



Effects of Single and Combined Application of Organic, Biological and Chemical Fertilizers on Quantitative and Qualitative Yield of Coriander (*Coriandrum sativum*)

M. Aghhavani Shajari¹- P. Rezvani Moghaddam^{2*}- R. Ghorbani³- M. Nasiri Mahallati⁴

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Introduction: Medicinal plants were one of the main natural resources of Iran from ancient times. Coriander (*Coriandrum sativum* L.) is from Apiaceae family that it has cultivated extensively in the world. Management and environmental factors such as nutritional management has a significant impact on the quantity and quality of plants. Application of organic fertilizers in conventional farming systems are not common and most of the nutritional need of plants will be supplied through chemical fertilizers for short period. Excessive and unbalanced use of fertilizers in the long period, reduce crop yield and soil biological activity, accumulation of nitrates and heavy metals, and finally cause negative environmental effects and increase the cost of production. The use of bio-fertilizers and organic matter are taken into consideration to reduce the use of chemical fertilizers and increase the quality of most crops. Stability and soil fertility through the use of organic fertilizers are important due to having most of the elements required by plants and beneficial effects on physical, chemical, biological and soil fertility. Therefore, the aim of this research was to evaluate the effects of organic, biological and chemical fertilizers on quality and quantity characteristics of coriander.

Materials and Methods: In order to study the effects of single and combined applications of organic, biological and chemical fertilizers on quantitative and qualitative characteristics of Coriander (*Coriandrum sativum*), an experiment was conducted based on a randomized complete block design with three replications and 12 treatments at Research Station, Faculty of Agriculture, Ferdowsi University of Mashhad, Iran, in - 2011. Treatments included: (1) mycorrhizae (*Glomus mosseae*) (2) biosulfur (*Thiobacillus* sp.), (3) chemical fertilizer (NPK), (4) cow manure, (5) vermin compost, (6) mycorrhizae + chemical fertilizer, (7) (mycorrhizae + cow manure, (8) mycorrhizae + vermicompost, (9) biosulfur + chemical fertilizer, (10) biosulfur + cow manure, (11) biosulfur + vermin compost and (12) control. *Glomus mosseae* was used at -2 cm depth below the seed. Chemical fertilizer, vermicompost (17 t. ha⁻¹) and cow manure (60 t.ha⁻¹) were used at 30 cm depth. Coriander was planted through furrow in mid-March 2010. The distance between rows was 60 cm and irrigation was applied once a week. The common cultivation practices used for this plant and no pesticides or herbicides were used during the growing season. Coriander harvested in early July 2011 when the plants became yellow. Then, plant indices were measured in laboratory which included plant height, the number of lateral branch, the number of umbels per plant, the number of seed per umbels and plant, hundred seed weight, biological and economical yield, harvest index, essential oil percentage and essential oil yield. Statistical analysis of the data was performed by SAS 9.1 and means comparison were compared by Duncan's multiple range ($P < 0.05$).

Results and Discussion: The results showed that the highest number of lateral branch per plant (6.6) was obtained from biosulfur + cow manure treatment. The highest number of umbel per plant (19) and number of umbelet per umbel (5) were also observed in mycorrhizae treatment. Mycorrhizae by improving the nutritional status of plants, soil microbial community strengthening and protecting plants against pathogens increases plant growth and development. The highest number of seeds per umbel (21.6), the number of seeds per plant (366), seed yield (1468 kg,ha⁻¹) and harvest index (55%) were obtained in mycorrhizae + chemical fertilizer treatment. Combined application of biosulfur with chemical fertilizer had a noticeable effect on 100-seed weights and biological yield indices. Ali et al. (2009) concluded that application of intermediate levels of nitrogen fertilizer and mycorrhizae increased biological yield of coriander, and they reported that the use of nitrogen fertilizer will speed up the establishment of mycorrhizae. Studies showed that the combined use of chemical fertilizer and manure improved crop yield by increasing the efficiency of nutrient absorption for plants. The highest essential oil percentage and essential oil yield were observed in mycorrhizae and mycorrhizae with chemical fertilizer treatments, respectively (0.2% and 2602 g.ha⁻¹). The essential oil yield was also about 7 times more in mycorrhizae+chemical fertilizer than biosulphur treatment. Combined application of cow manure and chemical

1, 2, 3 and 4- Ph.D. Student and Professors of Agroecology, Faculty of Agriculture, Ferdowsi University of Mashhad, Respectively

(*-Corresponding Author Email: rezvani@um.ac.ir)

fertilizer increased quality of indices of Ajowan. It seems that combined application of organic and bio fertilizers and cow manure improve soil physical and chemical properties, increase the availability of nutrients and finally increase the yield and quality of plants.

Conclusions: Overall, results of this experiment showed that the application of biological fertilizer especially mycorrhizae had a significant effect on improving quantitative and qualitative yield of Coriander. Furthermore, the combined application of mycorrhizae with organic and chemical fertilizer had better effects than their single application.

Keywords: Biosulfur, Biological yield, Essential oil, Essence yield, Harvest index, Mycorrhiza



Effects of Deficient Irrigation on Some of the Morpho-physiological Characteristics of Four Fig Cultivars

Gh. Davarynejad^{1*} - S. Shirbani² - M. Zarei³

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Introduction: The amount of water available to plants is one of the most important factors that affect the growth of plants. The objective of the present study was to investigate and compare the tolerance of different fig types (*Ficus carica* L.) to different low irrigation treatments.

Materials and Methods: A factorial trial based on a completely randomized design with 3 replications was carried out in Ferdowsi University of Mashhad. The treatments of this experiment were four levels of irrigation including, supplying enough water to pots (100% field capacity), mild stress (75% field capacity), average stress (50% field capacity) and severe stress (25% field capacity) on Green, Black, Shah Fig and Matthew cultivars. Some of morphological and physiological traits like stem growth, leaf number, leaf area, root length, root area, fresh and dry weight of shoot and root, root to shoot ratio, relative water content, electrolyte leakage, total chlorophyll and proline were measured.

Results and Discussion: Significant differences were observed between different irrigation treatments for all measured parameters. The highest level of stem growth, leaf number and leaf area were detected in control treatment (100% field capacity), while the lowest contents were observed in severe stress (25% field capacity). The results showed that the fresh and dry weight of shoot and root decreased with increasing drought stress, so that the lowest amounts were observed in severe stress treatment (25% field capacity). The levels of relative water content were significantly affected by different irrigation treatments, since treated plants with severe stress treatment (25% field capacity) had the lowest relative water values, while the highest levels were observed in control treatment (100% field capacity). The highest and lowest of total chlorophyll content were observed in control treatments (100% field capacity) and severe stress (25% field capacity), respectively. Among the study treatments, severe stress treatment (25% field capacity) had the highest amount of root length, root area, root to shoot ratio and control treatment had the lowest root length, root area, root to shoot ratio. The obtained results detected that electrolyte leakage increased with increasing drought stress. The severe stress treatment (25% field capacity) had the highest proline content, followed by the average stress treatment (50% field capacity), while the lowest value was observed in control (100% field capacity). A variation in terms of all measured parameters was also observed among the cultivars and the differences were statistically significant. Among the presently tested cultivars, Black has the best resistant ability to drought stress than in other cultivar.

Conclusion: This research showed that all measured parameters were significantly affected by irrigation treatments and cultivars. These data demonstrated that cultivar was the main parameter which influences the morpho-physiological properties of figs.

Keywords: *Ficus carica* L., Drought stress, Electrolyte leakage, Chlorophyll, Proline

1 and 2- Professor and Former M.Sc. Student, Department of Horticulture Science, Faculty of Agriculture, Ferdowsi University of Mashhad, Mashhad, Respectively

(* - Corresponding Author Email: davarynej@um.ac.ir)

3- Assistant Professor, Department of Crop Production, Faculty of Agriculture and Natural Resources, Gonbad Kavous University, Gonbad Kavous



Effect of Potassium Sulphate and Humic acid on Growth, Yield and Essential Oil Content in *Hypericum perforatum* L.

H. Kaboli Farshchi¹- M. Azizi^{2*} - H. Nemati³ - V. Roshan-Sarvestani⁴

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Introduction: Medicinal and aromatic plants play an important role in commercial crops, which also represent a safe alternative for chemical pharmaceutical industries. St. John's Wort (*Hypericum perforatum* L.) due to its therapeutic efficacy has been used for decades in folk medicine and is considered as a promising medicinal plant with valuable potential as a source of hypericin, essential oils and antioxidants. Studies on agronomic factors such as application of potassium and humic acid as well as nitrogen fertilization on yield, essential oil and antioxidant activity of *Hypericum perforatum* have not been investigated thoroughly until now. This study was designed to study the effect of using humic acid and potassium sulphate on morphological and phytochemical characteristics of *Hypericum perforatum*.

Materials and Methods: The plant material was prepared from Science and Technology Park in Khorasan-e Razzavi-Mashhad. In spring, the plants were transplanted into the field of Horticulture department, Ferdowsi University of Mashhad, for fertilizing treatments. The experimental layout was factorial in a complete randomized design (CRD), with three replications. Potassium Sulphate (K_2SO_4) was applied at the rates of 0.0(K0), 60 (K60) and 100 (K100) $kg\ ha^{-1}$. The other treatment were humic acid, which was applied at three rates 0 (H0), 20 (H20) and 40 (H40) $L\ ha^{-1}$. Plants were treated at two stages, before flowering by potassium fertilizer and fertigated four times in 15-day intervals with humic acid. Besides the fresh and dry weight, number of flowers, stem height and number of flowering stems were determined at the end of the growing stage.

