# Fertility evaluation of land for maize cultivation using GIS, fuzzy logic and ANP (Case study: four basins of Golestan province)

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**Abstract**

**Background and objectives:** One of the most important factors in the production of high yield of plants is the presence of soil nutrient elements. Therefore, the accurate study of the amount of available elements such as macronutrients and micronutrients in soil is essential for the production of important products such as maize. For this purpose, preparing the soil fertility map of four basins agricultural in Golestan province was examined by Geographical Information System (GIS), Fuzzy logic and Analytic Network Process (ANP) for maize cultivation.

**Materials and methods**: This research was carried out in four basins of Qaresoo, Qarnabad, Mohammadabad and Zaringol in Golestan province. The information of 858 sampled points were used for the preparation of soil elements layers including K and P available, total N, Ca, Mg, Fe, Zn, Cu and Mn absorbable of the soil. First, the raster layer of each element was prepared in ArcGIS10.4 media by ordinary Kriging method in the agricultural lands of the study area. Then, with the help of fuzzy functions, each fuzzy standardization element map was prepared, the maps for each element were weighed using ANP and the soil fertility map was prepared by the layers' overlay the soil fertility map was prepared. In order to adapt the layers produced with the nutritional needs of maize, nutritional requirements of this plant were determined using the scientific resources. Finally, the final layer was divided into five categories of very high fertility, high, moderate, low and very low.

**Results**: The results showed, the fuzzy value of the agricultural land in the study area was between 0.30 and 0.78. 119771.47 ha, equivalent to 59.87% of the studied area, had a moderate fertility that was more in the middle part of the study area and 80212.65 ha, equivalent to 40.9% had low fertility that was more in the north and south. 84.24 ha, equivalent to 0.04 percent had high fertility and two categories of very low fertility and very high fertility had no share of the study area. Among the basins, Zaringol basin had the highest fertility and the Mohammadabad basin had the lowest fertility. The mean fuzzy value showed, the elements of Mn and K had the highest fuzzy value and the elements of Ca and Zn had the lowest fuzzy value, respectively. The elements of K, P, N, Ca, Mg, Fe, Zn, Cu and Mn reduced the fertility value of the studied lands' area 69.38, 76.02, 96.98, 94.68, 47.81, 49.10, 96.98, 69.57 and 30.28%, respectively.

**Conclusion**: The results of the fertility zoning of the four studied basins with the help of fuzzy logic and ANP for maize cultivation showed, almost the entire study area (with the exception of 84.24 ha) faced with problems in terms of fertility. Zaringol basin was the most fertile basin for corn cultivation and Qaresoo, Qarnabad and Mohammadabad basins were in the next rank of fertility, respectively.

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***Keywords***: ANP, Fertility, Fuzzy logic, GIS, Maize.

# Study Qualitative and quantitative traits of sugar beet cultivars at different planting times in transplanting and seedling cultivation system in West Azarbaijan area

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## Abstract

**Background and objectives:** One of the problems of sugar beet planting in West Azarbayjan province in early spring, not preparing the land for cultivation due to poor weather conditions. Since the proper economic yield in sugar beet is due to proper vegetative growth in the early growing season and appropriate allocation and distribution of photosynthetic materials to the root, the timely cultivation of this plant is very important. The accelerated growth of the plant can be controlled under controlled conditions with the use of cultivation in the greenhouse and its transfer to the main land at a time when the risk of late winter cold and the problem of water scarcity is resolved. The present study was conducted to compare and evaluate quantitative and qualitative traits of sugar beet cultivars in in transplanting and seedling cultivation in different planting dates in western Azarbayjan province.

**Materials and methods:** In order to study the quantitative and qualitative characteristics of sugar beet cultivars (Dorotea, Isabella and Ekbatan) in transplanting and seedling cultivation system in West Azarbaijan area in three planting date (25 March, 8 and 18 April), A split plot experiment based on randomize complete blocks in three replications was carried out in two regions of Miandoab and Bokan in 2016. In this research, leaf area index, leaf relative water content, sugar yield, branching root number, root yield and white sugar yield were measured.

