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Effects of foliar application of micronutrients on yield and yield components of castor bean (*Ricinus communis* L.) varieties

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ABSTRACT

In order to study the effects of foliar application of micronutrients on yield and yield components of castor bean varieties, an experiment was conducted at the Agricultural Research Station of Saatlo in Urmia, Iran, during 2010 growing season. Experiment was arranged as factorial in randomized completely block design with three replications. Treatments were two local varieties of castor bean (V_1 = Arak and V_2 = Tafresh) and micronutrients spraying time (T_1 = at flowering stage of first raceme, T_2 = at flowering stage of first raceme + at flowering stage of secondary racemes, T_3 = at flowering stage of first raceme + at flowering stage of secondary racemes + grain filling of secondary racemes, and T_4 = control; without foliar application). Analysis of variance showed that the maximum grain yield (2308.87 kg ha^{-1}) obtained from varieties treatment (var. Tafresh) and the maximum grain yield (2423.31 kg ha^{-1}) in spraying time treatment, obtained from T_2 (at flowering stage of secondary racemes). Interaction of two factors (variety × spraying time) was significant only in grain yield at 1% level and maximum grain yield (2581.2 kg ha^{-1}) was obtained from Tafresh variety in flowering stage of secondary racemes ($V_2 \times T_2$).

Key words: Castor bean, first raceme, grain yield, variety.

INTRODUCTION

The effect of climatic factors on different medicinal plants is various and with proper research, we can discover the role of climatic factors on medicinal plants characteristics. Plants above all other agents have been used for medicine from time immemorial because they have fitted the immediate personal need are easily accessible and inexpensive (17). Castor bean plant (*Ricinus communis* L.) is a member of the family Euphorbiaceae and due to having medical properties is valued in medicinal industries. Castor bean is native to tropical Africa, but because the plant was recognized for its production of oil with many desirable properties, it has been introduced and cultivated in warm temperate regions throughout the world (4). At maturity, castor bean produces fruits which are globular with at least three beans with each bean containing certain percentages of oil and protein (1). The seeds of castor bean contain more than 45% oil and its oil is rich (80 to 90%) in an unusual hydroxyl fatty acid, ricinoleic acid (11). Although, the genus Ricinus is considered monotypic, castor bean varies greatly in its growth habit, color of foliage and stems, seed size and oil content (7, 9). Foliar sprays are widely used to apply micronutrients for many crops. Plants normally take up nutrients from soils through their roots although nutrients can be supplied to plants as fertilizers by foliar sprays. Foliar feeding is a relatively new and controversial technique of feeding plants by applying liquid fertilizer directly to their leaves (12, 18). Throughout the world microelements as Fe, Zn, Mn and Cu are added to foliar fertilizers, in order to compensate their deficiency especially in arid and semi-arid regions (13). Micronutrients, especially Fe and Zn, act either as metal components of various enzymes or as functional, structural, or regulatory cofactors. Foliar spraying with zinc (100 ppm) in blue sage (*Salvia farinacea* L.) enhanced the length of peduncle, length of main inflorescence, number of inflorescence and florets, and fresh and dry weight of inflorescences / plant (10). Essential oil of Mentha piperita increased by 28.2% by foliar application of 3 ppm zinc chloride foliar application compared with the control (14).

Therefore, the purpose of this research was to study the effects of foliar application of micronutrients on yield and yield components of castor bean varieties in West Azerbaijan climate.

MATERIALS AND METHODS

Location

This experiment was conducted at the Agricultural Research Station of Saatlo in Urmia, Iran, (37°44'18"N latitude and 45°10'53"E longitude), during the 2010 growing season.

Methodology

Experiment was arranged as factorial in randomized completely block design with three replications. The treatments were two local varieties of castor bean (V_1 = Arak and V_2 = Tafresh; the studied castor bean varieties collected locations, as reported in Table I) and micronutrients (i.e. Fe, Zn, Cu, B and Mo) spraying time (T_1 = at flowering stage of first raceme, T_2 = at flowering stage of first raceme + at flowering stage of secondary racemes, T_3 = at flowering stage of first raceme + at flowering stage of secondary racemes + grain filling of secondary racemes, and T_4 = control; without foliar application). The amount of application of micronutrients (Micro max) for each spraying time, according to the company recommendation for each hectare 1.5 liter was considered. Planting was done in rows and each plot consisted of 6 rows, 6 m length, inter row spacing was 100 cm and inter plant spacing was 50 cm. The plant characteristics were studied in terms of number of leaves per plant, plant height, number of seeds per plant, number of fertile capsules per plant, number of racemes per plant, 1000 seed weight, grain yield, biological yield, harvest index. To determine the effect of the treatments, 2 border rows in each plot were considered as sidelines, and the plants of middle 2 rows were harvested after drying plants, panicles of plants were separated and sifter. Then grain yield with 9% moisture content was measured. The straw remaining were dried in a dry oven at 75°C for 62 h, and then biological yield of the total weight of stems, leaves and panicles was calculated. The data were processed by analysis of the variance (ANOVA) and analyzed with SAS program and we used Excel software for drawing of the charts. The means were compared using the Duncan test.