Results and Discussion: The ANOVA indicated that most of measured attributes of *Hypericum perforatum* plant were significantly affected by both treatments. Data presented revealed that the highest stem (91.6 cm) was recorded at the highest level of potassium sulphate (K100) treatment, while the shortest height (60.4 cm) was recorded at the lowest level of potassium sulphate (K0) treatment. On the other hand, the highest stem (80.33 cm) was achieved with the highest level of humic acid treatment. No significant difference was observed between the highest level of humic acid (H40) and the second level (H20), while both mentioned levels showed a significant difference with control (H0). This means that the control plants possessed the lowest stem height (66.7 cm). The DPPH method for evaluation of antioxidant activity reflects the ability of the present compounds to scavenge hydrophilic free radicals. DPPH inhibition was investigated and the results were evaluated as relative activities against α -tocopherol as positive control. A lower EC50 indicates a higher antioxidant activity. As it is shown, the least EC50 which indicates the highest antioxidant activity belonged to plants treated with potassium sulphate at (100 $kg\ ha^{-1}$). Control plants possessed the least antioxidant activity and showed no significant difference compared with plants treated with 60 $kg\ ha^{-1}$ of this fertilizer. Humic acid had a significant effect on antioxidant activity of *H. perforatum*. The lowest value of EC50 was related to the highest level of humic acid, while the highest value of EC50 was obtained from control plants. There was also significant difference between control and two other levels (20 and 40 $L\ ha^{-1}$) of humic acid. Applied fertilizers at their high levels showed significant effects on EC50 decrease, which means the increment of antioxidant activity of *H. perforatum*. The high antioxidant activity of this medicinal plant is the reason of flavonoids and phenols existence. It seems that application of these fertilizers have led to increment of the mentioned secondary metabolites and followed by an increase of antioxidant activity in comparison with control plants. Totally, *H. perforatum* possessed a high antioxidant activity. Application of the mentioned fertilizers separately or simultaneously increased of this important medicinal plant fresh and dry weight, and finally the yield. Number of flowers, stem height and flowering stems reached the highest value at the highest level of both fertilizers (K100H40). As potassium plays an important role in the development of reproductive parts of plants, it might be one of the reasons of the abovementioned increase. The highest essential oil content was recorded at high levels of both fertilizers (K100H40). Since the highest essential oil content accumulates in the flowering stems, an

1, 2 and 3- Former M.Sc. Student, Professor and Assistant Professor, Department of Horticulture, Faculty of Agriculture, Ferdowsi University of Mashhad, Respectively

(*-Corresponding Author Email: azizi@um.ac.ir)

4- Assistant Professor, Agricultural and Natural Resources Research Center of Fars Province, Shiraz

increase of these stems height and a higher number of flowers would increase the essential oil content of *H.perforatum*. It seems that application of these fertilizers increased the antioxidant activity by an increase of this pigment content.

Keywords: Medicinal Plants, Inorganic Fertilizers, Organic Fertilizers



The Effect of Potassium on the Controlling of Salt in Evening Primrose (*Oenothera macrocarpa*)

M. Goldani^{1*} - E. Keshmiri²

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Introduction: Salinity has been recognized as one of the major abiotic factors affecting crop yields in arid and semi-arid irrigated areas of the world and various efforts for breeding salt-resistant crop plants have been made. Approximately one-third of the world irrigated soils and a large proportion of soils in dry lands are saline. Two major effects have been identified as the probable causes of high salt toxicity in crop plant i.e., the ionic effect and the osmotic effect. The ionic effect results in alterations in enzymatic processes, disturbances in accumulation and transport of different ions or a combination of all these factors. As a result, shoot and root growth will reduce and uptake of nutrient elements by plants will be adversely affected. While excess Na accumulated in plants under salinity stress conditions hinders K uptake, Cl hinders NO₃ uptake by plants and destroys ionic balance in plants. Evening primrose is a plant which belongs to Onagraceae. Its seed oil has a special arrangement in Glycerol molecule, so it has been used a lot in medical treatments and also feeding. Many studies have showed that using the best techniques and methods in farming can increase the amount of oil of seeds. The wrong method of agricultural activities in Iran have caused increasing of salt in the soil, and growing plants in such situation is not possible. For confronting with this phenomenon knowing and choosing kinds of plants that can resist the situation of salt is really necessary.

Materials and Methods: This study was conducted as a factorial experiment based on completely randomized design with three replicates with five levels of NaCl salinity (0, 30, 60, 90 and 120 mM) and potassium chloride levels (zero and 15.02 mM) It is performed in the Faculty of Agriculture, Ferdowsi University of Mashhad in 1390. Salt treatment to prevent osmotic shock was applied to four-leaf stage and treated with potassium was gradually and simultaneously applied with irrigation water. The rate of photosynthesis, chlorophyll relative content and stomata conductance was measured six weeks after imposing the treatments. The analysis of variance was calculated using SAS software. The statistical comparison was done by Duncan's multiple range tests. Charts were drawn using Excel software.

Results and Discussion: According to the result of the analysis of variance, increasing the density of sodium chloride in the planting areas had a special effect on the size of the leaves and the weight of dried plant and the weight of each leaf and dried root. This effect showed a meaningful variation between the weight of dried leaves and its dried root and shoots. The salty areas have a lot of negative ions like magnesium, chlorine, sodium and sulfate. These materials are harmful by themselves or cause effective disorder in plants metabolism. Salinity treatments applied to significant influence ($01/0 > p$) on the characteristics of photosynthesis, stomata conductance and numbers were monitored by spad. For example, sodium and potassium competition and competition between chlorine and nitrate impairs the absorption of nutrients which results in higher demand for energy for plants for producing organic matter. This situation causes a low activity of the root and the growing of the shoot consequently reduce their growth. The weight and length of the plant will be reduced too. For example existing potassium in salty lands cause the reduction of sodium in the shoot of the plants. This research was done in a pot with the same amount of salt. Potassium causes the reduction of toxicity effects of sodium. Research has shown that the potassium in regulating osmotic pressure and permeability of plant cell membranes is effective and cause higher plant tolerance to salinity.

Conclusion: Some biological indexes of evening primrose plant were negatively affected by increasing rates of NaCl and KCl applications. In salty condition, increasing the amount of sodium reduces the potassium, comparing with sodium. Potassium causes a suitable osmotic pressure and reduce the destructive effect of oxidation. So higher potassium than sodium in salty lands is known as the standard resistance. NaCl and KCl compounds should be applied at precise amount to evening primrose, otherwise, quantity and quality of evening

1 and 2- Associate Professor and Ph.D. Student of Agronomy, Department of Agronomy, Faculty of Agriculture, Ferdowsi University of Mashhad, Mashhad

(* - Corresponding Author Email: goldani@um.ac.ir)

primrose plant will be impaired.

Keywords: *Oenothera macrocarpa*, Potassium Nutrition, Ratio Potassium to Sodium, sodium chloride



The Efficiency of Mycorrhizal Fungi on Growth Characteristics and some Nutrients Uptake of Plane tree Seedling (*Platanus orientalis* L.)

H. Alipour^{1*} - A. Nikbakht² - N. Etemadi³ - F. Nourbakhsh⁴ - F. Rejali⁵

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Introduction: Drought stress is one of the most important abiotic stresses which significantly reduce yield and growth of most of plants. Plane tree is one of the important trees planted in the urban landscapes of Iran. One of the major limiting factors of landscapes development is providing water for plants. Deficit irrigation is a desirable method for saving water use in water deficit conditions and ultimately reducing necessary cost of water securement to landscape plants. Moreover, inoculation of plant root with mycorrhizal fungi can be considered as a method to reduce water demand of plants. In addition, mycorrhiza can increase plant resistance against environmental stress, such as salinity, temperature stress, drought stress and etc. Mycorrhiza can improve drought stress through enhancing water uptake as result of extra radical hyphae and stomatal regulation or transpiration. Increasing P concentration by mycorrhiza inoculation can be another mechanism for drought resistance in plants. The purpose of the present study was to evaluate two *Glomus* species in combination together on plane tree under water deficit for growth characteristics and nutrients uptake such as P, Fe and Zn concentration.

Materials and Methods: This outdoor experiment was conducted at - Isfahan University of Technology, Isfahan, Iran, with average temperature 14.2 °C and 27.9 °C night/day, respectively and relative humidity 35-70% between Mar and Aug 2012 and repeated under the same condition in 2013. This experiment was carried out to evaluate the effect of inoculation with mycorrhizal fungus on plane saplings response to different applicable water levels (50 and 100% of water needs) based on a completely randomized design with 3 replications. The treatments were control (without fertilizer), Germans peat + fertilizer, Germans peat + fertilizer + mycorrhiza in 50% of field capacity and Germans peat + fertilizer + mycorrhizain 100% of field capacity. The Mycorrhiza fungi (mycorrhizal root, soil containing spore and extra radical mycelium) were obtained from Institute of Soil and Water Research (Tehran, Iran). There were inoculums treatments: two AM fungus inoculums (*G. intraradices* and *G. mosseae*) with combination of both. The inoculated dosage was approximately 80 spores g⁻¹ for *G. intraradices* and 80 spores g⁻¹ for *G. mosseae*, calculated by microscope before the experiment. Plants were irrigated daily based on 100% FC to make sure the establishing plants for about 2 months and then differential irrigations were applied. The amount of 100% and 50% ET was applied for full irrigation, moderate and severe deficit irrigation, respectively. To monitor the soil water content, tensiometry probe tubes were inserted into the soil in control pot around the root. Irrigation was performed whenever 40% of the available water was consumed. In order to calculate the amount of water necessary to bring each soil to FC, soil samples were collected and the water content determined by drying. Photosynthesis rate was measured by a LCI portable photosynthesis system. Soluble sugars measured according to Phenol-Sulfuric Acid method. Extraction of the Leaf chlorophyll pigments using with 100% acetone. The extraction of P, K, Fe, and Zn from the plant tissue material was performed by using dry ashing method. The mean data of two years were analyzed with SAS 9.1 software, the means were compared for significance by the least significant difference (LSD) test at $P < 0.05$.