**Results:** The results of analysis of variance showed that there was a significant difference between two direct and transplanting systems in terms of effect on all studied traits except for leaf chlorophyll index.

The effects of planting time and cultivar were significant. The interaction effect of planting time + culture system on leaf relative water content, number of branching roots, Coefficient of sugar extraction, root yield and white sugar yield was significant. The interaction of cultivar in planting date was significant on leaf relative water content and root yield. Results showed among the planting date, the highest leaf chlorophyll index (36.87) was allocated to the cultivation date of 25 march. Among the cultivars studied, Dorotea showed the highest leaf chlorophyll index (27.39), leaf area index (4.72), coefficient of sugar extraction (81.57%) and white sugar yield. Among cultivation system in planting date interaction treatments the highest leaf area index (5.72), leaf relative water content (36.87), Coefficient of sugar extraction (78.12%), branching root number (8.57), root yield (62.58 t/ha) and white sugar yield (9.50 t/ha) was recorded in transplanting system with planting date of 25 march. The highest relative leaf water content (72.30%) and root yield (62.67 t/ha) were allocated to Dorotea cultivar with planting date of 25 march.

**Conclusion:** According to the results of this study, Dorothy cultivar had higher qualitative and quantitative characteristics than two other cultivars, therefore the use of this cultivar in both areas can be recommended. Also, early planting of cultivars on March 25th in the form of transplanting system showed the highest root yield and yield of pure sugar. It can be concluded that the early planting in the form of transplanting system due to better deployment, As well as maximum leaf area index, compliance with the most favorable temperature and environmental conditions improves the qualitative and quantitative qualities of sugar beet.

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**Keywords:** Cultivation time, Chlorophyll leaf index, white sugar yield, transplanting.

# Estimation of yield gap and potential for rainfed barley production increase in iran

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**Abstract**

**Background and objectives:** Barley (*Hordeum vulgare.* L) is well adapted to drought and saline conditions as the most important limiting factors for crop production in Iran. This consistency, as well as widespread application in animal feeding, are the reasons for cultivating approximately 1.77 million hectares of barley, in which, 1.04 million hectares was attributed to rainfed barley. The previous studies demonstrated that there was a significant difference between the actual and potential yield of crops. According to the calculated yield loss, the optimized crop field management is necessary to increase agricultural production. Therefore, in recent years, crop yield estimation as a practical way of improving food security has been widely considered by researchers around the world. This study was aimed to estimate the yield and production gap of barley under rainfed condition as the first step in the terms of the schematization of stable increase in Iran.

**Materials and Methods:** This study is conducted based on the Global Yield Gap Atlas (GYGA) Protocol. As the first step in the implementation of present study, the main rainfed barley harvested areas were determined using GYGA climate zones and the distribution of rainfed barley harvested area maps and the country's meteorological station points layer. After defining the designated climate zones (DCZs) and the reference weather stations (RWSs), the collected data (2000-2014) of agronomic management, meteorological and soil characteristics in each region were employed to estimate the potential yield at the RWSs of rainfed barley (as one of components of the yield gap calculation). Estimating barley potential yield under water-limited condition ($Y_w$) was carried out by SSM-iCrop2 during 15 growing seasons. Moreover, the actual yield ($Y_a$) data of rainfed barley was collected at the RWS level as another constituent for yield gap calculation. At the end, the estimated rainfed barley yield gap ($Y_g$) in the RWSs was aggregated to DCZs and finally country-level.

