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THE EFFECT OF PARENT PLANT NUTRITION ON GERMINATION AND VIGOR OF SEEDS OF BALANGU (*Lallemantia royleana* L.) UNDER DIFFERENT IRRIGATION PERIODS

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ABSTRACT

Environmental conditions in which the seeds are produced affect seed characteristics and development. The aim of this experiment was to study the effect of parent plant nutrition on germination and vigor of seeds of Balangu medicinal plant (*Lallemantia royleana* L.) under different irrigation periods. For this purpose an experiment was conducted at Medicinal Plants Research Center of Shahed University, Tehran, Iran in 2014. First, maternal plants were exposed to irrigation periods and chelate nano-iron fertilizer in the form of a split plot statistical design according to an RCBD with three replications. After harvesting, seeds were subjected to germination test. Germination percentage (GP), mean germination time (MGT) and the seed vigor index (SVI) were calculated. Results revealed that the highest GP, MGT and SVI were observed when irrigation was cut off after seed formation stage suggesting drought during seed maturity may increase GP, MGT and SVI. Also, the highest GP was obtained when a solution of nano-iron fertilizer (8/1000) was sprayed on leaves rather than adding to the soil suggesting nano-Iron can be absorbed better and faster through spraying on leaves. Moreover the interactive effect resulted in a further increase in studied traits. In conclusion, results of the present study suggested that cut off irrigation after seed formation stage as well as foliar application of chelate nano-Iron fertilizer in Balangu maternal plants increased germinablity of seeds. However, a further increase was obtained under the impact of the interaction effect.

Keywords: germination percentage, medicinal plant, Nano-iron fertilizer, means germination time, seed vigor index.

INTRODUCTION

Seed is one of the most important methods of plant reproduction. Seeds are the delivery systems for agricultural biotechnology, and high levels of “field” performance (seed quality) are essential for predictable seedling establishment. High seed quality and seedling establishment can be considered as cornerstones of profitable, efficient and sustainable crop production (Finch-Savage, 1995).

Balangu (*Lallemantia royleana* L) belongs to the *Labiatae* family which is growing extensively in different regions of European and Middle East countries especially Turkey, Iran, and India. Seeds of this plant has small globular pone with white color in thin position and other terminal is convex with a notch. Balangu is a good source of fiber, oil and protein and has some medicinal, nutritional and human health properties (Naghibi *et al.*, 2010).

This seed adsorbs water quickly when soaked in water and produces a sticky, turbid and tasteless liquid. Balangu seeds are used in a wide range of products made in traditional or industrial such as a beverage (namely Tokhme Sharbati) and bread in Iran and Turkey.

In most plant species, the seeds vary in their degree of germinability and vigor between and within populations even between and within individuals. Some of this variation may be of genetic origin, but much of it is known to be phenotypic (Gutterman, 2000).

Environmental conditions in which the seeds are produced affect seed characteristics and development. These conditions often lead to changes in the size and weight of the seed. There are numerous cases recorded of seed germinability being modified by environmental factors operating during development and maturation (Gutterman, 2000).

Among environmental conditions, drought and nutrition of the parent plant are of the two major factors affecting geminablity of seeds.

Most of the earlier works over impact of the maternal effect on seed germination have been mainly focused on crops, therefore.

The purpose of this experiment was to study the effect of parent plant nutrition on germination and vigor of seeds of Balangu under different irrigation periods.

MATERIALS AND METHODS

Experimental site

The study was conducted at Medicinal Plants Research Center of Shahed University, Tehran, Iran in 2014 (latitude: 51°, 08´, longitude: 35°, 34´, altitude: 1190 m above the sea with average annual temperature of 17.1°c). Soil physicochemical specifications as well as available nutrients were measured before conducting the experiment (Table-1).

Table-1. Some physicochemical properties of the soil of the experimental site.

Clay%	Silt%	Sand%	OM%	SH%	pH	ECe	N%	P ($mg.kg^{-1}$)	K ($mg.kg^{-1}$)	Fe ($mg.kg^{-1}$)
20.0	6.0	74.0	0.7	40.7	7.8	4.2	0.04	10.2	234.2	4.7

OM; organic matter, SH; saturated humidity, P; phosphorus, K; potassium, Fe; Iron

Experimental design

The experiment was conducted in two separate parts as follows:

Field trial

In field part, Balngu maternal plants were exposed to irrigation periods and chelate nano-iron fertilizer in the form of a split plot statistical design according to an RCBD with three replications. Different irrigation periods were allocated to whole plots (including Cut off irrigation after A_1: emergence A_2: flowering and A_3: seed formation) while application of nano-iron fertilizer was considered as sub-plots (including B_1: control B_2: spraying on leaves at a concentration of 8 per1000 and B_3: incorporation with soil at the rate of 12 kg per hectare).

In order to eliminate the marginal effects, rows were separated by a distance of 2 m. Each row involved three plots separated by 1 m. Each plot with area of 4 m^2 (2×2) consisted of six rows 25 cm apart from each other. The length of rows was 2 m. The distance between plants on each row was 5 cm.

