

## Effects of rhizobial bacteria on K, Ca and Na concentration of wheat (*Triticum aestivum* L.) in saline soils

S. Homayoun<sup>1</sup>, A. Lakzian<sup>2\*</sup>, G.H. Haghnia<sup>3</sup> and R. Khorassani<sup>4</sup>

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**Keywords:** Bacterial inoculation, K/Na ratio, Salt tolerance

### Introduction

Soil salinity is one of the major agricultural problems and it is limiting crop productivity in many parts of the cultivated areas all over the world. Saline soils are differentiated by the presence of great ratios of Na/Ca, Na/K, Ca<sup>2+</sup>, Mg<sup>2+</sup>, and Cl/NO<sub>3</sub> (Gratan & Catherine, 1993) and high levels of neutral salts in the surface layers, which are resulting from the capillary action (Al-Falih, 2002). Osmotic stress occurs when soluble salts increase in the soils and then results in specific ion toxicity (Agarwal & Ahmad, 2010). Therefore, one of the most important side effects of salinity is nutritional disorders. High concentration of NaCl in the root medium usually reduces nutrients uptake and affects the transportation of potassium and calcium ions in plant. (Gratan & Catherine, 1993) reported that the salinity of soils changes ionic strength of the substrate and it can influence mineral nutrient uptake and translocation. Salinity also changes the mineral nutrient availability and disrupts the mineral relations of plants. Hence, the main purpose of this research is to evaluate the effects of rhizobial bacteria inoculation on K, Ca and Na concentration of wheat (*Triticum aestivum* L.) in saline soils.

### Material and methods

Soil sample was collected from Astan Ghodse Razavi farm, Mashhad Iran, and then was dried and passed through a 12-mesh (approximately 2 mm) screen. Soil sample was divided into three parts and then was placed into three containers. Each container was watered by a different proportion of saline water (EC= 10 dS.m<sup>-1</sup>). Salinity of soils was regularly monitored until three salinities (2, 6 and 10 dS.m<sup>-1</sup>) came out. Then, a completely randomized design with a factorial arrangement was carried out in a greenhouse condition. The experimental factors included four levels of inoculation (*Sinorhizobium meliloti*, *Bradyrhizobium japonicum* and *Rhizobium leguminosarum* and control) and three levels of soil salinity (2, 6 and 10 dS.m<sup>-1</sup>) with three replications. Wheat seeds were sterilized in 5% sodium hypochlorite for 2-3 minutes and were washed several times and then were germinated and seedlings were inoculated with bacterial strains. Inoculated wheat seedlings were grown in 1 kg pots. Wheat seedling was watered with sterilized water for one month and was harvested for chemical analysis. Potassium and sodium concentrations in plant tissues were determined by flame photometer and calcium concentration was measured by using Atomic absorption spectroscopy (AAS).

### Results and discussion

The results showed that the root and shoot dried weight, K and Ca concentrations and K/Na ratio in wheat shoot were significantly decreased with increasing soil salinity. The lowest shoot and root dry weight were observed in high level of salinity (10 dS.m<sup>-1</sup>). Inoculation of wheat seedlings with rhizobial bacteria had a positive effect on shoot and root dry weight. The highest shoot and root dry weight were obtained when wheat seedlings were inoculated with *Sinorhizobium meliloti* in non-saline soil treatment (2 dS.m<sup>-1</sup>). Calcium concentration increased significantly in all levels of salinity when wheat seedlings were inoculated with *Rhizobium leguminosarum*. Among all tested strains, *Rhizobium leguminosarum* had a prominent effect on growth of wheat seedlings. With increasing soil salinity, the concentration of sodium increased in shoot and root tissues and K/Na ratio declined dramatically. The lowest K/Na ratio was found in the highest level of salinity (10 dS.m<sup>-1</sup>). On contrast, the K/Na ratio in wheat shoot was amplified when wheat seedlings were inoculated with rhizobial strains. The highest K/Na ratio was observed in *Rhizobium leguminosarum* treatment. There are data that show that wheat cultivars having greater leaf K:Na, K ion flux, and growth improve under saline conditions

1, 2, 3 and 4- MSc Student, Associated Professor, Professor and Assistant Professor of Soil Science Department, College of Agriculture, Ferdowsi University of Mashhad, Iran, respectively.

(\*- Corresponding author Email: alakzian@yahoo.com)

(Mayak et al., 2004; Morant Manceau et al., 2004; Yao, 2010). It seems that *Rhizobium leguminosarum* reduced the detrimental effect of salinity to some extent.