Results Discussion: Mycorrhiza inoculation significantly increased fresh and dry weight, chlorophyll content, total sugar, leaf area, photosynthesis rate and P and K concentration as compared to control. As compared to the 100 and 50% FC, total chlorophyll, fresh and dry weight and P concentration significantly was increased in 100% FC (Table 4 & 5). The results showed that inoculation of plants with mycorrhizal fungus significantly increased most growth parameters including leaf area, chlorophyll content and leaf fresh and dry weight of plane saplings. Phosphorus content significantly increased in inoculated plants as compared to non-inoculated plants. It is recommended that in dry regions and water shortage conditions, the deficit irrigation method accompanied with mycorrhizal fungus inoculation to save water .

1, 2 and 3- Ph.D. Student, Assistant Professor and Associate Professor Department of Horticulture, College of Agriculture, Isfahan University of Technology, Respectively

(*-Corresponding Author Email: h.ali@ag.iut.ac.ir)

4- Professor, College of Agriculture, Isfahan University of Technology

5- Assistant Professor, Soil and Water Research Center, Karaj

Conclusion: Our data showed that mycorrhiza inoculations increased most growth parameters including leaf area, chlorophyll content and leaf fresh and dry weight of plane saplings. In conclusion, mycorrhiza inoculations can increase plant tolerance against drought stress by increasing phosphorus concentration, chlorophyll content, and photosynthesis rate. Generally, results of this study revealed that inoculation of plane trees with mycorrhizal fungi, improved plant growth under stress conditions through its positive influence on nutrients uptake, chlorophyll content and other growth parameters.

Keywords: Landscape, Irrigation level, Tree, Symbiosis



Effect of Postharvest Application of Thyme essential Oil on Quality and Shelf-life of Pomegranate (*Punica granatum* cv. Tarom red skin) Fruit

M. Ghfour¹ - A. Soleimani^{2*} - V. Rabie³ - R. Hemmati⁴

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Introduction: Iran pomegranate is quite competitive compared to other countries due to high quality and has great economic importance. Using essential oil is a new idea to reduce postharvest losses and increase the horticultural crop storage life and control of fungal infection. In this context, a factorial experiment based on completely randomized design was conducted to study the postharvest spraying of thyme essential oil on storage life and qualitative characteristics of pomegranate fruit (cv. Tarom red skin).

Materials and Methods: Pomegranate fruit (cv. Tarom red skin) was prepared and transferred to University of Zanjan, Horticulture postharvest physiology lab. Treatments were included essential oil of thyme at four levels (0, 500, 1000, 1500 mg/l) and the cold time storage (6°C and 85% of relative humidity) at three levels (one, two and three months) by four replications. In the first experiment, 180 normal pomegranate fruits were treated with thyme essential oil. In the second experiment, fruits were infected with spores of the fungus *Aspergillus niger* and then treated with essential oil. During experiment, total soluble solids (TSS), titratable acidity (TA), TSS/TA ratio, pH, anthocyanin, electrolyte leakage, chilling injury, weight loss and fungal decay were evaluated. Fruit juice TSS was determined with a hand-refractometer at room temperature. TA was determined by titration an aliquot (20 mL) of the juice with 0.1N NaOH and the results were expressed as a percentage of citric acid. The maturity index (TSS/TA ratio) was evaluated as the TSS/TA ratio. Fruit juice pH was measured using a pH meter. Anthocyanin measurement was performed by the method of Fuleki and Francis. Electrolyte leakage was measured according to McCollum & McDonald method. Weight loss was measured according to Ershadi method. Chilling injury was measured by Wang method. Decay was visually evaluated and expressed as percentage. An analysis of variance was used to analyze difference between treatments and the Duncan test was applied for mean separation at $p < 0.05$. All analyses were performed using SAS statistical software.

Results Discussion: Results showed that chilling injury and fungal decay increased by storage time in both infected and no infected fruits, while this trend was slower in non-infected ones. Treated fruits by essential oil of thyme had more anthocyanin in comparison to control fruits. Essential oil of thyme prevents the reduction of titratable acid and catalysis of sugars. An interactive effect of treatments showed that weight loss and electrolyte leakage was highest in control at the third month of storage. Interaction between essential oil of Thyme and storage time in pomegranates not infected with fungus spore showed the lowest TSS in essential oil of thyme (500 mg/l) in second month of storage.

Essential oil of thyme reduces decay and increases the storage life of the fruits. It seems that the phenolic compounds of thyme essential oil form molecular hydrogen bond with the cytoplasmic membrane proteins of fungus and make them inactive. Essential oil of thyme has a positive effect in controlling weight loss during storage of pomegranates. Essential oil forms a thin layer of the skin that covers fruit and prevents water evaporation from the skin and keeps skin moisture. It also, maintains fluidity of the plasma membrane and prevents disintegration. So electrolyte and substances leakage of vacuole into the cytosol and the cytoplasmic space is controlled. One of the constituents of essential oil of thyme is phenolic compounds that are rich in carbonyl group. Carbonyl group has ability to disintegrate the free radicals formed by cold stress resulted in reduction of chilling injury in the fruit tissue. Essential oil has antioxidant that prevents anthocyanin oxidation during storage time. Meanwhile, the probably conversion of other competent compounds to anthocyanin caused an increasing of total water-soluble anthocyanin during storage time.

Conclusion: Results showed that Thyme essential oil has positive impact on reducing chilling injury and

1, 2 and 3- Former M.Sc. Student, Assistant Professor of Horticultural Department (first affiliation) and Research Institute of Modern Biotechniques (Second affiliation), Associate Professor at Horticultural Department, Faculty of Agriculture, University of Zanjan, Zanjan, Respectively

(* - Corresponding Author Email: asoleimani@znu.ac.ir)

4- Assistant Professor at Plant Protection Department, Faculty of Agriculture, University of Zanjan, Zanjan

electrolyte leakage also, controlling weight loss and fungal decay of pomegranate fruit. Nowadays, production of organic fruit are increasing because of their role in human health, hence by maintaining the fruit quality during storage time it can be used as a substitute for chemical compounds and fungicides.

Keywords: Chilling Injury, Electrolyte Leakage, Fungus Decay, Storage Time, Weight Loss



Effects of GA₃, BA, Thiamine and Ascorbic Acid on Some Morphological and Biochemical Characteristics of Periwinkle (*Catharanthus roseus* L.)

F. Baniasadi^{1*} - V.R. Saffari²

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Introduction: *Catharanthus roseus* (L.) belongs to Apocynaceae family and is an important medicinal plant and also cultivated as an ornamental plant almost throughout the tropical and subtropical areas all over the world. Recently, the uses of natural substances are considered very helpful to improve plant growth and development. Application of plant growth regulators (PGRs) and vitamins are reported in many horticultural crops. Ascorbic acid is the most abundant antioxidant in plant which protects plant cells. This substance affects cell differentiation and growth. Thiamine or vitamin B1 is water soluble and one of the B complex vitamins. This study was conducted to investigate the effect of the ascorbic acid, thiamine, BA and GA on growth and biochemical parameters of periwinkle.

Materials and Methods: The experiment was performed as a completely randomized design with 5 replications at research greenhouse of Shahid Bahonar University of Kerman in 2014. The treatments used include spraying water (control), ascorbic acid 100 mg.l⁻¹, gibberellic acid 100 mg.l⁻¹, thiamine 100 mg.l⁻¹, BA 200 mg.l⁻¹ and combinations of two, three and four of them to determine the response of plants to these substances alone or in combination of them. When the seedlings reach to 6-leaves stage, the first foliar spray was carried out. In other two steps, it was repeated with interval of 10 days. In this study, longevity of the flower, flower diameter, the number of lateral branches, branches length, fresh and dry weight, chlorophyll content and reduced sugars were measured. Chlorophyll content and reduced sugars were measured according to method of Somogy (1952) and Lichtenthder (1987), respectively.

Results and Discussion: The results showed that the effect of thiamine on the number of flowers was more pronounced than other substances. The lowest number of flowers per plant was found in plants treated with gibberellic acid. All growth promoter substances increased flower diameter. Combined application of BA with gibberellic acid had more influence on this parameter than other treatments, and increased flower diameter by about 25%. Ascorbic acid plays an important role in cell division, plasma membrane, proton pumps and enlargement cell. According to the theory of acidic growth, ascorbic acid weakens cell wall and increases cell enlargement. Among the applied treatments combination of banzyladenine, thiamine and ascorbic acid increased the number of lateral branches to 100%. Results showed that GA in all concentrations and combinations used in this experiment increased lateral branches length. Several reports about plants such as croton, hibiscus and pot marigold indicated that BA can increase the number of branches per plant. Therefore, BA is used to enhance branching and to reduce the total height of the plants. The highest fresh and dry weight were observed in plants treated with the combinations of BA, thiamine and ascorbic acid. Thiamine increased chlorophyll a content more than other substances. There was no significant difference between thiamine or thiamine combined with ascorbic acid treatment on chlorophyll b content. Thiamine in combinations with all the other treatments significantly improved carotenoids content compared to control. Chlorophyll plays a key role in plants for absorption and utilization of light energy which used in photosynthesis. Therefore, effects of PGRs on chlorophyll biosynthesis or degradation influence directly on photosynthesis. Thiamine was reported that in some plants assist resynthesize of chlorophyll in plant without chlorophyll and increased growth and yield eventually. All the treatments significantly increased reducing sugar. Although all of the substances improved the amount of reducing sugar, the role of thiamine was more dramatic compared to other treatments. The greatest amount of reducing sugar 85.3 mg. g⁻¹ fresh weight was observed in the combination of BA, thiamine and ascorbic acid. Thiamine is an essential part of the biosynthesis of pyrophosphate thiamine coenzyme which has an important role in carbohydrate metabolism. Application of vitamin c it was reported the increased soluble sugar in Chinese hibiscus.

1 and 2- Graduated of M.Sc. and Associate Professor, Department of Horticultural Science, Faculty of Agriculture, Shahid Bahonar University of Kerman, Kerman, Respectively

(*-Corresponding Author Email: baniasadi.fatemeh@yahoo.com)

Conclusion: Periwinkle is a bedding plant that the number of flowers and lateral branches is very important. BA with thiamine and ascorbic acid combination has the best effects on these traits and improved growth condition of it. On the other hand, application of gibberellic acid, either simple or combined with other materials, due to the excessive increase in plant height, led to the bending of the plant.