**Results:** In the current study, 38 RWSs within 17 DCZs of rainfed barley harvested areas were identified. The results showed that the average $Y_w$ was estimated 2723 kg. $ha^{-1}$ and the range varied from 1072 to 4002 kg. $ha^{-1}$. $Y_a$ range in the zones were calculated between 390 and 1510 with average of 1009 kg. $ha^{-1}$. The results illustrated that there was a significant correlation between mean rainfall and maximum temperature during anthesis to harvest maturity period and $Y_w$ within 17 DCZs. Hence, with simultaneous increase in rainfall and decrease in average maximum temperature during this phenological period, concomitantly, the $Y_w$ value has been amplified. $Y_g$ values was estimated between 615 to 3125 kg. $ha^{-1}$ (equivalent to 53 to 82% of yield gap (%)) with an average of 1714 kg $ha^{-1}$. Improving the current management conditions to advance toward the attainable yield ($Y_a$) (equivalent to 80% of $Y_w$) in farmers' lands, can increase the average yield of rainfed barley from 1009 to 2178 kg $ha^{-1}$. Based on the results, the country's production will grow from 1.05 million tons to 2.26 million tons in rainfed conditions through increasing yield to the level of attainable yield (80% of potential yield). The rate of barley import from other countries will decrease due to improvement in the production.

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**Conclusion:** Our results showed 85 percent of rainfed barley production had been attributed to 17 designated climate zones. Due to the presence of more than 50% yield gap (1714 kg ha (63%)) in rainfed barley fields, by considering 80% of this value as exploitable yield gap, the production can be increased to about 1.22 million tons which is appreciable for the economical and food security issues in Iran. It is not possible to achieve the potential yield at the farmer level owing to existing constraints, but approaching the attainable yield by improving field management conditions can be an accessible goal in the current situation.
**Keywords**: Actual Yield, Climate Zones, GYGA, Weather station.

## Evaluation of seed priming with salicylic acid on yield and yield components of oilseed rape (*Brassica napus* L.)

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**Abstract**

**Background and objectives:** Oilseeds are an important part of agricultural products which are important for nutrition, in addition to industrial applications. Plant oils are used to cooking, manufacture of cosmetics, plastics, lubricants, and insulators for the electricity and as biofuels (to reduce greenhouse effect). Rapeseed is one of the most important oilseeds that ranks third after soybeans and oil palms. Rapeseed oil contains less than 2% erosic acid and low saturated fatty acids levels, which help to reduce blood cholesterol levels. This research was carried out to investigate the effect of rapeseed priming with salicylic acid on its yield and yield components. The research was carried out at University of Zanjan.

**Materials and Methods:** This research was performed as randomized complete block design with four treatments during growing seasons 2014-2015. Treatments in the research included control (just distilled water), 50, 75 and 100 µM salicylic acid concentrations. The seeds were soaked for 12 hours in salicylic acid solution, then, were exposed to airflow and air-dried to return to its original state as was before the treatment with salicylic acid. The treated seeds were then sown in four plots in five replications. To remove the marginal effect and evaluate the factors, 7 plants in the middle row of each plot were randomly marked. The relevant traits measured 15 days after the physiological maturity of rapeseed.

**Results:** The results indicated that seed priming with salicylic acid caused a significant difference in yield, yield components and dependent traits. Salicylic acid treatments significantly increased the number of stems, pods, length and dry weight of the plants, length of the pods and number of seeds in each pod, the seeds weight in main and secondary stems, total weight of seeds and dry weight of roots compared to control. In contrast, no significant effect was observed on the empty pods and 1000- seeds weight.

**Conclusion:** The results of this research showed that seed priming with salicylic acid can increase yield and yield components of rapeseed plants. This is due to the effect of salicylic acid on the number of pods in plant and the number of seeds in pods. Also, plant height and

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the secondary stems in plants were increased with salicylic acid application. In addition, height increase resulted in more development of reproductive organs, also allowed for an increase of leaf area index and greater carbon absorption potential in the treated plants.

**Keywords:** Canola, Priming, Salicylic acid, Yield.

## Evaluation of sesame yield stability using statistical parameters and GGE biplot graphical methods

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**Abstract**

**Background and objectives**: Sesame is a short- day plant and sensitive to heat and moisture stresses and the yield show a wide variation as the environmental factor change in growing seasons. Therefore a commercially successful cultivar must perform well in a wide range of agricultural and climatic conditions. Plant breeders focus on estimating the interaction of genotypes and environment through repeated experiments to introduce stable cultivars able to perform better in changing environments. This study follows the same strategies to introduce sesame cultivars