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## Allelopathic effect of different castor bean organs (*Ricinus communis* L.) on reducing germination and growth of dodder (*Cuscuta campestris* Yuncker)

S.M. Seyyedi<sup>1</sup>, P. Rezvani Moghaddam<sup>2\*</sup>, R. Shahriari<sup>1</sup> and M. Azad<sup>1</sup>

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### Introduction

Dodder (*Cuscuta campestris* Yuncker) is an annual parasitic plant from the Convolvulaceae family (Mishra et al., 2007). It wraps around many adjacent dicot and a few monocot plants, penetrates in their vascular tissue and exploits photosynthates, nutrients and water (Lanini & Kogan, 2005). Consequently, the growth, vigor and production of the host plant will be severely reduced (Nadler-Hasasr & Rubin, 2003). Dodder is not able to complete its cycle, if it is not attached to a host. Therefore, it is entirely dependent on its host for supplying water, assimilates and minerals (Mishra et al., 2007).

Considering the nature of dodder habit, it is rarely possible to completely control dodder by using different chemical herbicides (Lanini & Kogan, 2005). In addition, because of increasing the environmental concerns caused by applying synthetic herbicides, there is considerable attention to alternative strategies for weeds management (Batish et al., 2002; Bowmik & Inderjit, 2003).

In recent years, allelopathic plants, an alternative strategy for weed management, have received massive attention (Narwal, 2010; Jamil et al., 2009). Due to the importance of dodder as a parasitic weed, this research was conducted with the purpose of studying the allelopathic effects of aqueous extracts and decay durations of castor bean (*Ricinus communis* L.) organs on germination and emergence of dodder.

### Materials and methods

The current study was conducted based on three separate experiments using a completely randomized design (CRD) with factorial arrangement with three replications. The first experiment was conducted in petri dishes and consisted of castor bean organs at four levels (root, stem, leaf and total plant without inflorescence) and their aqueous extract concentrations at 11 levels (0, 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10%). The second experiment was conducted in pots and factors were castor bean organs at 4 levels (root, stem, leaf and total plant without inflorescence) and their aqueous extract concentrations in 5 levels (0, 2.5, 5, 7.5 and 10%). The third experiment was conducted with castor bean organs at 4 levels (root, stem, leaf and total plant without inflorescence) and decay durations at 8 levels (0, 15, 30, 45, 60, 75 and 90 days of decay and control).

All experimental data were analyzed by ANOVA and the means were separated by Duncan's multiple range test at 5% probability level.

### Results and discussion

The results of the first and the second experiment showed that aqueous extract of castor bean organs has a significant effect on dry weight, length of seedling and germination of dodder. From the third experiment, decay duration had a significant effect on the mentioned traits. Leaf aqueous extract in comparison with other organs had the most effect on the studied traits. The complete suppression of emergence was observed in 0, 15, 30 and 45 days of decay by using castor bean leaves.

In conclusion, castor bean residues showed great potential for reducing germination and growth of dodder. Therefore, allelopathic potential of castor bean can be considered as a sustainable approach in integrated dodder management systems. In the future, the effective concentrations of aqueous extracts of castor bean organs may be useful as sources for producing biological herbicides.

1 and 2- MSc Student and Professor, Faculty of Agriculture, Ferdowsi University of Mashhad, Iran, respectively.  
(\* - Corresponding author Email: rezvani@ferdowsi.um.ac.ir)

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## The effect of biological fertilizers on yield, yield components and seed oil contents of three cultivars of canola (*Brassica napus* L.)

A. Koocheki<sup>1\*</sup>, A. Ruhi<sup>2</sup> and F. Nurbakhsh<sup>3</sup>

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**Keywords:** *Azospirillum*, *Azotobacter*, Nitroxin, Phosphate Solubilizing Bacteria

### Introduction

Canola is the world third oil crop with 25 to 55 percent oil content (Hezbavi & Minaei, 2008). In recent years, tendency towards expansion of the acreage of canola in Iran has been increasing and for the years 2010-2011 an area of 93000 ha with a total production of 190000 tons has been reported (Ministry of Jihad of Agriculture, 2013). Application of biological fertilizers which are environmentally friendly agents have been reported to enhance yield and quality of different crops (Shoghi Kalkhoran et al., 2012; Afrasiabi et al., 2011). The purpose of the present study was to investigate the effects of biological fertilizers on quantitative and quality criteria of canola.

### Material and methods

For this study, a factorial arrangement based on randomized complete block design and three replicates was used. The experimental treatments were three canola cultivars namely Okapi, Zarfam and Modena which was combined with four levels of biological fertilizers: Nitroxin, Phosphat solubilizing bacteria (PSB), Nitroxin+PSB and a control. Seeds were planted in plots of 2×3 m<sup>2</sup>. All field managements were carried out based on conventional practices. The measured criteria were plant height, number of pods per plant, 1000- seed weight, biomass yield, harvest index, oil content and yield.