Keywords: Reduced sugar, Pigment, Flowering, Vitamin



The Effect of Enrichment with Bio-fertilizers and Three Nutrients of Iron, Zinc and Manganese on Germination Characteristics of Ajowan (*Carum copticum* L.)

M. Motamednezhad^{1*} - S. V. Eslami² - M. H. Sayyari³ - S- Mahmoodi⁴

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Introduction: Cultivation of medicinal and aromatic plants has always had a special situation in the traditional system of agriculture and these systems have played a major role on diversification and sustainability of agricultural ecosystems. Tend to produce medicinal and aromatic plants and demand for natural products, especially in terms of ecological culture in the world is increasing. Ajowan is an annual herbaceous plant from the Apiaceae family. Biological fertilizers produced by the activity of microorganisms are associated with nitrogen fixation or availability of phosphorus and other nutrients in the soil. Enrichment means increasing the concentration of nutrients in plants especially micronutrients. Application of biological fertilizers instead of using chemicals is one of the most important nutritional strategies in sustainable management of agro-ecosystems. In this regard, the effect of enrichment with bio-fertilizers and micronutrients on Ajowan (*Carum copticum* L.) germination characteristics was studied at Birjand Agricultural Research Laboratory.

Materials and Methods: A factorial experiment based on a CRD (completely randomized design) was conducted with three replications at Birjand Agricultural Research Laboratory during 2011. Experimental treatments consisted of bio-fertilizer application with three levels including without inoculation, and seed inoculation with *Azospirillum* and *Azotobacter* and seed enrichment with ten different treatment levels including without enrichment, and enrichment using 1, 2 and 3 mM of Fe, Zn and Mn elements. Bacteria were provided by Soil and Water Research Institute of Tehran. Initially, the seeds were disinfected through immersing them in 1% sodium hypochlorite for 3 minutes and then washing them with the tap water for 2-3 times. For the Enrichment of seeds, depending on the treatments, Petri dishes were treated with 10 ml of micronutrients solution for 24 hours. Then for bacterial inoculation depending on the type of treatments, seeds were soaked in 7 ml of inoculums containing 10^8 alive and active bacteria per ml for 5 hours. In each treatment, 15 seeds were placed in Petri dishes sealed with parafilm and placed in a germinator set at 70% RH and 25/15 °C. The traits studied were: germination percentage, germination rate, root and shoot length, as well as root and shoot fresh and dry weight. Before analyzing the data, normality test was performed and analysis of variance was performed using Genstat and graphs were drawn using Excel software.

Results and Discussion: The Analysis of variances results showed that seed inoculation with biological fertilizers and micronutrients significantly increased germination rate, root and shoot length, root fresh weight and dry weight of root and shoot of Ajowan compared with the control. Results showed that there were not significant differences between treatments in terms of germination percentage. Using micronutrients for seed enrichment caused increased germination rate. The maximum germination rate value was obtained from the Mn 1mM treatment (2.164 seeds per day), and its minimum value was obtained from Zn1 (1.55 seeds per day). The maximum and minimum values of root length were obtained from the combined treatments of *azotobacter* + Fe2 and *Azospirillum* + Zn3, respectively. The maximum and minimum values of shoot length were obtained from the combined treatments of *azotobacter* + Mn2 and *Azospirillum* + Zn3, respectively. The highest and lowest values of shoot dry weight were obtained from *azotobacter* + Fe3 and *azotobacter*, respectively. The highest and lowest values of root dry weight were obtained from Zn1 (2.35 mg) and Mn2 (0.4 mg), respectively. The highest and lowest values of root fresh weight were obtained from *Azospirillum*+ Mn3 and *Azospirillum*+ Zn2, respectively. The highest and lowest values of shoot fresh weight were obtained from *Azotobacter*+Mn2 and Mn3, respectively.

Conclusion: During the evaluation of the measured traits regarding to bio-fertilizers application on ajowan, it was observed that all biological treatments were superior to the control (non-biological fertilizer) and *Azotobacter* was the most effective amongst them. Bio fertilizers applications used in this study showed significant effects on root and shoot length, as well as fresh weight of root and shoot. The use of micro-nutrients on ajowan, showed that the application of 1 and 2 mM of Mn and all three concentrations enhanced the examined characteristics, while the application of 1 mM of

1, 2 and 4- M.Sc. Student of Seed Science and Technology, Associate Professors, Department of Agronomy, Faculty of Agriculture, University of Birjand, Respectively

(*-Corresponding Author Email: m.motamednejad@yahoo.com)

3- Assistant Professor of Department of Soil Science, Faculty of Agriculture, University of Birjand

Zn was just effective on root and shoot dry weight. Overall, application of these micronutrients had significant effects on germination rate and root length and fresh weight of root and shoot as well as dry weight of shoot and root.

Keywords: *Azospirillum*, *Azotobacter*, Fe, Medicinal Plants, Zn



Physiological Responses of Some Iranian Grape Cultivars to Iron Chelate Application in Calcareous Soil

H. Doulati Baneh¹ - E. Montazeri²

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Introduction: Iron chlorosis is considered to be one of the most important nutritional disorders in grapevines, particularly in calcareous soils that under these conditions fruit yield and quality is depressed in the current year and fruit buds poorly develop for following year. Symptoms of iron chlorosis in orchards and vineyards are usually more frequent in spring when shoot growth is rapid and bicarbonate concentration in the soil solution buffers soil pH in the rhizosphere and root apoplast. Several native grapevine (*Vitis vinifera* L.) genotypes, highly appreciated for their organoleptic characteristics and commercial potential, are widely cultivated in Iran. Cultivated plants differ as to their susceptibility to Fe deficiency in calcareous soils, some being poorly affected while others showing severe leaf chlorotic symptoms. Selection and the use of Fe-efficient genotypes is one of the important approaches to prevent this nutritional problem. In this research the response of three local grapevine cultivars was evaluated to iron chelate consumption in a calcareous soil (26% T.N.V.)

Material and methods: Well rooted woody cuttings of three autochthonous varieties (Rasha, Qezel uzum, Keshmeshi Qermez) were cultivated in pots filled with a calcareous soil with iron chelate consumption at three rates (0, 7.5 and 15 mg Fe/ Kg soil). The study was conducted with two factors (cultivar and iron chelate) and 3 replicates in a factorial arrangement based on randomized complete block design. Plant parameters including vegetative growth, chlorophyll index and leaf area were monitored during the growth period. At the end of the treatment, fresh and dry weight of shoots and roots were determined. The concentrations of macro and micro elements in the leaves were assayed using an atomic absorption and spectrophotometer. One-way-ANOVA was applied comparing the behavior of the cultivars growing.

Results and Discussion: Analysis of variance showed that chlorophyll index and leaf area differ significantly among tested cultivars. The highest and the lowest chlorophyll index were observed in Rasha and Keshmeshi Qermez cultivars, respectively. Fe chelate consumption up to 7.5 mg/kg significantly increased chlorophyll, leaf area, shoots growth and fresh weight of shoot and root compared to the control. The highest leaf area was related to Rasha cultivar in 7.5 mg/kg treatment. In all tested cultivars by increasing Fe concentration to 15 mg/kg, leaf area was decreased. According to the laboratory results, there was a significant difference in the concentrations of some macro and micro nutrient of leaves among tested cultivars. The highest amount of K, Fe, Mn and Zn was recorded in leaves of Rasha cultivar. Qezel uzum has also the highest P, N, Ca, Mg and Cu in its leaves. Application of 7.5 Fe mg /Kg soil increased calcium, magnesium and copper concentrations in leaves of Rasha cultivar and nitrogen concentration in Qezel uzum cultivar. In Keshmeshi Qermez cultivar, the sensitive cultivar to iron chlorosis, iron chelate consumption up to 7.5 Fe mg /Kg soil increased nitrogen, zinc and copper concentrations. Increase in iron consumption up to 15 mg/Kg soil caused significant increase in copper concentration. Among the study cultivars, Rasha significantly absorbed the highest iron, zinc, manganese and potassium from the soil and did not show iron chlorosis, so it can be as a suitable rootstock with respect to iron chlorosis.

Conclusion: In this study we have studied the influence Fe-chelate on some features of three Iranian grapevine cultivars (*Vitis vinifera* L) grown in calcareous soils. Our findings confirm the variable response of native grapevines to bicarbonate-induced iron deficiency. The most susceptible cultivar, Keshmeshi Qermez, have been very impaired by the calcareous soil; it produced less shoot growth and dry matter since these factors of the tolerant cultivars was decreased very little. The different behavior of potted cultivars with respect to iron chlorosis is related to modifications of some physiological parameters at the root level. A parameter which emphasizes the differential response of the genotypes to stress conditions was the capability of the genotypes to take up elements from the soil. Rasha cultivar showed a high degree of tolerance by taking up more iron when

1- Associate Professor, Horticulture Crop Research Department, Research and Education Center of West Azarbaijan Agricultural and Natural Resources Research Center, AREEO

(*-Corresponding Author Email: ah_dolati@yahoo.com)

2- M.Sc. Soil and Water Research Department, Research and Education Center of West Azarbaijan Agricultural and Natural Resources Research Center, AREEO

growing on calcareous soil, while keshmeshi cultivar took less iron. It will be recommended use of Rasha cultivar in calcareous soil as on rooted vine or rootstock. These findings suggest that biochemical parameters may constitute reliable criteria for the selection of tolerant grapevine genotypes to iron chlorosis.