**Materials and methods:** In order to identify high yielding and stable sesame genotypes suitable different regions of Iran, a total of 36 native sesame populations (obtained from National Gene Bank of Seed and Plant Improvement Institute, Iran) were cultivated in three regions (Karaj, Moghan and Jiroft) in a randomized complete block design for two years (2016-2017). Each genotype was planted in a plot with three rows of 1.5 m long. The distance between rows was 60 cm and seeds were planted with 8-7 cm intra-spacing. At the end of the growing period following the physiological, seeds were harvested and the yield of each genotype was calculated. Simple and combined analysis of variance were performed on data then the univariate statistics methods including regression coefficient, deviation from regression parameter, Shukla's stability variance, and Wricke's ecovalence were used to evaluate the grain yield stability of the genotypes. Finally, GGE biplot analysis was used to understand the interaction between genotype and the environment.

**Results:** The results of combined analysis indicated that the effect of location, year, genotype and genotype-location interaction were significant for grain yield. The results also showed that the grain yield was significantly affected by environmental factors. Based on all stability parameters and biplot analysis, genotype no. 10 had higher yield, lower Wricke's ecovalence and Shukla's stability variance value. Furthermore regression coefficient was equivalent to one and deviation from regression was the least. Accordingly this genotype was selected as the most stable genotypes. This result was also reconfirmed by GGE biplot analysis. Other stable and high yielding genotypes include 11, 9, 8 and 7.

**Conclusion:** Genotype 10 is a land race genotype from Haji Abad region of Hormozgan province and showed less fluctuations in tested environments, and in terms of the average yield, it is the most stable genotype compared to the others. So based on the findings from this study this genotype could be suggested to cultivate in future breeding programs.

**Keywords:** Genotype-environment interaction, land race, Sesame, Stability parameters.

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**Stability Analysis of Grain Yield of Some of Rice Genotypes by Parametric and Nonparametric Univariate Methods**

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**Abstract**

**Background and objectives:** Rice is one of the major global food crops, which is the second crop in Iran after wheat. Rice grain yield is strongly influenced by environments and breeders often determine the stability of high yield genotypes across environments before recommending a stable cultivar for release. Genotypial adaptability to environmental fluctuations is important for the stabilization of crop production over regions and years. The purpose of this study is the distinguishing the superior genotypes in terms of grain yield and yield stability in nine selected rice lines from preliminary yield test.

**Materials and Methods:** The nine selected lines obtained from crosses beteen IRRI lines and Iranian improved and landrace vareties and resulted from preliminary yield test of 2008-2009 cropping season, along with control cultivar Shiroudi, were evaluated in a randomized complete block design with four replications in three regions including Tonekabon, Amol and Gorgan during three cropping seasons of 2009-2012. Stability analysis were performed with environmental variance ($S^2_i$), coefficient of variation ($CV_i$), Shukla's variance ($\sigma^2 i$) and deviation variance ($S^2$), Wrick equivalence ($W_i$), regression coefficient ($b_i$), coefficient of determination ($R^2$), Eberhart-Russell analysis of variance, yield sability index (YSi) and nonparametric methods, $S_i^{(1)}$ , $S_i^{(2)}$ , TOP and mean and standard deviation of rank.

**Results:** Simple analysis of variance showed genetic differences among genotypes. Combined analysis of variance was performed after Bartlett test and not significant of it and assurance of uniformity of experimental errors. The combined analysis of variance indicated the significant effects of genotype, year, location and interactions of genotype × year, genotype × location and genotype × year × location. Comparison of means of showed that genotypes 2, 5 and 4 were in the same group with 6565.1, 6495.1 and 6450.1 $kg.ha^{-1}$, respectively and produced the highest grain yield. Analysis of variance indicated significant effect of genotype on plant height, tiller number, unfilled grain number, filled grain number, panicle length and 1000 grain weight. According to parametric stability G5, G3, G10 and G2 were stable genotypes. YSi indicated G2, G3, G4, G5 and G10 had the highest grain yield stability. Also, according to the TOP nonparametric index, genotypes 4, 10, 1, 2 and 5, and based on two criteria $S_i^{(1)}$ and $S_i^{(2)}$, genotypes 1 and 5 were the most stable genotypes. Correlation between indices showed the use of a number of them is not very necessary and some of them that have a high correlation with each other can be removed from the analysis.