### Results and discussion

The results showed that in all studied criteria except 1000- seed weight there were significant differences between cultivars. Different fertilizer treatments had a significant effect on all criteria except 1000- seed weight and HI. Modena cultivar had the highest oil yield and quantitative characteristics. Composition of phosphate solubilizing bacteria+nitroxin also had the highest oil yield and quantitative characteristics. The interactions between biofertilizer treatments and cultivars in all criteria were not significant. The result of this experiment indicated the effectiveness of use of biofertilizers.

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1, 2 and 3- Professor, MSc Student and PhD Student in Agroecology, Department of Agronomy, Ferdowsi University of Mashhad, Iran, respectively.

(\* - Corresponding author Email: akooch@um.ac.ir)



## The effect of organic, biological and chemical fertilizers on yield, essential oil percentage and some agroecological characteristics of summer savory (*Satureja hortensis* L.) under Mashhad conditions

E. Gholami Sharafkhane<sup>1</sup>, M. Jahan<sup>2</sup>, M. Banayan Avval<sup>3</sup>, A. Koocheki<sup>4</sup> and P. Rezvani Moghaddam<sup>4</sup>

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### Introduction

Savory (*Satureja hortensis* L.) is an annual herbaceous plant that belongs to the Lamiaceae family. Nowadays, the use of biofertilizers is increased in agriculture and their role in increasing the crops production has been demonstrated in many research works (Vessey, 2003; Chen, 2006; Mahfouz & Sharaf- Eldin, 2007). One of the most important visions is sustainable production of enough food plus paying attention to social, economical and environmental aspects. (Gliessman, 1998) stated that the first step to achieve this goal is optimization and improvement of resources use efficiencies.

Considering medicinal importance of savory and its role in the food and pharmaceutical industries (Omidbeigi, 2000), beside the limited nutrient resources and need to increase healthy production through using ecological inputs, this study was designed and conducted aimed to evaluate agroecological characteristics of savory as affected by the application of bio fertilizers, chemical and organic fertilizers under Mashhad conditions.

### Materials and methods

In order to study the effects of organic, biological and chemical fertilizers on quantitative and qualitative characteristics of summer savory, a split-plot design based on RCBD with three replications was conducted during the growing season of 2012 at the Agricultural Research Station, College of Agriculture, Ferdowsi University of Mashhad, Iran. Different levels of cattle manure (0 and 25 t.ha<sup>-1</sup>) were assigned to the main plots and different types of bio fertilizers (Nitroxin, containing *Azotobacter* sp. and *Azospirillum* sp., Biophosphor, containing phosphate-solubilizing bacteria (*Bacillus* sp. and *Pseudomonas* sp.), Biosulfur, containing sulfur-solubilizing bacteria (*Thiobacillus* spp.), combination of Nitroxin+Biophosphor+ Biosulfur), vermicompost (7 t.ha<sup>-1</sup>), chemical fertilizers (NPK: 60, 60 and 70 kg.ha<sup>-1</sup>) and control (no fertilizer) were used in the sub- plots.

### Results and discussion

According to the results, all studied characteristics including plant height, lateral branches, flowering shoot yield, stem yield, percentage of essential oil and dry matter yield were affected positively by cattle manure. The highest plant height and number of lateral branches resulted from vermicompost and combination of Nitroxin+Biophosphor+Biosulfur, respectively. Biosulfur fertilizer produced the highest dry matter yield, flowering shoot yield and stem yield. Percentage of essential oil was also significantly affected by fertilizer treatments as the most percentage of essential oil was obtained from Nitroxin, vermicompost and combination of Nitroxin+Biophosphor+Biosulfur. A positive and strong correlation was observed between dry mater yield and flowering shoot yield and stem yield, respectively.

### Conclusion

The results indicated that application of organic and inoculation of biological fertilizers have positive effects

1, 2, 3, and 4- MSc Student of Agroecology, Assistant Professor, Associate Professor, Professor and Professor, Department of Agronomy and Plant Breeding, College of Agriculture, Ferdowsi University of Mashhad, Iran, respectively.

(\* - Corresponding author Email: gholamisharafkhane.eghsh@gmail.com)

on improvement of qualitative and quantitative traits of summer savory, so it could be considered as an alternative method for healthy production of summer savory.