Keywords: Grapevine, Leaf area, Chlorophyll index and Iron chlorosis



Plant Residual Management in Different Crop Rotations System on Potato Tuber Yield Loss Affected by Wireworms

A. Zarea Feizabadi¹

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Introduction: Selection a proper crop rotation based on environmental conservation rules is a key factor for increasing long term productivity. On the other hand, the major problem in reaching agricultural sustainability is lack of soil organic matter. Recently, a new viewpoint has emerged based on efficient use of inputs, environmental protection, ecological economy, food supply and security. Crop rotation can not supply and restore plant required nutrients, so gradually the productivity of rotation system tends to be decreased. Returning the plant residues to the soil helps to increase its organic matter and fertility in long-term. Wireworms are multi host pests and can be seen in wheat and barley too. The best approach for their control is agronomic practices like crop rotation. Wireworms population and damage are increased with cultivation of grasses and small seed gramineas in mild winters, variation in cropping pattern, reduced chemical control, and cover crops in winter. In return soil cultivation, crop rotation, planting date, fertilizing, irrigation and field health are the examples for the effective factors in reducing wireworms damage.

Materials and Methods: In order to study the effect of crop rotation, residue management and yield damage because of wireworms population in soil, this experiment was conducted using four rotation systems for five years in Jolgeh- Rokh agricultural research station. Crop rotations were included, 1) Wheat monoculture for the whole period (WWWWW), 2) Wheat- wheat- wheat- canola- wheat (WWWCW), 3) Wheat- sugar beet- wheat- potato- wheat (WSWPW), 4) Wheat- maize- wheat- potato- wheat (WMWPW) as main plots and three levels of returning crop residues to soil (returning 0, 50 and 100% produced crop residues to soil) were allocated as sub plots. This experiment was designed as split plot based on RCBD design with three replications. After ending each rotation treatment, the field was sown with potato cv. Agria in each plot in 2011. At harvest time, tuber yield and also percentage and severity of infection was determined. All data was analyzed statistically and Duncan test was used for comparison of means.

Results and Discussion: Analysis of variance results showed that, potato tuber yield was statistically ($P \leq 0.01$) affected by the crop rotation, the rate of returning residues, and also interaction between rotation \times returning residues. When 1000 tuber was considered, analysis of variance results showed, crop rotation had a very significant effect ($P \leq 0.01$) on number and percent of infected tubers to wireworm and its holes. The most infected tubers i.e. 42.3% and holed i.e. 61.4% and totally 4.24% of tubers belonged to the rotation 2, where rapeseed crop was the preceding plant. The least one was achieved in rotation 1, with the rates of 27%, 37% and 2.8% where potato crop was not planted previously. The highest infection to wireworm was found in 100% residue returning to the soil with 3.8% and the lowest one in no residue returning to the soil, i.e. 3.4 %. Results showed that with increasing residue returning to the soil, the damage of wireworms increased too.

Conclusion: Generally applying crop rotation using different crops and residue returning to the soil is resulted in higher potato tuber yield. This increasing rate for tuber yield was 116% and 57% when the preceding crops were wheat and rapeseed respectively compared to the mean of rotations 3 and 4. sustainable production of potato and reduction of wireworm damage, it is necessary to focus on other crop rotation and the importance of C:N ratio and the rate of residue returning to the soil.

Keywords: Agroecosystem, Crop Residues, Sustainable Production, Tuber Pests

1- Professor of Seed and Plant Improvement Research Department, Khorasan Razavi Agricultural and Natural Resources Research Center, Agricultural Research, Education and Extension Organization (AREEO), Tehran
(*-Corresponding Author Email: azarea.2002@yahoo.com)



Beneficial Effects of Selenium on Some Morphological and Physiological Trait of Hot Pepper (*Capsicum annuum*)

L. Shekari^{1*} - M. M. Kamelmanesh² - M. Mozafarian³ - F. Sadeghi⁴

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Introduction: Aluminum (Al), cobalt (Co), sodium (Na), selenium (Se), and silicon (Si) are considered as beneficial elements for plants. They are not required for all plants but they can improve the growth and development of some plant species. Selenium is an essential element for human with antioxidant and antiviral functions but is not considered essential for higher plants. Selenium is reported to be protective against cancer and more than 40 types of diseases are associated with Se deficiency. The amounts of selenium in food also depends on the amount of the element in the soil. However, its beneficial role in improving plant growth and stress tolerances is well established. Plants revealed different physiological reactions into the Se levels, some species accumulate it and in contrast some others are sensitive and Se is a toxic element for them. Some studies showed that Se can reduce adverse effects of salinity, drought, high and low temperatures and also heavy metal stress by enhancing antioxidant defense and MG detoxification systems. Pepper is one of the most important vegetable crops which have strong antioxidant properties. The effect of Se on vegetable especially on hot pepper is not well documented.

Materials and Methods: Present experiment was designed in order to study the effects of different concentrations of selenium on vegetative growth and physiological trait of hot pepper (*Capsicum annuum* cv. *kenya*) under hydroponic conditions in the greenhouse at the Department of Horticulture Science, Islamic Azad University of Shiraz (Iran) under natural light with a day/night average temperature of 25/17 °C, relative humidity of 50±8.5% and photoperiod 14/10 (day/night). This experiment was carried out based on completed randomized design (CRD) with 5 Se levels at (0 as control, 3, 5, 7 and 10 μM) with 3 replications. 30 days old seedling with uniform size were selected and transplanted into 4L pot containing a mixture of peat moss and perlite (1:1). The nutrient solution was a modified Hoagland's solution and each plant received 400 mL nutrient daily. Selenium concentrations were added by 0, 3, 7 μM Na₂SeO₃ (Merck, Germany) 10 days after transplanting. Leaf number (by counting), leaf area (with leaf area meter), relative water content (RWC), membrane stability index (MSI), chlorophyll and carotenoids content were determined one month after treatment applications. All data were subjected to one-way ANOVA by Statistix 8 (Tallahassee FL, USA) and the means were compared for significance by the least significant difference (LSD) test at p < 0.05.

Results and Discussion: The results showed that selenium supplement at 5 μM significantly increased relative water content by 12.8% compared to control. Se increased root growth and thus absorbed more water and increased RWC in present experiment. Selenium at 7 and 10 μM Se increased membrane stability index by 33.61 and 80.06, respectively, compared to control which may be due to increasing potassium by Se application. Selenium at 3 and 5 μM increased leaf area by 24.6% and 25.1% relation to plants which were grown without Se supplementation. Leaf number increased by application of 5 μM Se by about 15.14% and chlorophyll a, b and total increased by 64.67%, 38.5% and, 55.8%, respectively, in comparison with plants grown without Se application. Carotenoid content was not affected by different Se concentrations. Se increased chlorophyll content by increasing Mg and Fe absorption, or protect of chlorophyll content against chloroplast enzymes. The highest leaf area was observed at 3 μM Se in comparison with other treatments. Se at 5 μM is beneficial for growth, photosynthesis pigments, leaf area and leaf number. Se application had no beneficial influence on lateral shoot. The highest starch concentration was observed at 5 μM Se (by about 60% in comparison with plants were grown without Se application).

Conclusion: In general, the result of present study indicated that selenium at low concentrations improved plant growth (such as leaf area and leaf number), physiological trait (relative water content and membrane stability index) and photosynthesis pigments (chlorophyll a and b) of hot pepper in hydroponic conditions. It is

1 and 3- Young Researchers and Elite Club, Shiraz Branch, Islamic Azad University, Shiraz

(* - Corresponding Author Email: parisa.shekari63@yahoo.com)

2- Associate Professor of Department of Plant Protection, Islamic Azad University of Shiraz, Shiraz

4- Associate Professor of Department of Horticulture, Islamic Azad University of Shiraz, Shiraz

also suggested that this experiment should be repeated on some other important vegetable during growth and reproductive stages in hydroponic and soil condition and also on hot pepper quality and quantity of fruit.

Keywords: Beneficial elements, Membrane stability index, Photosynthesis pigments, Relative water content



Assessment of Direct Regeneration in Germany (*Matricaria chamomilla* L.) and Shirazi Chamomiles (*Matricaria recutita* L.)

A. Masoumiasl^{1*}- A. Aryiaeineghad²- M. Dehdeari³

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Introduction: German (*Matricaria chamomilla* L.) and Shirazi (*Matricaria recutita* L.) chamomiles are the most important medicinal plants of the Astraceae family which are used in the pharmaceutical, health, food and cosmetics industries. Production of this plant has been undertaken in Iran mainly in Isfahan, Kohgiluyeh and Boyer-Ahmad, Golestan and Hamedan provinces. *In vitro* propagation of plants have higher potential to produce qualified natural products, restoring and preserving of endangered plants, induction of somaclonal variation, industrial reproduction, valuable secondary metabolites and increased active ingredients. Various studies have reported successful micro propagation system for five chamomile varieties on MS medium contained 0.01 mg/l NAA and 2.5 mg/l kinetin. The aim of this study was to investigate the effects of stem (with and without node), leaf and cotyledon explants and different plant growth regulators on direct regeneration of German and Shirazi chamomiles. Although the Shirazi chamomile is native to Iran, but German chamomile is Iran non-indigenous cultivar. Up to now, there have been no compare is on reports about responses of these cultivars to tissue culture.

Materials and methods: This research was performed in the central laboratory of Agriculture Faculty in Yasouj University. Seeds were provided from Pakan-Bazr institute, Isfahan. Chamomile seeds were disinfected by ethanol (70%) for 5-10 min and sodium hypochlorite 3% for 5-12 min and then washed for several times by distilled water. Then, seeds were sown on MS medium for germination. After 2-3 weeks, seedlings were grown and then planted in MS medium supplemented with hormonal combinations of NAA at two levels (0.1 and 0.5 mg/l), kinetin at three levels (2, 2.5 and 3 mg/l) and Zeatin, BAP and 2ip at three levels (0.5, 1 and 1.5 mg/l). The experiment was performed in a completely randomized design with four replications. Factors included explants, cultivars and hormonal combinations. In this experiment, traits such as stem induction percentage, stem length, stem fresh and dry weight root induction percent, root length and stem fresh and dry weight were measured. Statistical analysis was performed using SAS software (version 9.1). In order to test the normality and perform mean comparisons, Minitab 14 and MSTAT-C software was used and excel software was used for drawing diagrams.

