of 100 NPK + HMC and 50 NPK + EVEO. The lowest amount of these traits were achieved in the treatment 100 NPK. However, it had no significant difference with treatments of application of EVEO and HMC alone.

Conclusion: Based on these results, the use of EVEO can reduce consumption of chemical fertilizers by 50%. Also, significant difference was not observed between chemical fertilizer treatment (100 NPK) and application of EVEO and HMC alone. Therefore, use of these organic materials can increase the absorption and efficiency of nutrition and consequently reduction of the consumption of chemical fertilizers will help to reduce environmental pollution.

Keywords: Chemichal Fertilizer, Growth stimulator, Humic acid, Potato yield

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Effect of potassium, zinc and boron foliar application on canopy temperature, physiological traits and yield of two bread wheat cultivars under optimum and late planting dates

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Abstract

Background and objectives: wheat (*Triticum aestivum* L.) is one of the most important sources of plant food for human. High temperature resulting from delay in planting is one of the major environmental factor limiting growth and production of wheat, especially in tropical regions. Canopy temperature is one of the parameters which is used for evaluating the effect of heat stress on wheat. Most of the Iranian soils have high pH and calcareous nature. In this type of soils solubility of nutrients low, absorption of these elements by plant reduced and requirement of plants increases to these nutrients. This experiment was conducted to study the effect of potassium, zinc and boron foliar application on physiological traits and yield of two bread wheat cultivars under optimum and late planting dates.

Materials and Methods: An experiment was conducted as split-split plot based on randomized complete blocks design with 20 treatments and three replications in Ramhormoz city with latitude 31°16' N and longitude 49°37' E and a height of 160 meters above sea level in farming year 2015-16. The experimental factors were included planting date in two levels: optimum (November 21) and late (January 5) as the main factor, nutrients foliar application in five levels: (water as a control, potassium, zinc, boron and combination potassium + zinc + boron (each 3 lit.h^{-1})) as the sub factor and two cultivars of bread wheat Pishtaz and Chamran 2 as the sub-sub factor. Solutions for foliar application were prepared by using potassium (21%), zinc-chelate (7.5%) and boron (5%). Traits measured were included leaf chlorophyll content, flag leaf relative water content, cell membrane stability index, maximum quantum efficiency of PSII (Fv/Fm) and leaf proline content.

Results: The results showed that with delay in planting all above traits except leaf proline content decreased significantly due to terminal heat stress. However, the delay in planting was increased canopy temperature. Potassium, zinc and boron foliar application separately and in combination reduced harmful effects caused by the delay in planting on the traits leaf chlorophyll content, flag leaf relative water content, cell membrane stability index, maximum quantum efficiency of PSII (Fv/Fm), leaf proline content and grain yield in both wheat cultivars. As well as, foliar application these nutrients reduced canopy temperature of wheat cultivars under both optimum and late planting dates. Despite the lack of significant differences in Pishtaz and Chamran 2 wheat cultivars in canopy temperature, cell membrane stability index, maximum quantum efficiency of PSII (Fv/Fm), leaf proline content and grain yield, these cultivars showed a more appropriate response to the zinc separate application and potassium + zinc + boron combined application in both optimum and late planting dates, respectively.

Conclusion: Chamran 2 wheat cultivar without nutrients foliar application of potassium, zinc and boron (control) showed more yield than Pishtaz cultivar under optimum condition but at late planting dates, wheat cultivars had different response to nutrients foliar application of potassium, zinc and boron. There is a significant relationship between canopy temperature with measured physiological traits and grain yield, so that loss of canopy temperature was improved physiological traits and subsequently increase yield bread wheat cultivars of Pishtaz and Chamran 2 under optimum and late planting dates, that this improvement was evident with the use of zinc foliar application for chamran 2 wheat cultivar and potassium+zinc+boron foliar application for Pishtaz wheat cultivar.

Keywords: Nutrients, Terminal heat stress

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