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## Evaluation of water productivity in tea (*Camellia sinensis* L. O. Kuntze) production in tea planting of the Guilan province

K. Majd Salimi<sup>1\*</sup>, E. Amiri<sup>2</sup> and S. Shaigan<sup>3</sup>

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**Keywords:** Water use efficiency, Supplemental irrigation, Tea yield, Rainfed field, Sprinkler irrigation

### Introduction

Tea leaves harvesting practically starts from April to November in two provinces (Guilan & Mazandaran), due to being located in rain fed and mountainous areas. In unirrigated fields during a drought season, the yield quality was reduced at the middle of growth periods (Majd Salimi & Mirlatifi, 2008). Therefore, to avoid the loss, improve the quality and increase yield, tea bushes needed supplemental irrigation during a drought season (Stephens & Carr, 1991a). According to reported research works in different tea cultivating countries, water use efficiency of produced tea was between 1.5-9 kg.ha<sup>-1</sup>.mm<sup>-3</sup> of used water. This variation practically depends on the type of irrigation system, amount of rain and irrigation, clone type, fertilizer amount and type, season, climatic conditions, field management, age of bushes as well as harvesting (Carr, 2010 a,b; Stephens & Carr, 1991 a,b). There is no report to indicate water use efficiency in tea fields in farmers management conditions. The results of some research works on optimal use of water and fertilizer showed that water use efficiency in rain fed (non irrigated) case was between 2.1-6.7 kg.ha<sup>-1</sup>.mm<sup>-1</sup> of used water (rain) and in complete irrigation condition it was between 4.6-8.7 kg.ha<sup>-1</sup>.mm<sup>-1</sup> of used water (rain and irrigation water). According to the results, water use efficiency variation depends on climatic condition (high temperature and air humidity deficit), applied nitrogen fertilizer and interval of irrigation (Majd Salami et al., 2011; Majd Salami, 2012). This investigation was conducted to ascertain yield quality, used water, irrigation use efficiency and water use efficiency in tea fields in the Guilan province and to analyze field management, harvest and effective irrigation variation factors on this index in farmers management conditions.

### Material and methods

The rate of water productivity (WP) was assessed in six irrigated tea fields and three rain fed (non irrigated) cases in farmers management method for two years (2009-2010). During the growing season, yield quality of each field in successive harvests, including soil moisture were assessed with the help of gravimetric soil method and water balance equation. Volume of water entered the irrigation system and amount of water reached to surface level were measured. The amount of rainfall was measured using rain gauge installed at the site. The United State Department of Agriculture (USDA) method was used to measure the effective rainfall. During the growing season, soil moisture balance equation and soil moisture monitoring and measurement were conducted in all selected fields, with the help of sampling weights method (average of weight in three depths of root). For selected tea fields in rainfed conditions (WS, CN and EM), production per unit of effective rainfall or water productivity due to effective rainfall (WPp) and gross irrigation water consumption productivity and actual water consumption productivity (evapotranspiration) in irrigated tea fields (WA, WB, CG, CK, EP & ED) were determined. Also, water irrigation productivity (IWP) in irrigated tea fields was calculated.

### Result and discussion

The mean quantities of made tea in irrigated and rainfed cases were 2843 and 1095 kg ha<sup>-1</sup>, respectively. Average of gross irrigation and effective rainfall (WP) and irrigation water productivity (IWP) in the irrigated fields were 4.39 and 4.55 kg. (made tea) ha<sup>-1</sup>.mm<sup>-1</sup> and average of net WP (actual evapotranspiration) and net IWP was 5.18 and 6.61 kg.ha<sup>-1</sup>.mm<sup>-1</sup>, respectively. Average WP in rainfed tea fields was 3.4 kg.ha<sup>-1</sup> for each mm

1, 2 and 3- Researcher, Technology and Engineering Department of Tea Research Institute, Associate Professor, Department of Agriculture, Islamic Azad University, Lahijan Branch and Researcher, Technology and Engineering Department of Tea Research Institute, respectively.

(\* - Corresponding author Email: k\_majdsalimi@yahoo.com)



of effective rainfall. The most effective factors on WP reduction in tea fields were improper harvesting operations (non-standard plucking) and economic problems. Moreover, improper operation and maintenance and old irrigation systems and unprincipled irrigation scheduling in irrigated tea fields were also effective on WP reduction. Comparing the results of this study with other studies in the past showed that implementing the proper methods in irrigation management and appropriate agricultural practices can improve water productivity in tea fields.