Results and discussion: For all traits except stem induction percentage and root dry weight, triple interaction of explants, hormonal combinations and cultivar were significant at 1% level. Triple mean comparisons for cultivar, explant and hormonal combinations showed that the highest mean for stem height, stem fresh weight, stem dry weight, root induction percent, root height and root fresh weight were obtained in Shirazi Chamomile cultivar with cotyledon explants in hormonal combinations of 0.1 mg/l NAA and 1.5 mg/l 2ip. The results showed that the best explants in both chamomiles for direct regeneration were stem (whit node) and cotyledon with 78.75% and 75% regenerations, respectively. The best genotype and hormone combination were monitored for Shirazi chamomile and MS medium supplemented with 1.5mg/l 2ip with 0.1mg/l NAA. To determine the best hormonal combination for root regeneration from direct regeneration, the stems were embedded in medium contained different concentrations of IBA. The first signs of rooting production were observed after 5-7 days. After completing the roots formation (4 weeks after transferring), the rooting percentage, root length, fresh and dry weight of roots were measured. Based upon variance analysis, effect of triple interactions of IBA, explants and cultivar on all traits were not significant, but the effect of IBA for all traits was significant at 1% level. The highest percentage of root regeneration (73.75 %), the highest root length (6.60 cm), root fresh weight (174.167mg) and the highest root dry weight (16.425 mg) were obtained from medium contained 0.5 mg/l IBA. Root differentiation was influenced by auxin (0.5 mg/l IBA) or spontaneously. Regenerated plantlets were transferred to pots contained sterilized soil (3:1:1 mixture of soil: sand: leaf compost). For plant adaptation to natural conditions, glassy caps were used. After adaptation, the caps were removed and the plants were transferred into a growth chamber. Previous studies reported that MS medium supplemented with 0.2 to 1 mg/l of BA and 2 mg/l of NAA induced adventitious bud formation and shoot

1, 2 and 3- M.Sc. Student of Plant Breeding, Assistant Professor and Associate Professor of Agronomy and Plant Breeding Department, Agriculture Faculty, Yasouj University, Respectively
(*- Corresponding Author Email: Masoumiasl@yu.ac.ir)

development in leaf explants of Roman Chamomile. A higher number of adventitious buds were observed at the proximal end of the explants. Plantlets were rooted on MS medium supplemented with 0.1 mg/l of IBA and successfully weaned **in vivo**.

Conclusion: Based on the results of this research, chamomile showed relevant response to direct regeneration.

Keywords: Explant, Genotype, Hormone, Micropropagation



Effect of Deficit Irrigation Treatments on Vegetative Characteristics and Quantity and Quality of Golden Delicious Apple

I. Arji^{1*} - B. Hassani² - H. Ghamarnia³

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Introduction: Since Iran is located in arid and semi-arid region of the world, so consumption and saving of water must be taking into account. Water is often a valuable natural resource, thus proper application methods - for increase water efficiency can be very important. Regulated deficit irrigation (RDI) is one of the most important methods to increase water use efficiency and fruit quality. Apple is one of the most important fruit trees from economical point of view. Studies showed that regulated deficit irrigation led to growth reduction in apple trees and sometimes fruit quality increased. The aim of this study was to evaluate the effect of deficit irrigation on vegetative growth and fruit quantity and quality of Golden delicious apple trees in Gahvareh region of Kermanshah province .

Materials and Methods: This experiment was conducted on 10 years old Golden delicious apple trees in a randomized complete block design with 5 irrigation treatments and three replications during 2006. Three apple trees assigned to each experimental unit. Irrigation treatments were: T1= early deficit irrigation (40% water requirement), T2= early deficit irrigation (60% water requirement), T3= late deficit irrigation (40% water requirement), T4=late deficit irrigation (60% water requirement), T5=control (C) (100% water requirement). Early deficit irrigation starts 55 days after full bloom (15th Jun) and continued 60 days (16th Aug), while late deficit irrigation starts 115 days after from full bloom (16th Aug) and continued 40 days near to harvesting time (23th Sept). Control trees were full irrigated based on water requirement, which calculated based on national water document of Iran and irrigation amount was calculated based on the following formulas: $Q=0.0184.L.H^3/2$

Where Q is volumetric flow rate (liter/Second), L is parshall flume crown length (cm) and H is water height (cm). Irrigation time was calculated based on national water document of Iran and volumetric flow rate as this formula $Q.t = di.a$, where Q is volumetric flow rate (liter/Second), t is time based on second, di is net water requirement and a is irrigated area. To evaluate irrigation effects some vegetative (shoot growth and trunk cross sectional area); reproductive (fruit volume, fruit weight and yield) and quality (Total soluble solid, total sugar, nitrogen, phosphorous, potassium and calcium) traits were measured .

Results and Discussion: Results showed that deficit irrigation had no effect on trunk cross sectional area, but shoot growth was affected significantly by deficit irrigation by . So, regulated deficit irrigation (RDI) can be used to control excessive vegetative growth in apple trees. There were no significant differences of fruit volume and weight of trees under deficit irrigation than the control exception to secondary 40% treatment. Fruit yield did not have significant differences under early and late 60% treatment in compare to the control. Where yield reduction was only 4 and 8 % in late and early 60% deficit irrigation respectively in compare to full irrigated trees. Water deficit had positive effect on qualitative traits of apple fruit, So that total soluble solids (TSS) and total sugar concentration (TSC) of fruit were higher in trees subjected to deficit irrigation as compared to the control. Regulated deficit irrigation led to 7-18% and 1.8-15% increase in total soluble solid and total sugar content in compare to full irrigated trees. Relative water content (RWC) was significant based of the time of applying deficit irrigation. Deficit irrigation did not have significant effect on fruit minerals such as P and K in compare to the control, but N content had significant reduction in deficit irrigation treatments in compare to the control and Ca fruit content of control trees had significant different in compare to trees were subjected to early deficit irrigation (40% of water requirement). . RDI favored reproductive growth over vegetative growth by suppressing vegetative growth. Water saving in deficit irrigation was 41, 27, 18 and 12 percent in early 40%, 60% and late 40% and 60% of water requirement respectively. Therefore, regulated deficit irrigation (RDI) applied with good intensity and at the right time not only reduces the amount of water used but also increased the yield performance and some fruit qualitative properties. RDI can be used to control vegetative growth and improve yield efficiency of apple trees.

1- Assistant Professor of Agricultural and Natural Resources Research and Education Center of Kermanshah, Kermanshah

(*-Corresponding Author Email: issaarji@gmail.com)

2- Former M.Sc. Student of Islamic Azad University Science and Research Unit, Tehran

3- Professor of Agricultural Faculty Razi University of Kermanshah, Kermanshah

Conclusions: Regulated deficit irrigation is more effective for water saving with a higher WUE and not reduction of fruit quality rather than to contain excessive vegetative growth in apple trees. Therefore, RDI can be suggested for commercial use and can be adapted successfully for the regions in similar soil and climate conditions. In general water deficit irrigation can cause increases quality of fruit in the Golden Delicious apple trees. Therefore, it is recommended to apply 60% of the water requirement for this cultivar.

Keywords: Drought Stress, Mineral Nutrition, Yield, Total Soluble Solids



Studies on Callus Induction and Regeneration of Medicinal Plant Chicory (*Cichorium intybus* L.) from Leaf and Petiole Explants

H. Hadizadeh¹- M. Mohebodini*²- B. Esmailpoor³- E. Chamani⁴

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Introduction: Chicory (*Cichorium intybus* L.) belongs to Asteraceae family and is commonly known as witloof chicory. The leaves and roots of this medicinal plant are edible and commonly used as salad. Some varieties are also cultivated as coffee substitute after roasting the roots. All parts of the plant contain these volatile oils, with the majority of the toxic components concentrated in the plant's root. In folk medicine, the plant is used for treatment of diarrhea, spleen enlargement, fever, and vomiting. Antihepatotoxic activity on damaged rat liver sections and anti-bacterial activity of this crop have been recently reported. *In vitro* regeneration from leaf explants with various hormonal combinations has been reported previously. Moreover, *in vitro* regeneration of Chicory from cotyledon explants using different combinations of plant growth regulators has been studied. A protocol for the regeneration of plantlets from leaf and petiole explants of witloof chicory has also been developed. The aim of the present investigation was optimization of callus induction and shoot regeneration from leaf and petiole tissues of Chicory (Esfahan genotype).

Materials and Methods: In this investigation, Esfahan genotype was used for callus induction and direct shoot regeneration. Seeds were first washed with running tap water for 30 min then seeds were surface sterilized by dipping in 70% ethanol for 90 s and rinsed with sterile distilled water, followed by immersing in 5% sodium hypochlorite solution for 25 min and thereafter rinsed for 30 min with sterile distilled water. The basal medium used in this investigation was MS. For shoot regeneration, leaf and petiole explants (5 mm segments) were excised from 4-week-old sterile seedlings and cultured on MS medium containing different combinations of NAA / BA and KIN / BA in two separate experiments. Experiments were performed factorial based on completely randomized design. Cultures were incubated at 25° C ± 2 with a 16/8 hour (day/night) photoperiod and an irradiance of 1500 LUX using Sylvania cool white fluorescent tubes. The percentage of callus induction, shoot regeneration and the number of regenerated shoots were calculated for the leaf and petiole explants. Data was subjected for analysis of variance and means were compared at 5% level with Duncan's multiple range tests.