Table I. The studied castor bean varieties collected from various location of Iran (8).

Number	Code in gene bank	Location	Latitude	Longitude	Altitude (m)
V1	80-25	Arak (Markazi State)	34º 20´	49º 49´	1753
V2	80-23	Tafresh (Markazi State)	34º 24´	49º 43´	1735

RESULTS AND DISCUSSION

Results of analysis of variance (ANOVA) for different traits are shown in Table II. As seen, effect of castor bean varieties had significant effects in the case of number of leaves per plant and grain yield at 1% level, and had significant effects on number of racemes per plant and biological yield at 5% level, indicating that varieties had not a considerable effect on most of studied traits. The mean comparison showed that, Tafresh variety was superior (due to genetic superiority) compared to the Arak variety in West Azerbaijan climate in all the treatments (Table III). Nabizadeh et al. (6) reported that 80-12-1 variety in castor bean had highest seed weight in primary raceme. Descriptive statistics analysis was also used for studying genetic variability in some other crops, such as garlic (*Allium sativum* L.) (5); groundnut (*Vigna subterranea* L.) (20) and melon (*Cucumis melo* L.) (2).

Analysis of variance showed that, micronutrients spraying time had significant difference on number of leaves per plant, number of seeds per plant, number of fertile capsules per plant, grain yield and biological yield at 1% level, and had significant effects on plant height and 1000 seed weight at 5% level, indicating that spraying time had not a considerable effect on number of racemes per plant and harvest index traits (Table II). The mean comparison for number of leaves per plant trait showed that, maximum number of leaves (45.14) obtained from T_3 (at flowering stage of first raceme + at flowering stage of secondary racemes + grain filling of secondary racemes), and minimum number of leaves per plant (37.44) obtained from T_4 (control) (Table III). The mean comparison for number of fertile capsules per plant trait showed that, maximum number of fertile capsules (273.44) obtained from T_2 (at flowering stage of first raceme + at flowering stage of secondary racemes), and minimum number of fertile capsules per plant (229.6) obtained from T_4 (control) (Table III). The mean comparison for grain yield trait showed that, highest grain yield (2529.2 $kg.ha^{-1}$) obtained from T_2 (at flowering stage of first raceme + at flowering stage of secondary racemes), and lowest grain yield (1685.6 $kg.ha^{-1}$) obtained from T_4 (control) (Table III). The mean comparison for biological yield trait showed that, highest biological yield (25264 $kg.ha^{-1}$) obtained from T_3 (at flowering stage of first raceme + at flowering stage of secondary racemes + grain filling of secondary racemes), and lowest biological yield (18047 kg.ha^{-1}) obtained from T_4 (control) (Table III). The high grain yield in T_2 stage (at flowering stage of first raceme + at flowering stage of secondary racemes) is due to appropriate use time of micronutrients in castor bean (flowering stage of first and secondary racemes); because of the increasing flowers fertilization in first and secondary racemes and was performed successful fertilization by feeding with micronutrients fertilizers. The results of many researches revealed that the application of balanced fertilization significantly increased grain yield. In addition, foliar application of micronutrients might raise dry matter transformation from store parts to sink part. As mentioned before the highest biological yield obtained from T_3 (at flowering stage of first raceme + at flowering stage of secondary racemes + grain filling of secondary racemes); the reason is continuous feeding conditions and increased fertilizer consumption in T_3 stage. Generally micronutrient deficiency limits plant growth and affects crop yield. Plants leaves ensure nutrient uptake for the development of plants (19). Photosynthesis and the regulation of transpiration are the primary tasks of foliage. Because of their structure, leaves can uptake nutrients under certain conditions and to a certain extent only (16). The advantage of nutrient uptake through the leaves is that it gets very quickly and directly to the leaf cells, where they are utilized. Field tests of more than 2500 different experiments have shown that micronutrients have a significantly positive effect on crop yield and quality.

The interactions of these treatments (variety and spraying time) had significant effect only on grain yield trait at 1% level (Table II). Also, mean comparison of treatments interaction (variety and spraying time) indicated that, highest grain yield achieved by Tafresh variety with spraying time at flowering stage of first raceme + at flowering stage of secondary racemes ($V_2 \times T_2$), and lowest grain yield was observed in Arak variety with control; without foliar application ($V_1 \times T_4$) (Figure I). According to the genetically superior in Tafresh variety and nutrition with micronutrients caused to increase the production potential. This result is consistent with the other researcher's results (15, 3).

Table II. Results of analysis of variance (mean squares) treatments in castor bean.