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## Whether farmers are willing to financially participate in reducing the undesirable environmental effects of polluted water? (A case study of Kashaf-Rood basin in Mashhad)

H. Aghasafari<sup>1\*</sup> and M. Ghorbani<sup>2</sup>

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**Keywords:** Contingent Valuation, Farmers financial participation, Polluted water, Tobit model, Undesirable environmental effects

### Introduction

Agricultural development in response to the growing demand for food is inevitable. Besides that, undesirable implications occur for human life and the environment that are requirements for problem-solving and change. Pollution of surface waters and ground waters includes the most important undesirable implications for agricultural development (Ongley, 2003). Chemical pesticides and fertilizers consist about 15 percent of water pollution. Chemical pesticides directly affect water quality. But chemical fertilizers affect water quality when large quantities of them enter the soil, so that its surplus enters rivers and lakes by outlet water and drainage and by providing food for algae causes their rapid growth. These materials consume the oxygen of water and cause the death of aquatic organisms (Ali Hosseini, 2011). Also, shedding liquids such as urban sewage, industrial sewage and domestic sewage on agricultural land particularly and the legal or illegal excretion of them in the water resources and failure or overflow of the sewage system cause water pollution. Since farmers are partners in the creation of water pollution, to reduce the environmental undesirable effects of polluted water we should examine farmers' behavior, until finally we become able to modify or reduce the undesirable environmental effects. For this reason, this study tried to examine farmers' financial participation to specifically reduce the undesirable environmental effects of polluted water in Kashaf-Rood basin.

### Materials and methods

In order to examine farmers' financial participation (willingness to pay), the Contingent Valuation approach was used. In this approach, willingness to pay (WTP) to maintain the present situation and to make positive changes in the environment and willingness to accept (WTA) to compensate loss of profit or increase a loss of Environment (Pearce & Turner, 1990) were examined. In this study, for extracting the value of the goods or service in the contingent valuation approach, Open End technique was used, because the farmers who were questioned, were aware of the undesirable environmental effects of polluted water and the cost of reducing these effects. Tobit model by Heckman's two stages was the model used in this study. Failure of Logit and Robit models in the distinction between the factors affecting the decision and the factors affecting the level of activity were the main reasons for using this model (Darijani, 1999; Tobin, 1958). To achieve the desired sample proportion with the study objectives, simple random sampling was used, because of the homogeneity of the studied population. To determine the number of samples the Cochran relationship and so were used. 100 questionnaires were collected from farmers of Kashaf-Rood Basin in the city of Mashhad in 2014. For estimation of Tobit model Shazam software version 11 was used.

### Results and discussion

The results showed that variables of age, farmers agreement with rural and urban sewage inflow into Kashaf-Rood river index, total amount of annual consumption of chemical pesticides and variables of sex, total cultivated land area, farmers agreement with benefits of preventing soil washing index, farmers agreement with desirable quality of available soil and water index and farmers agreement with investments to protect the soil and

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1 and 2- Msc Student and Professor of Agricultural Economics Department of Ferdowsi University of Mashhad, Iran, respectively.

(\*- Corresponding author Email: h.aghasafari@yahoo.com)

water index, experience in the use of soil and water conservation practices had significant positive and negative impacts on farmers' decisions to financially participate in reducing the undesirable environmental effects of polluted water, respectively. Also, variables of age, type of agricultural activity, crops under cultivation, the total amount of annual chemical fertilizer consumption per year, the total amount of annual chemical pesticides consumption, farmers agreement with rural and urban sewage inflow into Kashaf- Rood river index and variables of net savings of agriculture, land ownership status, experience in the use of soil and water conservation practices, total cultivated land area, farmers agreement with desirable quality of available soil and water index, and sex had significant positive and negative impacts on the amount of farmers' financial participation to reduce the undesirable environmental effects of polluted water, respectively. The results indicated that the maximum amount of farmers' financial participation for reducing the undesirable environmental effects of polluted water per hectare in five scenarios were 134500, 179500, 225500, 271000 and 354500 rials, respectively.

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## Study the effects of bio and organic fertilizers on growth characteristics and yield of fennel (*Foeniculum vulgare* Mill.)

A. Gholami<sup>1\*</sup>, I. Akbari<sup>2</sup> and H. Abbasdokht<sup>1</sup>

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**Keywords:** Anethol, Bio fertilizer, Essence, Fennel, Organic manure

### Introduction

Today, economic and environmental losses due to excessive use of chemical fertilizers in agriculture are well known. Obviously, a good alternative should be considered for this type of fertilizer. The objectives of sustainable agriculture are, by reducing off-farm inputs such as chemical fertilizers, to increase the nutrient cycle and the use of biological and organic fertilizers to increase agricultural yields. Studies on medicinal plants indicate that the use of sustainable farming systems provide the best conditions for the production of these plants. Biofertilizers are populations of beneficial soil organisms, or one or more of their metabolic products. Mycorrhizal fungi, vermicompost and humic acid are samples of biological and organic fertilizer that can be used, to eliminate or substantially reduce the use of chemical inputs in order to increase the quantity, quality and stability of the products. Mycorrhizal fungi is one of the most important rhizosphere microorganisms which has symbiotic relation with root of most crops. Mycorrhizal symbiosis improves the soil physical quality (through expansion of hyphae of fungus), chemical (through increased absorption of nutrients) and biological (the soil food web). This fungus increased nutrient uptake, such as phosphorus and some micronutrients, water uptake, reduces the negative effects of environmental stress, increases resistance to pathogens and improves the quality of their host plants (Ardakani et al., 2000; Gupta et al., 2002; Kapoor et al., 2004). Vermicompost is the production process of a certain species of earthworms to convert organic materials. Vermicompost contains absorbable nutrients that are available for plants. Humic acid is a completely natural organic matter produced from the final decomposition of soil organic matter by microorganisms. Humic acid stimulates the growth of the aerial parts and plants (Arancon et al., 2004; Atiyeh et al., 2002; Darzi et al., 2008; Ayas & Gulser, 2005; Rezvani Moghadam et al., 2009).