Results and Discussion: Explants cultured on medium containing either no plant growth regulators (control) or cytokines alone produced no callus. However, after 2 weeks, other concentrations of NAA and BA indicated callus formation from leaf and petiole explants in all hormone combinations. In leaf explants, the highest callus induction were obtained in the medium containing 0.3 mg l⁻¹ NAA with 1 mg l⁻¹ KIN and 0.3 mg l⁻¹ NAA with 1.5 mg l⁻¹ KIN (81.25%). Leaf and petiole explants cultured on medium containing no plant growth regulators (control treatment) and medium containing NAA produced no shoots. The combination of 0.3 mg l⁻¹ NAA and 0.1 mg l⁻¹ BA was the best treatment tested. This treatment produced 2.7 shoots per explant at 71% shoot regeneration frequency in leaf explant and 2.73 shoots per explant at 73% shoot regeneration frequency in petiole explants. The results also showed that the highest percentage of regeneration and the highest number of regenerated shoots were obtained in the medium containing 0.1 mg l⁻¹ NAA and 1 mg l⁻¹ KIN in leaf explants (65.6% regeneration and 1.37 shoots per explant, respectively). The highest number of regenerated shoots was obtained in the medium containing 0.3 mg l⁻¹ NAA and 0.5 mg l⁻¹ KIN in petiole explants (40.6% regeneration and 0.5 shoot per explants, respectively). Shoot regeneration requires plant cells to undergo dedifferentiation which is known to be affected by not only exogenous plant growth regulators but also endogenous content of the hormones. Different tissues may have different levels of endogenous hormones and, therefore, the type of explant source would have a critical impact on the regeneration success. In our study, when leaf and petiole explants were compared, it was clear that leaf explants were much more productive for regeneration than petiole explants.

Conclusion: Callus induction and shoot regeneration are *in vitro* tissue culture methods. Plant growth regulators and types of explant are the most important factors for callus induction and shoot regeneration phases. Therefore, optimization of these factors is essential to establish a high frequency of callus induction, shoot

1, 2, 3 and 4- M.Sc. Student, Assistant Professor and Associate Professors of Horticultural Sciences, University of Mohaghegh Ardabili, Ardabil, Respectively

(*- Corresponding Author Email: Mohebodini@uma.ac.ir)

regeneration and gene transfer to this plant.

Keywords: BA, KIN, Medium, NAA, Shoot



Effects of Salicylic acid and Humic acid on Vegetative Indices of Periwinkle (*Catharanthus roseus* L.)

E. Chamani^{1*} - M. Bonyadi² – A. Ghanbari³

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Introduction: Vinca flower (*Catharanthus roseus* L.) is one of the most important medicinal plants of Apocynaceae (31, 27). Tropical plant native to a height of 30 to 35 centimeters (9) and a perennial shrub which is grown in cold areas for one year (27). One of the plants in the world today as a medicinal plant used the periwinkle plant. Among the 130 indole – terpenoids alkaloids which have been identified in the plant periwinkle vinca alkaloids vincristine and vinblastin are the most important component is used to treat a variety of cancers. Including therapies that are used for a variety of cancer, chemotherapy to help Vinca alkaloids collection (including vincristine and...). Vinblastin as effective member of this category, due to the low percentage of venom and effects at very low doses, is widely used today. These materials are generally formed as inhibitors of mitotic spindle in dividing cells have been identified. Vinblastin with these structural changes in connection kinetochore - microtubules and centrosomes in a dividing cell, the mitotic spindle stop (45). Salicylic acid belongs to a group of phenolic compounds found in plants, and today is widely regarded as a hormone-like substance. These classes of compounds act as growth regulators. Humic substances are natural organic compounds that contain 50 to 90% of organic matter, peat, charcoal, rotten food and non-living organic materials are aquatic and terrestrial ecosystems (2).

Materials and methods: In this experiment, vinca F2 seeds in the mixed 4: 1 perlite and peat moss to the planting trays were sown. The seedlings at the 6-leaf stage were transferred to the main pot (pot height 30 and 25 cm diameter) The pots bed soil mix consisting of 2 parts soil to one part sand and one part peat moss (v / v) were used and after the establishment of seedlings in pots every two weeks with. Salicylic acid and humic acid concentrations 0 (control), 10, 100, 500 and 1000 mg were treated as a foliar spray. Salicylic acid and humic acid used in the Merck has the solutions according to plant size in proper volume has been prepared and will be sprayed on aerial spraying. According to the bootblack periwinkle flowers and leaves to prevent leaf burn and create the solution at one point, for every cc100 solution, two drops of Tween 20 was added to the solution, then spray on the leaves and leaf fire does not spread. The experiment was conducted in a completely randomized design with 10 replicates at the end of the results by the SAS software analysis and comparison of means by Duncan's multiple range test was performed.

Results Discussion: According to the results of the data analysis of different treatments significant impact on the level of 1% of the height, number of leaves, chlorophyll, stomatal conductance, pods and stems of the side. Also, the tally was significant at 5%. According to the results of the data analysis of different treatments on stem diameter had no significant effect. Results of comparing the average of the data showed that treatment with 10 and 500 mg/l of salicylic acid per liter respectively in the first and second measurement and control showed lowest height. Treatment of 100 mg/l of humic acid maximum height was measured in two stages. The results of the comparison showed that an average of 500 mg/l of salicylic acid in a two-step measurement and control had the lowest number of leaves. Treatment with 10 mg/l in the first stage of the operation (L1) and treated with 100 mg/l of humic acid in the second vector data (L2) had the highest number of leaves. Treatment with 10 mg/l of salicylic acid and 100 mg/l of humic acid had the highest chlorophyll. The treatment of 10 mg/l of salicylic acid and 100 mg/l of humic acid had the highest stomatal conductance. The results of the comparison average showed that the 500 mg/l of salicylic acid and humic acid had the greatest impact on the number of flowers. As well as 500 mg/l salicylic acid and humic acid had the greatest impact on the number of pods. The results showed that treatment with 1000 mg/l salicylic acid and humic acid had the greatest effect on stem diameter .

Conclusion: The results of this study indicated that low concentrations of salicylic acid increased plant height, the number of leaves, chlorophyll content and stomatal conductance, which can increase plant resistance against unfavorable environmental conditions. As a result, the plants treated with salicylic acid can be increased two driven in adverse environmental conditions. The treatment of humic acid by increasing the rate of

1, 2 and 3- Associate Professor, Former Student and Assistant Professor Department of Horticultural Science, Faculty of Agriculture, University of Mohaghegh Ardabili, Ardabil, Respectively
(*- Corresponding Author Email: echamani@uma.ac.ir)

photosynthesis and increases the amount of material available for plant growth. This increase can accelerate the growth of the main branch and side periwinkle plant medicinal plants and enhances the appearance of the plant.

Keywords: Alkaloid, Chlorophyll, Stomata conductivity



The Effect of Phosphorus and Zinc Fertilizers on Nutrient Content and Essential Oil Yield of German Chamomile under Drought Stress (*Matricaria recutita* L.)

M. Ghaedi Jeshni^{*1} - M. Mousavinik² - J. Aminifar³

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Introduction: The German chamomile (*Matricaria recutita* L.) is mainly cultivated for essential oil. Nowadays, it is considered as a highly favored and much-used medicinal plant in regular and traditional medicine. Water deficit is one of the most important limiting factors on crops production in arid and semi-arid regions (Sharafi et al. 2002). Drought stress limits the growth of plants by reducing water content of tissues and causes some metabolic and physiological changes. On the other hand, the availability of nutrients in the soil is affected by drought stress. Thus, nutritional management of plants under drought stress conditions is one of the most important factors in crop production. A better understanding of the role of nutrients in plant resistance to drought is associated with improvement of fertilizer management in arid and semi-arid areas. Our objectives were to investigate the effects of phosphorus and zinc fertilizers on nutrient content and essential oil yield of German chamomile under drought stress.

Material and methods: The experiment was conducted in split plot factorial based on randomized complete block design with three replications at Research farm of University of Zabol in 2013. Drought stress consisted of three levels 75% (control), 50% (mild stress) and 25% of field capacity (severe stress) as main plots, and factorial combinations of three triple superphosphate fertilizer ($\text{CaH}_4\text{P}_2\text{O}_8$) levels (0, 150, and 300 kg ha⁻¹) and two zinc sulphate fertilizer ($\text{ZnSO}_4\text{H}_2\text{O}$) levels (0 and 30 kg ha⁻¹) as sub plots (the fertilizers were applied before planting time). The seeds were sown at 20 cm apart in rows 40 cm wide, on first half of March 2013. Drought stress levels were determined by the Time Domain Reflectometry (TDR). The success of chamomile cultivation as a commercial venture lies in how efficiently and effectively one can collect the flowers at the right stage during the peak flowering season extending over a period of 3–6 weeks. So, flowers were selectively collected on 27 April, 30 April, 4 May, 8 May, and 12 May 2013. German chamomile essential oil was extracted from the dried flowers and using Clevenger system. In the study, the content of potassium, sodium, zinc, phosphorus, chlorophyll a, chlorophyll b and essential oil yield were measured. Statistical analysis was carried out using SAS software (version 9.1). Significant difference was set at $P \leq 0.05$ and determined using the Duncan's multiple-range test.

Results and discussion: The results showed that exposing chamomile plants to soil moisture stress during its life cycle might lead to a significant effect on essential oil yield and the nutrient content except zinc and phosphorus. The phosphorus fertilizer also affected the content of potassium, sodium, zinc, phosphorus, chlorophyll and essential oil yield while the zinc fertilizer just affected zinc and phosphorus content, chlorophyll b and essential oil yield significantly. We also observed that high application of phosphorus fertilizer (300 kg ha⁻¹) had a negative effect on yield of chamomile. This plant growth disorder may occurred because of interaction between P and Zn that is usually termed 'P-induced-Zn deficiency'. This disorder in plant growth is associated with high levels of available P or with application of P to soil. Thus, it is important that the application of nutrients to be in balance. Having a good nutrient balance is therefore an important factor to improve plant growth by indicating the actual amount and the combination of nutrients that the production needs. This is also a good way to save money. In summary, the results of this study indicated that drought stress caused significant effects on physiological traits, essential oil yield and nutrient content. The results showed that optimum amount of Zn and P can improve the studied traits of chamomile. According to the results of this experiment, it seems that the application of Zn under drought stress condition can decrease damage of drought stress that this is maybe because of the critical role of that in plant nutrition and production.