**Conclusion:** Overall, genotype 5 was stable in almost all stability methods and 2, 3, 4 and 1 in some of the methods. Therefore, Ggenotype 5 [Number 16 from IR64669-153-2-3 (A8948); (4Surinam × Deilamini)] due to its higher grain yield than all genotypes except genotype 2, low plant height, higher number of tillers, filled grain and 1000-grain weight, as well as more uniform plants and better grain types, can be selected as the superior genotypes and evaluated in field trials.

**Keywords:** Adaptability, Quality, Rice, Stress, Yield.

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# Evaluation of heterosis and heritability of yield and yield components in bread wheat, durum wheat and triticale

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**Abstract**

**Background and objectives:** Given the increasing demand for food supply due to human population growth and the limited arable land, the role of plant breeding in increasing crop production is evident. Wheat (*Triticum spp*.) is known as an important food source in the world because of its adaptation to different environments. Triticale (*X. Triticosecale* Witmack) has high adaptability to biotic and abiotic stresses and is able to produce efficiently even in poorly fertilized soils and low input farming systems. Heterosis is a natural phenomenon that depends on the species and genetic variation and is called the increase in hybrid vigor of parents, which can be explored to increase crop production. Since the exploitation of heterosis is promising in wheat, the employment of putative hybrids for sustainable food supply has potentially increased. Hence, the aim of this study was to estimate heterosis and to evaluate the coefficients of phenotypic and genetic variation as well as heritability estimates.

**Materials and methods:** A total of 79 genotypes including 19 common wheat, 3 durum wheat, 4 triticale along with their 53 F1 hybrids were used, in this study. Morphological traits including yield and yield components viz. plant height, number of spike per plant, number of grains per spike, grain weight per spike, 1000 grain weight and grain yield per plant were measured. The heterosis estimates in the studied hybrids were calculated based on the mid-parent and better-parent. After analysis of variance, coefficients of phenotypic variation, coefficients of genetic variation and general heritability were estimated.

**Results:** The results of analysis of variance showed significant differences among the genotypes for the studied traits. Mean squares of parents versus hybrids were significant for all traits, indicating heterosis in the studied traits. $F_1$ hybrid derived from Long Spike 2 × Sirvan cross had the lowest heterosis compared to the mid-parent and superior parent for plant height. The highest percentage of heterosis for grain yield per plant belonged to the hybrid derived from the cross between Long spike 5 × Roshan. The estimated heterosis for grain yield based on mid-parent value showed a range of 25.34 to –25.41, indicating the high genetic diversity of the parents used to produce the 53 $F_1$ hybrids studied.

**Conclusion:** Given the genetic diversity observed in this study indicating heterosis in the studied traits as well as high heritability in the traits, the diversity can be explored either by hybrid breeding strategy or advancing segregating generations toward developing new cultivars.

**Keywords:** Diversity, Heterosis, Heritability, Wheat, Triticale.

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# Optimization of nitrogen and phosphorus fertilizer rates on yield and quality indices of wheat using a Response-Surface Methodology

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**Abstract**

**Introduction:** Imbalanced application of nitrogen (N) and phosphorus (P) fertilizers can result in reduced crop yield, low nutrient use efficiency, and high loss of nutrients. Applications of N and P fertilizers have been considered as important approaches to increase grain yield and improve seed quality in wheat production systems. P is often a limiting nutrient in crop production, and is fundamental for the efficient use of N fertilizer. Response- surface methodology (RSM) is defined as statistical technique for optimization of multiple parameters which determine optimum process conditions by combining experimental treatments. In this work, optimization of N and P fertilizers on yield, yield components and seed quality of wheat using RSM were studied.