Nano-iron chelate fertilizer was purchased from Khazra Company, Keshavarz Blvd, St. Abdullah Zadeh, Afshin Lane, No. 1, Unit. 2, Tehran, Iran, (http://khazra.ir/). According to the manufacturer, the fertilizer contains 9% of water-soluble iron together with Manganese (1%) and Zinc (1%). Nano-iron chelate fertilizer was applied at the four-leaf stage.

After seed ripening, the seeds were harvested from 10 plants randomly selected from each plot.

Laboratory studies

In laboratory section, the harvested seeds were firstly disinfected using Sodium hypochlorite and then were grown in a growth chamber according to a CRD statistical design with four replications. The number of germinated seeds was counted daily. After 14 days, the seedlings' length was measured.

Germination percentage (GP), mean germination time (MGT) and the seed vigor index (SVI) were calculated according to the following equations:

$$GP = \frac{\sum N}{N_t} \times 100$$ (Camberato and Mccarty, 1999)

where GP is the germination percentage and N and N_t represent the number of germinated seeds and total number of seeds, respectively.

$$MGT = \frac{\sum N_i \times T_i}{\sum Ni}$$ (Ellis and Robert, 1981)

where MGT is the mean germination time and N_i and T_i represent the number of germinated seeds per day and the number of days after the start of the test, respectively.

$$SVI = MPL \times GP$$ (Abdul- Baki and Anderson, 1973)

where SVI is the seed vigor index and MPL and GP are the average length of 10 seedlings and germination percentage, respectively.

Statistical analysis

Data were subjected to analysis of variance using SAS (SAS-Institute-Inc, 2009) software ver. 9.1.3.

RESULTS AND DISCUSSIONS

Effect of irrigation periods

Analysis of variance showed that all studied traits were affected by the irrigation periods (Table-2).

Table-2. Analysis of variance for germination and vigor of seeds of Balangu (*Lallemantia royleana* L.) harvested from maternal plants exposed to chelate nano-Iron fertilizer under different irrigation periods.

		Mean squares		
Source	**DF**	**GP**	**MGT**	**SVI**
Factor A	2	625.33**	0.671*	207457.05**
Factor B	2	561.33**	0.079 n.s	32065.26 n.s
A×B	4	1098.67**	0.504*	116739.72**
Error	27	5.78	0.17	11388.70
CV%		3.35	6.53	17.21

Factor A: Irrigation periods, Factor B: Application of chelate nano-Iron fertilizer including spraying on leaves at a concentration of 8 per1000 and incorporation with soil at the rate of 12 kg per hectare
GP: germination percentage, MGT: Mean germination time, SVI: Seed vigor index

Mean comparison of the studied traits under different irrigation levels showed that the highest GP (79.33 ± 5.21), MGT (6.39 ± 0.13) and SVI (734.17 ± 37.34) were observed when irrigation was cut off after seed formation stage (CISF). This result revealed that applying drought during grain maturity stage may increase GP, MGT and SVI in Balangu medicinal plants (Table-3).

Likewise, previous studies have shown that desiccation during maturation enhanced germinability of crop seeds (Gutterman, 2000). For example, Evenari (1965) and Adams *et al.* (1983) reported that immature developing seeds will not germinate when wetted unless they are previously desiccated. However, some investigations revealed that increase in the number of days of drought stress during seed fill led to low germination percentage (Dornbos *et al.*, 1989).

Table-3. Mean comparisons of germination and vigor of seeds of Balangu (*Lallemantia royleana* L.) harvested from maternal plants exposed to different irrigation periods.

Irrigation periods	**GP** (Mean±SE)	**MGT** (Mean±SE)	**SVI** (Mean±SE)
CIE	65 ± 2.83 c	6.35 ± 0.09 a	476.23 ± 47.48 b
CIF	70.67 ± 2.8 b	5.96 ± 0.16 b	649.49 ± 51.99 a
CISF	**79.33 ± 5.21 a**	**6.39 ± 0.13 a**	**734.17 ± 37.34 a**

GP: germination percentage, MGT: Mean germination time, SVI: Seed vigor index, CIE: Cut off irrigation after emergence, CIF: Cut off irrigation after flowering, CISF: Cut off irrigation after seed formation stage
Means have been grouped using Duncan method and 95.0% confidence
Means that do not share a letter are significantly different.

Also, in one study, water addition in the maternal environment caused a significant decrease in germination percentage and rate (Luzuriaga *et al.*, 2006). Luzuriaga *et al.* (2006) suggested that decrease in germination rate was related to higher dormancy levels of seeds. Consequently, adequate moisture during seed formation is expected to result in the production of more dormant seeds than in drier conditions.

In this study, the observed growth in GP was mainly due to changes occurred in the properties of the maternal tissue surrounding the seed. In this regard, Arnold *et al.* (1992) believed that the increased germination of seeds subjected to drought during maturation was due to a modification of the glumes rather than of the caryopses themselves.