Fennel (*Foeniculum vulgare* Mill.) is one of the most important medicinal plants. As the essential oil from the seeds is used in a variety of industries, pharmaceutical, food and cosmetics, Anethole is an important component of the essential oil of fennel seed. The aim of this study was evaluation of the effects of bio (*mycorrhiza*) and organic fertilizers (vermicompost and humic acid) on growth characteristics and the yield of fennel.

### Materials and methods

This experiment was conducted as a factorial-based on a randomized complete block design in order to evaluate the effects of vermicompost application, humic acid and mycorrhizal fungi on quantitative and qualitative aspects of fennel yield at the experimental farm of Shahrood University during the growing season of 2012-2013. This experiment includes 12 treatments and 3 replications. Vermicompost levels include:  $v_1$  (no application)  $v_2$  (4 t.ha<sup>-1</sup>)  $v_3$  (8 t.ha<sup>-1</sup>). Mycorrhizal fungi includes:  $m_1$  (no inoculation) and  $m_2$  (inoculation) and humic acid includes:  $h_1$  (no application) and  $h_2$  (application). Each plot had 5 rows which were considered with row spacing of 50 cm and row length of 5 m. Mycorrhizal fungi were added to the soil under each seed rows with amounts of 10 grams. Humic acid was sprayed in 3 stages (vegetative, reproductive and seed filling stage) according to the recommended dose (200 mg per liter). Sampling and measuring of traits were done at the end of the season and after removal of border rows. A 50 gram grain sample of each plot was milled and then essence was collected with Clevenger for three hours using water distillation. Percent of fungal colonization was obtained with Gridline Intersect Method. Finally, for analysis of data and drawing shapes, Mstat-C software and Microsoft Excel were used. Comparison of the least significant difference test (LSD) was conducted at the 5% level.

1 and 2- Associated professor and Post Graduate (MSc) agricultural college, Shahrood University, Iran, respectively.  
(\* - Corresponding author Email: ahgholami@yahoo.com)

## Results and discussion

In this study, plant height, umbels per plant, seed weight per plant, seed and biological yield were significantly affected by the main effects of mycorrhiza, vermicompost and humic acid. The interaction effect of three factors on plant height was significant. The result showed that the highest plant height was obtained with application of 8 t.ha<sup>-1</sup> vermicompost with mycorrhizal inoculation and humic acid application. The effects of mycorrhiza, vermicompost and their interaction with the number of seed per umbel were significant. The effects of vermicompost, humic acid and combination effects of mycorrhiza and vermicompost on 1000 seed weight were significant. The interaction effects of vermicompost and mycorrhiza on seed yield were significant. So, mycorrhizal inoculation and 8 t.ha<sup>-1</sup> vermicompost application increased about 45% of seed yield over the control plots. The highest value of biological yield was recorded from combination of all factors. So, mycorrhizal inoculation with humic acid and 8 t.ha<sup>-1</sup> vermicompost application produced 4823 kg.ha<sup>-1</sup> biological yield compared with the control plots (2463 kg.ha<sup>-1</sup>).

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## Spatial zoning of saffron (*Crocus sativus* L.) cultivation based on climatic factors using hierarchical analysis process method (case study: Torbate Hydariyeh city)

M. Rashid Sorkh Abadi<sup>1\*</sup>, A. Shahidi<sup>2</sup> and A. Khashei Siuki<sup>2</sup>

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**Keywords:** Agroecosystem, Expert Choice, Geostatistical, GIS, Zoning

### Introduction

Amongst effective factors in agricultural crops production, climatic condition is important from the view of environmental variables (Seidy Shahivandy et al., 2013). On the other hand, the basic in agricultural development is having detailed knowledge of the environmental characteristics in any place and applying specific management. Saffron as the world's most valuable agricultural and medicinal product is among the plants that has acquired a significant role in the economic and social conditions of arid and semi-arid areas of Southern and Central Khorasan and identifying fit regions for its cultivation around the country will provide the context for necessary planning about its development (Farajzade & Myrzabyati, 2007). According to the influence of various environmental factors on the growth and function of saffron, the process of assessing land ratio for its cultivation needs using detailed and various spatial and descriptive information. Geographical information systems have provided the opportunity to use this kind of data and have facilitated the spatial analysis of information based on intended models (Jafarbeyglu & Mobaraky, 2008). Thereafter, this study was conducted with the purpose of evaluation of climatic conditions for Saffron cultivation in the city of Torbate Heidariyeh.