Conclusion In general, the results suggested that irrigation based on 50% of field capacity with application of 150 kg phosphorus fertilizer ha⁻¹ and 30 kg zinc fertilizer ha⁻¹ can improve essential oil yield and medicine components of German chamomile essential oil.

Keywords: Chamomile, Fertilizer, Physiological traits, Water deficiency, Yield

1 - M.Sc. Student of Medicinal Plants, Faculty of Agriculture, University of Zabol, Zabol
(*Corresponding Author Email: meysamsalar68@gmail.com)

2 and 3- Associate Professor and Ph.D. Student, Agronomy Department, Faculty of Agriculture, University of Zabol, Zabol



Evaluation and Selection for Drought Tolerance in Iranian Fenugreek (*Trigonella foenum-graecum*) Landraces at Germination and Seedling Growth Stages

D. Sadeghzadeh Ahari^{1*} - M. R. Hassandokht² - A. Kashi³ - A. Amri⁴

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Introduction: Fenugreek (*Trigonella foenum-graecum* L.) has been cultivated in vegetable farms at the most parts of Iran. It is an annual crop belonging to the Leguminosae family. It is originated from west Asia and Iran and cultivated, at present, mostly in European, Asian and African countries. With distinguished of feeding and medicinal values, low needs from soil and its width adaptability to cultivation in different regions, the range of fenugreek cultivation areas have been extended from America to India. In most parts of Iran there is limiting possibilities for cultivation of horticultural and agricultural crops due to limiting water harvesting and unsuitable rainfall distributions. There is no doubt that introduction of new crops for such conditions could increase variation of crops production and stability of farming systems. Plants landraces have been created in thousands of cultivation years under different climatologically and local cropping systems. They are evolved by natural and artificial selection under environmental conditions where they were grown and there have accumulative adaptive genes for tolerance to biotic and abiotic stresses and are the most precious materials in breeding programs. Germination phase is the most important period that guaranties the growth and establishments of crops. One of the basic activators of germination starters is water and limiting of it (drought) is the most important retardant of seed growth during germination period under field condition. Fast germination and emergence of seedling from soil and high preliminary growth rate have been known as drought escape mechanisms for most crops such as chickpea, lentil and bean. In breeding programs of crops, using *in vitro* method is one of the most used methods in germplasm selection for drought tolerance. This study carried out under laboratory condition in order to evaluate some Iranian fenugreek landraces reactions to drought stress.

Materials and Methods: In order to evaluate the Iranian fenugreek landraces reactions to drought stress induced by Poly Ethylene Glycol 6000, twenty fenugreek landraces originated from different parts of Iran were used in this study. The experiment was conducted at Maragheh experimental station of the Dry land Agricultural Research Institute (DARI) under laboratory condition, with a factorial experiment based on randomized complete blocks design and three replications. The stress levels were zero (di-ionized water), -2, -4, -6 and -8 bar. Fifteen normal and health seeds from each landraces were cultivated in petridishes and stayed under fixed temperature (25 ± 1 degree of centigrade), 12 hour day/night for fourteen days. Seedling characteristics (seed germination percentage, root and stem lengths, ratio of stem length to root length, root and stem fresh weights, ratio of stem fresh weight to root fresh weight, root and stem dry weights) were noted. Data were analyzed by MSTAT-C software and comparisons of noted traits means done by Duncan's Multiple Range Test at 5% probability level. In order to distinguish tolerant and susceptible genotypes, landraces ranked by using of Sarmadnia *et al.*, (1988) and Kafi *et al.* (2005) methods, and with using of the main traits such as seed germination percentage, root and stem lengths, root and stem fresh weights, root and stem dry weights.

Results Discussion: Results showed that, drought stress levels had significantly affected on all study traits (seed germination percentage, root and stem lengths, ratio of stem length to root length, root and stem fresh weights, ratio of stem fresh weight to root fresh weight, root and stem dry weights). The differences among landraces were highly significant in all traits except in primary root dry weight. The most visible differences among the genotypes in germination percentage monitored at less than -4 bar. Based on ranking of genotypes with seven main studied traits (seed germination percentage, root and stem lengths, root and stem fresh weights, root and stem dry weights), Kashan and Neyshaboor were the most tolerant and Rey and Khash were the most susceptible landraces among the studied genotypes at germination and seedling growth stages.

Conclusion: It could be concluded that, there are differences among the Iranian fenugreek landraces in case of reaction to drought stress at germination and seedling growth stages that shows suitable diversity among them. Moreover, using from less than -4 bar drought stress levels recommended for screening and selection of drought tolerance fenugreek

1- Associate Professor of Faculty Member of Dryland Agricultural Research Institute (DARI), Agricultural Research, Education and Extension Organization (AREEO), Maragheh

(*Corresponding Author Email: dsadeghzade@yahoo.com)

2 and 3- Associate Professor and Professor, Horticulture Department, Agriculture College (Karaj), University of Tehran, Iran

4- Senior Scientist of International Center for Agricultural Research in Dry Areas (ICARDA), Rabat, Morocco

genotypes. Also, it is recommended attention to Iranian fenugreek landraces and using the hidden potentials of them same as drought tolerance and resistance. It is suggested protection of them as a precious genetically resources in gene bank.

Keywords: Drought tolerance, Poly Ethylene Glycol, Ranking, Seedling traits



Effects of Lavender Essential Oil and Methyl Salicylate on Gray Mold Control and Postharvest Quality of Strawberry

M. Sayyari^{1*} - R. Gharibi²

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Introduction: Strawberry (*fragaria*×*ananassa*Duch.) fruit characterized by short storage life, often estimated last less than one week even under optimum conditions at 8°C. The loss of fruit quality is often caused by gray mold (*Botrytis cinerea*) that is the most frequent reported postharvest disease in strawberry during storage (6). In recent years, considerable attention has been given to elimination of synthetic chemical and fungicides application and development of various alternative strategies for controlling fruit and vegetables diseases (2). One strategy is replacement of natural products with plant origin such as essential oil and methyl salicylate (MeSA). Essential oils are volatile, natural and complex compounds characterized by a strong odor formed by aromatic plants in form of secondary metabolites. In nature, essential similar oils that extract from lavender (*Lavandula angustifolia*) play an important role in protection of the plants against pathogen incidence that can be replaced by synthetic fungicides (1, 4 and 14). MeSA is also a volatile natural compound that synthesized from salicylic acid and has an important role in the plant defense-mechanism, as well as plant growth and development (5, 19 and 20). Therefore, the main objective of this research was to study the effects of MeSA and lavender essential oil (LEO) on decay control caused by *Botrytis cinerea* as well as post-harvest quality indices of strawberry fruits during cold storage.

Material and Methods: First, antifungal activity was studied by using a contact assay (in vitro), which produces hyphal growth inhibition. Briefly, potato dextrose agar (PDA) plates were prepared using 8 cm diameter glass petri dishes and inhibitory percentage was determined. For in-vivo assessment of LEO and MeSA effects on *Botrytis*-caused fungal disease control, the experiment was conducted as factorial in completely randomized design (CRD) with 3 replicates. The treatments were 3 concentration of LEO including 0, 500 and 1000 $\mu\text{l L}^{-1}$ and 3 levels of MeSA including 0.0, 0.1 and 0.2 mM. After treatment, the fruits were inoculated by *Botrytis* suspension and transferred to storage and quality parameters were evaluated after 7, 14 and 21 days. At each sampling time, disease incidence, weight loss, titratable acidity, pH, soluble solids content, vitamin C and antioxidant activity were measured.

Result and Discussion: The results showed that both LEO and MeSA treatments had significant effects on inhibition of mycelium growth within in-vitro condition ($p < 0.05$). Inhibition rate of mycelium growth significantly improved by higher LEO and MeSA concentrations (Table 1). Under in-vivo assessment, diseases incidence of treated fruits with 500 $\mu\text{l L}^{-1}$ LEO and 0.1 mM MeSA were 32% and 64% lower than untreated fruits, respectively (Fig. 1 and 2). During storage period, the percentage of infected fruits increased. In addition, LEO and MeSA treatments affected quality parameters of strawberry fruits including titratable acidity, soluble solids content, vitamin C and antioxidant activity. Treated fruits had a high content of soluble solids, vitamin C and antioxidant activity in comparison to untreated fruits (Table 3 and 4). Probably ascorbic acid decreased through fungal infection due to cell wall break down in storage. Any factor such as essential oil and salicylate that inhibit fungal growth can help preserving vitamin C in stored products. High level of vitamin C and antioxidant activity were observed in treated fruits with 0.1 mM MeSA and 500 $\mu\text{l L}^{-1}$ LEO. In controlling weight loss of fruits, 0.2 mM of MeSA and 500 $\mu\text{l L}^{-1}$ of LEO had significant effects, although MeSA was more effective than LEO treatments, possibly due to elimination of respiration rates and fungi infection (Table 4). Therefore, LEO and MeSA with fungicide effects could be replaced by synthetic fungicides in controlling fungal diseases of strawberry and maintain fruits quality during storage.

Conclusion: In conclusion, our results showed that LEO and MeSA treatments could be safe and used to prevent infection of strawberry during storage, although LEO was more effective than MeSA treatments. Concentration of 500 $\mu\text{l L}^{-1}$ of LEO and 0.1 mM MeSA could control fungal infection of fruits during storage. LEO and MeSA treatments can also extend shelf life for over the minimum period required to transit strawberries to foreign markets and without adversely affecting quality. However, future studies are necessary to fully understand the mechanisms by which LEO and MeSA treatments may act as a fungicide and increase their

1- Assistant Professor, Department of Horticultural Sciences College of Agriculture, University of Bu-Ali Sina

(*- Corresponding Author Email: m.sayyari@basu.ac.ir)

2- Former M.Sc. Student of Horticultural Sciences Department, College of Agriculture, University of Ilam

postharvest life.

Keywords: Antioxidant Activity, Fungi Diseases, Qualitative Parameters, Vitamine C