**Materials and methods:** An experiment was conducted with 13 treatments and two replications at the Research Field of Ferdowsi University of Mashhad during the growing season of 2017-2018. The treatments were allocated based on low and high levels of N fertilizer (0 and 400 kg Urea per ha, respectively) and P fertilizer (0 and 100 kg triple super phosphate per ha, respectively). Biological yield, seed yield, harvest index, growth criteria, yield components (such as tiller No./$m^2$, plant height, spike length, seed No./ spike, seed weight/ spike, seed weight/ plant, spike No./ plant, spike weight/ plant and dry weight of stem per $m^2$) and seed quality characteristics (including N percentage, protein percentage and P percentage) of wheat were calculated as dependent variables and changes of these variables were evaluated by a regression model. Lack-of-fit test was used to evaluate the quality of the fitted model. The adequacy of the model was tested by analysis of variance. The quality of the fitted model was judged using the determination coefficient ($R^2$). Finally, the optimum levels of N and P fertilizers were calculated based on three scenarios including economic, environmental and economic-environmental.

**Results and discussion:** The results showed that effect of linear component was significant on harvest index, spike length, yield components (such as seed weight per plant, spike No./plant, spike weight per plant and tiller No./$m^2$), N percent and protein percent of seed. Effect of square component was significant on biological yield, seed yield, tiller No./$m^2$, seed weight per plant and spike weight per plant, N percent, protein percent and P percent of seed. Interaction effect was significant on plant height, spike length and seed No./spike and N percent of seed. Lack-of-fit test had no significant effect on the studied traits. The full square model for the response variables gave insignificant lack-of-fit indicating that the data of experimental were satisfactorily explained. The highest observed and predicted values of seed yield were recorded for 400 kg Urea per ha+100 kg triple super phosphate per ha and 200 kg Urea per ha+50 kg triple super phosphate per ha with 717.54 and 594.89 $g.m^{-2}$, respectively. The maximum observed and predicted amounts of seed N percent (with 1.72 and 1.62 percent, respectively) and seed protein percentage (with 10.76 and 10.02 percent, respectively) were recorded for 400 kg Urea per ha+50 kg triple super phosphate per ha. Both seed yield and N and P percent of seed were considered in economic-environmental scenario, so the estimated levels for N and P fertilizers were 141.41 kg Urea.$ha^{-1}$ and without P fertilizer.

**Conclusion:** Increasing rates of N and P fertilizers up to optimum rates increased yield and seed quality of wheat. Nutrient optimization enhances nutrient absorption and yield in the wheat cropping systems

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may reduce the dependence on external sources of chemical fertilizers that increase the costs of production and can potentially contribute to environmental contamination. The optimization of soil nutrients provides information on the sustainability of cropping systems and potential environmental pollutions. Generally, nutrient optimization is a useful technique widely used in modern agriculture.

**Keywords:** Determination coefficient, Lack-of-fit test, Regression model, Sustainability of cropping systems.

# Ecotypic variation in NaCl salinity tolerance of rocket (*Eruca sativa* L.) in germination stage and whole plant

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## Abstract

**Background and objectives**: Salinity is one of the major abiotic stresses limiting crop productivities in arid regions of the world like Iran. In order to meet the food demand for growing population, utilization of marginal fields which are typically areas of lower productivity and show some extents of nutrition imbalance and salinity to grow alternate crops like promising oil crops without substantial decrease in economic value of cash crop seems a practical approach. Rocket (*Eruca sativa* L.) is an old native plant well adapted to warm, dry climates of the Middle East region. It can play a role in crop rotation programs as green manure and/or cover crop to conserve soils in fallow lands. Nonetheless, little is known about its response to salt stress. This study aimed to evaluate main germination characteristics and yield components of some local *Eruca sativa* ecotypes and identify salt-tolerant ecotypes in order to use in breeding programs.

**Materials and Methods**: This study was conducted as two separate experiments. In the first experiment, germination percentage and rate and seed vigor of seven ecotypes of rocket named based on the region of collection as Sirjan, Bardsir, Rigan, Shahdad, Abadeh, Dehmurd and Darjaveh were assayed in a completely randomized design with two factors and four replicates. Salinity (NaCl) treatments were control (distilled water), 3, 6, 9, 12, 15 and 18 dS/m. In the second experiment, seeds of the same ecotypes as the first experiment were sown outdoor in cement boxes filled with soil (EC=1.8 dS/m) as semi-filed condition and watered normally until 4-leaf stage when treatments applied by salinized water to achieve 4, 8 or 12 dS/m. At the end of growing season, shoot biomass, grain yield, plant height and number of capsules were measured. Some stress indices were calculated and results were discussed by correlation and biplot analysis.