In addition, water stress during seed maturity stage may change the messenger RNA content which leads to change in plant protein patterns (Lalonde and Bewley, 1986; Beweley *et al.*, 1989). Such changes may cause seeds to switch from the developing system to the germinating system (Kermode *et al.*, 1986). Also, water stress during seed development decreases dormancy leading to increase of GP (Baskin and Baskin, 2014).

Effect of chelate nano-iron fertilizer

Results of the present study showed that the use of chelate nano-iron fertilizer improved GP. However, the highest GP was obtained when a solution of nano-iron fertilizer (8/1000) was sprayed on leaves rather than adding to the soil (Table-4).

Table-4. Mean comparisons of germination and vigor of seeds of Balangu (*Lallemantia royleana* L.) harvested from maternal plants exposed to chelate nano-Iron fertilizer.

Application of chelate nano-Iron fertilizer	**GP** (Mean±SE)	**MGT** **(Mean±SE)**	**SVI** (Mean±SE)
Spray on leaves	**78.33 ± 5.1 a**	6.33 ± 0.1	676.1 ± 66.18
Mixed with Soil	64.67 ± 2.91 c	6.19 ± 0.13	574.33 ± 51.51
Control	72 ± 3.07 b	6.18 ± 0.18	609.47 ± 44.46

GP: germination percentage, MGT: Mean germination time, SVI: Seed vigor index
Chelate nano-Iron fertilizer was applied via spraying on leaves at a concentration of 8/1000 and incorporation with soil at the rate of 12 kg/hectare
Means have been grouped using Duncan method and 95.0% confidence
Means that do not share a letter are significantly different.

These results suggested that, due to the size of the molecules which are at the nano-scale, nano-Iron can be absorbed better and faster through spraying than adding to the soil. Review of earlier works shows that the study of the impact of nutrients on seed germination have been mainly focused on the main elements (especially nitrogen). Fenner (1991) reported that the addition of nutrient fertilizers to parent plants decreased dormancy in the seeds. However he did not mention to the possible physiological mechanism involved.

It seems that foliar application of micro-nutrients affects seed yield as well as seed biological properties mostly through their effects on plant photosynthetic activity, transmission of photosynthetic materials from source to destination and efficiency of water use.

Interactive effects

Analysis of variance showed that the interactive effect of chelate nano-Iron fertilizer and irrigation periods was significant for all studied traits (Table 2). Also, mean comparisons revealed that the interaction between the two mentioned factors resulted in a further increase in studied traits. For example, the highest GP obtained under the impact of each of the treatments were 78.33% and 79.33% (Tables 3 and 4) while, their interaction raised GP to 100% (Table 5). Such trend was also observed for MGT and SVI. In fact, the interaction had greater impact on traits compared to each of the main effects. Therefore, it can be assumed that main effects had additive property relative to each other.

In conclusion, results of this study suggested that cut off irrigation after seed formation stage as well as foliar application of chelate nano-Iron fertilizer in Balangu maternal plants increased germination percentage and seed vigor index. However, the highest amount of the studied traits was obtained under the impact of the interaction effect.

Table-5. Mean comparisons of germination and vigor of seeds of Balangu (*Lallemantia royleana* L.) harvested from maternal plants exposed to chelate nano-Iron fertilizer and different irrigation periods.

Irrigation periods	Application of chelate nano-Iron fertilizer	GP (Mean±SE)	MGT (Mean±SE)	SVI (Mean±SE)
CIE	Spray on leaves	59 ± 1 d	6.61 ± 0.08 a	405.34 ± 40.55 d
	Mixed with Soil	58 ± 1.15 d	6.28 ± 0.18 abc	382.9 ± 85.26 d
	Control	78 ± 1.15 bc	6.27 ± 0.17 abc	640.44 ± 48.19 bc
CIF	Spray on leaves	76 ± 1.63 c	6.37 ± 0.14 ab	807.46 ± 59.51 ab
	Mixed with Soil	78 ± 1.15 bc	5.87 ± 0.19 bc	707.2 ± 25.76 abc
	Control	58 ± 1.15 d	5.65 ± 0.37 c	433.82 ± 24.51 d
CISF	Spray on leaves	**100 ± 0 a**	6.01 ± 0.19 abc	**815.5 ± 79.57 a**
	Mixed with Soil	58 ± 1.15 d	6.43 ± 0.25 ab	632.88 ± 44.89 c
	Control	80 ± 1.63 b	**6.63 ± 0.12 a**	754.14 ± 35.17 abc

GP: germination percentage, MGT: Mean germination time, SVI: Seed vigor index, CIE: Cut off irrigation after emergence, CIF: Cut off irrigation after flowering, CISF: Cut off irrigation after seed formation stage
Chelate nano-Iron fertilizer was applied via spraying on leaves at a concentration of 8/1000 and incorporation with soil at the rate of 12 kg/hectare
Means have been grouped using Duncan method and 95.0% confidence
Means that do not share a letter are significantly different.

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