### Materials and methods

For this reason, climatic data of 10 meteorological stations in the province for a period of 10 years (2000-2010) was selected and with the help of Arc GIS software environment, the modeling and spatial analysis of information was conducted. By using suitable climatic conditions in different growth stages of Saffron, information layers were classified and the value of the maps was determined. Finally, for integrating information layers, multi-criteria decision-making methods were used based on the Analytic Hierarchy Process (AHP). A Climatic potential map of Saffron cultivation in the city of Torbate Hydariyeh was prepared.

### Results and discussion

The results of the study showed that the effects of rainfall, temperature and solar radiation climatic factors, appropriate for the different growth stages in each region are different. And from the total 9570.2071 kms<sup>2</sup> area of the the city of Torbate Hydariyeh according to Saffron cultivation zoning, 6% has a very good quality, 56% of the area has a good quality, 28% has relative conditions for cultivation, 8.5% has poor and 1.5% of the area has a quite unsuitable quality for the cultivation of Saffron.

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## Effects of drought stress and biofertilizers inoculation on growth, essential oil yield and constituents of thyme (*Thymus vulgaris* L.)

R. Mohammadpour Vashvaei<sup>1\*</sup>, M. Galavi<sup>2</sup>, M. Ramroudi<sup>2</sup> and B.A. Fakheri<sup>3</sup>

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**Keywords:** Dehydration stress, Medicinal plants, Mycorrhiza, Organic fertilizer,  $\rho$ -cymene

### Introduction

Thyme (*Thymus vulgaris* L.) is a perennial aromatic shrub belonging to the mint family (Davis, 1982) which has anti-spasmodic, antiseptic, carminative, sputum and antioxidant properties (Dapkevicius et al., 2002). Essential oil of thyme contains variable amounts of phenolic compounds such as thymol and carvacrol (20 to 80%), mono-terpinene hydrocarbons such as  $\rho$ -cymene,  $\gamma$ -terpinene and alcohols such as linalool,  $\alpha$ -terpinene and tojan (Nickavar et al., 2005; Rustaiyan et al., 2000). Increasing the desired compounds of medicinal plants is possible by manipulation of cultivation techniques such as irrigation, fertilization or photo-bioreactor systems. Water deficiency is the most important factor limiting the growth and yield of drug crops, especially in arid and semi-arid regions (Babaei et al., 2010). Biofertilizers as an alternative in some cases and in most cases as a complement to chemical fertilizers can help to ensure the sustainability of agricultural production systems (Han et al., 2006). (Vital et al., 2002) mentioned the positive effects of biofertilizers in growth and yield of thyme. The present study was designed to evaluate the effect of biofertilizers and drought stress on growth, yield and essential oil compounds of thyme.

### Materials and methods

This experiment was conducted in a split-plot based on randomized complete block design with two replications, at the Research Farm of Zabol University, during the growing season of 2012 and 2013. The main plots consisted of irrigation with 30, 50, 70 and 90% of field capacity and subplots including plant inoculation with nitroxin, biophosphorus and mycorrhiza. Plant traits such as plant height (cm), fresh and dry weight of herbs (g.plant<sup>-1</sup>), essential oil percentage, essential oil yield (ml.plant<sup>-1</sup>) of thyme were measured. Chemical compositions of the oil were determined by gas chromatography (GC) and gas chromatography with mass spectrometer (GC/MS). For statistical analysis, analysis of variance (ANOVA), Duncan's multiple range test (DMRT), simple correlation and stepwise regression were performed using SAS version 9.3 (SAS Institute Inc., Cary, NC, USA).

### Results and discussion

In this experiment, the effects of drought stress, biofertilizer and their interactions with all studied traits were significant at the 1% probability level. The highest plant height (35.09 cm), fresh and dry weight of herbs per plant (103.52 and 43.27 g.plant<sup>-1</sup>, respectively) and essential oil yield (0.350 mL.plant<sup>-1</sup>) belong to treatment of irrigation with 90% field capacity and nitroxin biofertilizer. The maximum essential oil percentage with 0.413% was obtained by irrigation with 70% field capacity and nitroxin biofertilizer. Fresh weight of herb per plant was the most crucial component in determining essential oil yield in thyme. Plants irrigated with 70% field capacity gave the highest relative percentage of thymol, which reached 71.32, 50.68 and 47.71% in nitroxin, biophosphorus and mycorrhiza biofertilizer, respectively. This effect was accompanied with a decrease in  $\rho$ -cymene content. Inoculation with nitroxin biofertilizer as compared to other fertilizers could further amend drought stress and improve the plant growth, essential oil percentage and yield and phenolic compound thymol of thyme. Thus, it appears that in order to achieve sustainable agriculture instead of chemical fertilizers, use of bio fertilizers is recommended.