**Results**: Final Germination percentage and rate as well as seed vigor decreased by increasing salinity in all ecotypes, although magnitude of response greatly differed among ecotypes. Germination rate and seed vigor were much more affected by the adverse effects of salinity. Based on scoring method, Sirjan, Bardsir and Darjaveh were identified as superior, inferior and

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moderate ecotypes in terms of salinity tolerance, respectively. In the semi-field experiment, however, responses of ecotypes to salinity were quite different to those of germination as Shahdad showed the highest grain yield and shoot biomass both in the control and 12 dS/m treatments. Shahdad also showed the highest values for STI, GMP, MP and HM while Darjave being the lowest. Biplot analysis confirmed that Shahdad was the ecotype with the highest grain yield and lowest salinity susceptibility.

**Conclusion**: Significant ecotypic variations were observed in terms of salinity response both in germination stage and whole plant growth, though ecotypes responded differently to salinity, indicating tolerance mechanisms may differ among developmental stages and not closely related to geographic and climatic origin of seeds. Results suggest that rocket is semi-tolerant to salinity and could be a potential subsistence crop for cultivation in some saline soils.

Keywords: Biplot, Germination, Stress indices, Tolerance, Yield.

# The effect of nitrogen fertilizer management and heat stress during quinoa anthesis under saline conditions

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**Background and objectives:** *Chenopodium quinoa* is a facultative halophyte plant which has been considered for cultivation in saline soils. Although most studies of the nutritional requirement of quinoa focus on nitrogen consumption management. Since the plant is considered for organic production in Peru and Bolivia and is also grown after crops such as potatoes, fertilizer is not recommended and the plant uses the fertilizer residues of the previous crop (19). Under these conditions, the optimal use of fertilizers, especially nitrogen fertilizers, to prevent lodging, mechanized harvesting and increase yield is very important. Climate conditions have a major impact on quinoa performance. The most important stress on the central plateau, in addition to salinity, is heat stress during the pollination and grain filling period, which causes a sharp decrease in yield (21). The purpose of this experiment is to optimize nitrogen fertilizer management in changing environmental conditions.

**Materials and methods:** In order to determine quinoa fertilizer requirements under normal and heat stress during pollination period the experimental was conducted based on complete randomized block design in three replications, it was performed in Sadough Research Station of Yazd. Treatment consisted of nine treatments with different amounts of nitrogen (50, 100, 150 and 200 kg of urea $ha^{-1}$) and splitting (two splitting at planting and early floral initiation and three splitting at planting, early floral initiation and flowering) plus a control treatment with three replications. Quinoa cultivation of Titicaca was carried out on September 1, 2017 and August 7, 2018. Applied irrigation water salinity after sowing was 8 dS/m and after emergence 14 dS/m saline water applied every two weeks. After harvesting, yield and yield components and nitrogen percentage of grain were measured. The efficiency of nitrogen consumption, partial efficiency, recycling of nitrogen consumption and the growing degree day for each growth stage were calculated. Data analysis was performed for each year separately due to the significance of the Bartlett test with SAS v9.1 software.

**Results**: The results showed that the level of application of fertilizer treatment had a significant effect on yield and biomass production. In the first year, the maximum grain yield obtained at 200 kg $ha^{-1}$ with seed yield of 2 t $ha^{-1}$. At lower level of fertilizer application, the adsorption efficiency and the amount of nitrogen recycled were higher, and the treatments of the three splitting were better than the two. At higher levels of fertilizer, the effect of splitting was less than lower levels of fertilizer. The amount of harvested available nitrogen in the control treatment was 2.8 and at 200 kg $ha^{-1}$ was 6.3 g $m^{-2}$. The highest recycling efficiency was observed in 50 kg treatment with 3 splitting. The percentage of seed nitrogen in the control was significantly lower than the fertilizer treatments and there was no significant difference between the fertilizer treatments, which shows the plant's ability to remobilize nitrogen to seeds and maintain protein percentage in low-input systems under saline condition. In the second year with heat stress during the anthesis period, grain yield and nitrogen yield decreased by 62% and 59%, respectively. The effect of thermal stress during the quinoa pollination period reduced the efficiency of fertilizer use and severely reduced yield, but did not affect the percentage of grain nitrogen and the thousand kernel weight.