Source of variation	d.f.	Number of leaves per plant	Plant height	Number of seeds per plant	Number of fertile capsules per plant	Number of racemes per plant	1000 seed weight	Grain yield	Biological yield	Harvest index
Rep	2	372.80**	8236.7*	14802 $^{n.s}$	1326.95 $^{n.s}$	6.89 $^{n.s}$	461.05*	54592 $^{n.s}$	274407665**	0.008**
Varieties	1	290.76**	1684.3 $^{n.s}$	40161 $^{n.s}$	3620.11 $^{n.s}$	15.98*	94.73 $^{n.s}$	813285**	103004931*	0.0002 $^{n.s}$
Spraying Time	3	247.45**	7087.1*	377895**	27490.17**	1.76 $^{n.s}$	319.8*	810869**	945964472**	0.0007 $^{n.s}$
V × T	3	247.45 $^{n.s}$	5904.2 $^{n.s}$	26116 $^{n.s}$	1341.07 $^{n.s}$	3.07 $^{n.s}$	76.34 $^{n.s}$	668121**	43668873 $^{n.s}$	0.0003 $^{n.s}$
Error	16	218.35	1489.5	25487	2165.86	2.21	187.51	658435	51256613	0.0004
CV (%)		22.18	18.56	13.86	14.15	22.16	28.44	19.53	11.56	15.52

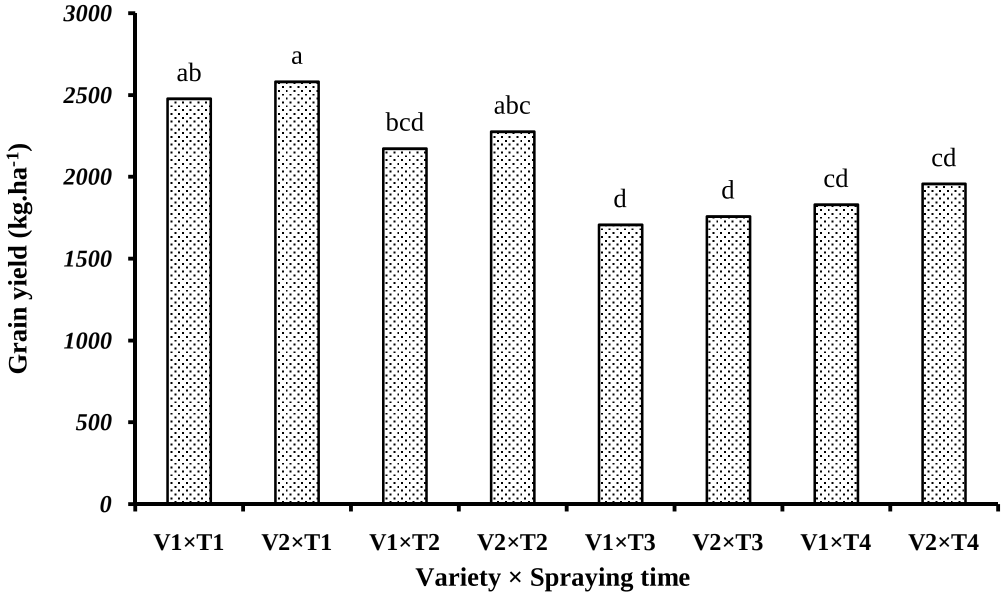
**, **, ns, Significant at P = 0.05, P = 0.01 and non-significant, respectively. d.f. degree of freedom.*

Table III. Mean comparison of varieties of castor bean and spraying time on traits.

Treatments	Number of leaves per plant	Plant height (cm)	Number of seeds per plant	Number of fertile capsules per plant	Number of racemes per plant	1000 seed weight (g)	Grain yield (kg.ha^{-1})	Biological yield (kg.ha^{-1})	Harvest index (%)
Varieties									
Arak	39.28 b	117.4 a	809.16 b	247.04 b	7.36 b	257.94 a	2122.6 b	21406 b	0.106 a
Tafresh	44.18 a	180.8 a	903.43 a	269.15 a	8.28 a	258.21 a	2308.9 a	24295 a	0.103 a
Spraying Time									
T1	38.45 b	172.6 b	842.62 a	246.42 bc	7.29 a	251.88 b	2011.3 c	20578 bc	0.105 a
T2	41.75 b	188.9 a	968.23 a	273.44 a	7.97 a	262.89 a	2529.2 a	22678 ab	0.115 a
T3	45.14 a	187.7 a	863.04 a	258.27 b	7.90 a	259.54 a	2316.9 b	25264 a	0.093 a
T4	37.44 b	156.1 c	766.86 b	229.6 c	7.38 a	250.55 b	1685.6 d	18047 c	0.105 a

In each section, means followed by the same letter within columns are not significantly different (p≤0.05) according Duncan test.

T_1 = at flowering stage of first raceme, T_2 = at flowering stage of first raceme + at flowering stage of secondary racemes, T_3 = at flowering stage of first raceme + at flowering stage of secondary racemes + grain filling of secondary racemes, and T_4 = control



V_1 = Arak variety, and V_2 = Tafresh variety.
T_1 = at flowering stage of first raceme, T_2 = at flowering stage of first and secondary racemes, T_3 = at flowering stage of first and secondary racemes + grain filling of secondary racemes, and T_4 = control.

Figure I. Comparison of interaction of castor bean varieties and spraying time on grain yield.

CONCLUSION

In general, it can be concluded that the best local variety of castor bean in this experiment is Tafresh variety in West Azerbaijani climate. The other hand the foliar application of micronutrients considerably improve the grain yield of castor bean, particularly if these micronutrients were applied together at flowering stage of first raceme + at flowering stage of secondary racemes.

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