1, 2 and 3- MSc student of Agroecology, Associate Professor, Department of Agronomy and Associate Professor, Department of Plant Breeding and Biotechnology, Faculty of Agriculture, University of Zabol  
(\*- Corresponding author Email: ro\_mohammadpour@yahoo.com)

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## Effect of soil disturbance methods and chemical weed control on density and diversity of weed species of cotton (*Gossypium hirsutum* L.) planted after wheat (*Triticum aestivum* L.)

M. Sardar<sup>1</sup>, M.A. Behdani<sup>2\*</sup>, S.V. Eslami<sup>2</sup> and S. Mahmoodi<sup>2</sup>

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### Introduction

Cotton shows its best growth where no weeds are present in the field and would give an acceptable yield and quality under these conditions. Soil cultivation is a part of cropping operations which is done to prepare the soil suitable for crop planting and consumes about 60% of the mechanical energy used in mechanized agriculture (Jacobs & Harrel, 1983). Herbicides are important tools of weed management in developed countries and they are one of the main pillars for IWM (Vencill & Banks, 1994). These chemicals, however, are most effective where weeds density has been reduced using other methods such as soil disturbances (Musavi, 2009). Trifloxysulfuron- sodium (Envoke) has been introduced as a low dose and is an effective tool in reducing chemical pesticides usage (Burke & Wilcut, 2004). It has been recommended to apply this herbicide at 2-8 leaf stage of cotton growth. The best result, however, has been achieved at 5-8 leaf stage (Richardson et al., 2007). Envoke is recommended at different dosages. The recommended dose in Iran is 15-20 g.ha<sup>-1</sup> Envoke WG 75% plus Citogate.

### Material and methods

To evaluate the effect of combined dose of different soil tillage methods and weed control on density and diversity of cotton weeds, a split-plot experiment based on randomized complete block design was conducted at the city of Boshruyeh during the rowing season of 2012. Experiment factors were tillage method as the main plot with three levels including conventional tillage, no- till and minimum tillage, and different methods of weed control as sub plots at five levels including the herbicide trifloxysulfuron sodium (Envoke granular formulation with 75% water content of 11.25 g.ha<sup>-1</sup>+ Citogate %2) at 10, 15 and 20 g.ha<sup>-1</sup>, as well as a non-weeding and a hand hoeing plot with four replications. Identification of dominant weeds and their density calculations were conducted at three stages including before spraying as well as 15 and 30 days after spraying. Samplings were carried out at these three stages using the data from two 50x50 cm quadrates fixed in each plot between two adjacent ridges. Cotton yield was measured through sampling 20 cotton plants (2.5 m<sup>2</sup>) from the two central lines after omitting 0.5 m from each side of the planting line as the margin effect. Analysis of variance was done using SAS v<sub>8</sub> and comparison of the means was conducted using FLAD at 5% level.

### Results and discussion

In this experiment, field weeds included broad-and narrow-leaved weed species including *Chenopodium album*, *Alhaji alhaji*, *Amaranthus* spp., *Cynodon dactylon*, *Sophora secundiflora*, *Setaria* spp., *Echinochloa crus-gali*, *Acroptilon repens* L. The results showed that weeds density and composition were considerably affected by tillage methods. The no- and minimum tillage systems increased narrow leaf weeds density by 22.72 and 14.47% compared with conventional tillage, respectively, while these systems decreased the broad leaf weeds density by 65.47 and 48.21%, respectively. Perennial weeds especially *Cynodon dactylon* were dominant species under the no tillage treatment, but annual weeds like *Setaria* spp., *Echinochloa crus-gali*, *Amaranthus* spp. and *Chenopodium album* were more dominant under conventional tillage. Both annual and perennial weeds

1 and 2- MSc of Agronomy and Associate Professor, Faculty of Agriculture, University of Birjand, Birjand, Iran, respectively.

(\*- Corresponding author Email: mabehdani@birjand.ac.ir)

were observed under reduced tillage treatments (chisel and disk). The greatest weed density reduction (narrow and broad-leaved) was observed where 20 g.ha<sup>-1</sup> of Envoke with Citogate was sprayed under conventional tillage and conservation tillage was next in the rank. The greatest cotton yield was observed under minimum tillage and hand weeding treatments.

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