**Conclusion:** The fertilizer requirement, the efficiency of fertilizer application and the recovery of quinoa seed nitrogen changed under different climatic conditions, although the percentage of nitrogen accumulated in the grain did not change significantly, so to achieve the desired result, fertilizer management would be altered in different climatic and soil conditions.

**Keywords**: *Chenopodium quinoa*, Splitting, Stress, Urea fertilizer.

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# Estimation of above-ground biomass of winter wheat (*Triticum aestivum* L.) using multiple linear regression, artificial neural network models remote sensing data

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## Abstract

**Background and objectives:** Above-ground biomass (AGB) provides a vital link between solar energy consumption and crop yield, so accurate estimation of biomass is very important for accurate monitoring of crop growth and yield prediction and helps agricultural managers to improve crop management. In recent decades, remote sensing has been widely used as a tool to estimate crop biophysical parameters. The potentials of remote sensing techniques promise fast, periodical, and non-destructive estimation of above-ground biomass. For this purpose, this study was conducted with the aim of applying remote sensing technology and comparing two statistical models of multiple linear regression and artificial neural network to estimate winter wheat biomass in Shahrekord County, Chaharmahal and Bakhtiari province in 2017.

**Materials and methods:** In this study, in order to estimate the wheat biomass by Landsat 8 satellite images, eight fields under winter wheat cultivation with an area between 10 to 60 hectares throughout Shahrekord County were considered. Then the location of 120 sampling units was randomly determined by GPS. Samples units were taken as 30 × 30 m squares according to Landsat pixels. Each of these units includes 5 plots of 0.25 $m^2$ in four corners and the center of the square. During the growing season, on 20$^{th}$ April, 22$^{nd}$ May, 23$^{rd}$ June, and 25$^{th}$ July 2017, at the same time the satellite passes, sampling was carried out on farms. Field data collection included above-ground biomass and counting the number of plants per plot. Then the samples were transferred to the laboratory and dried and weighed. At the same time, data from Landsat 8 satellite remote sensing were obtained at these dates, and vegetation indices were calculated using satellite bands. In this study, wheat biomass was estimated using 25 vegetation indices and multivariate linear regression (MLR) and artificial neural network methods (ANN). Multilayer perceptron artificial neural network model (feed-forward) was designed and its performance was compared with multivariate linear regression model. To construct and validate the model and compare the results of these two models, statistics such as coefficient of determination ($R^2$), root mean square error index (RMSE) and mean error (ME) were used.

**Results:** The results showed that the ANN model with $R^2$=0.83 and RMSE=53.91 g/$m^2$ for training data and $R^2$=0.85 and RMSE=46.74 g/$m^2$ for test data and multivariate linear regression model with $R^2$=0.78 and RMSE=65.68 g/$m^2$ estimated biomass. In multivariate linear regression, EVI, CIgreen, PSRI, CRI, VARI, and GNDVI indices are the most effective indices for estimating crop biomass, respectively. GI, SAVI, ARVI, CRI, EVI, NDWI, MSR, and NDVI indices were the most sensitive to wheat biomass in ANN model, respectively.

**Conclusion:** The findings of the present study showed that the use of satellite images and developing parametric and non-parametric statistical models helps to estimate winter wheat biomass in the study area. Also, the artificial neural network method has better predictive accuracy than the multiple linear regression method. Therefore, the use of this method as a suitable approach in estimating winter wheat biomass is suggested.

**Keywords:** Artificial Neural Network, Biomass, Remote Sensing, Vegetation Index, Wheat.

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