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EFFECT OF PLANT VARIETY, BORIC ACID SPRAY AND POTASSIUM SOIL APPLICATION ON SEED YIELD PARAMETERS OF TABLE BEET *BETA VULGARIS* L.

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Abstract

A study was conducted in a private farm the rural area of province o Najaf during the 2017 and 2018 growing seasons to study the effect of three factors including two plant varieties, spraying with boric acid at three levels and soil application with potassium sulfate at three levels on seed yield parameters in table beet. The experiment was factorial split-split plots based on Randomized Complete Block Design (R.C.B.D) with thee replicates. The main factor was two plant varieties (Local and Imported) treated with or boric acid (17% B) at 0 (B0), 5 (B1) or 10 (B2) g/L and potassium sulfate (50% K_2O) at 0 (K0), 100 (K1) or 150 (K2) kg/hectare, results showed that plant variety and spraying with boric acid had significant effect on number of seeds.fruit^{-1}, total yield and fruit yield per unit area for both seasons and weight of 100 fruit.plant^{-1} for the 2nd season. However, fertilization with potassium sulfate significantly affected speed of seed germination and was the most effective in reducing germination period and rate, beside its effect on some studied parameters. Generally, best results were obtained from the total interaction of the three factors especially at highest concentration levels. Among all the treatments, the K2-B2 treatment resulted in the highest values in weight of 100 fruits, total yield.plant^{-1} and number of seed.fruit^{-1} for both varieties and highest pollen viability for local variety. The K1-B2 on the other hand had the best results in terms of fruit yield per unit area. In this study, we clarified the synergistic effect of boron when combined with potassium in improving plant growth in general and increasing quantitative and qualitative parameters of seed yield in table beet.

Key words: Boric acid. Potassium sulfate, table beet, seed yield, *Beta vulgaris*.

Introduction

Table beet belongs to the Chenopodiaceae family, a two-season herbaceous root plant complete with vegetative growth and the second to flowers to form seeds inside the fruits (Hassan, 2011). It is one of the most widely distributed vegetable crops in the world. It is grown in large areas by farmers for direct consumption or export and its roots are eaten boiled or used in preparation of salads (Boras, 2006). Specific time and in appropriate concentrations so that the plant can be absorbed by stomata or openings on the leaves or through cell walls (Jamal *et al*., 2006). Therefore, foliar feeding has become a good way to prepare plants with nutrients, especially micro-nutrients, to meet its needs more quickly compared to land fertilization (Al-Jawari, 2002). Jones, (1991) argued that foliar feeding is a modern method of fertilization but is not a substitute for, but a supplement to, ground fertilization.

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Boron is a micronutrient that plants need to grow essentially (Shorrocks, 1984), an important nutrient in the activation of vital processes, especially in relation to fruit nodes by stimulating physiological processes during the flowering phase and this leads to increased pollen Boron plays an important role in the division and elongation of growing peak cells and its role in promoting pollen germination and the growth of pollen tube as a result of the manufacture of gibberellic acid (GA) in those seeds. The walls of parenchyma cells thus affect the growth of the vessels and this leads to the fall of flowers (Al-Sahaf, 1989) and Jankowski *et al*., Sprayed on the leaves as it was found that spraying boron at a concentration of 150 and 300 g.ha^{-1} increased pollination and fertilization and increased production.

Potassium in the soil is the only source of potassium the plant needs. Potassium plays an important role during the different stages of plant growth and is necessary during the stage of flower formation and fruits in the plant. It

Table 1: Effect of foliar application with boron and soil potassium on yield of 100 fruit of two table beet *Beta vulgaris* varieties.

		Local variety				Imported variety			
		B0	**B1**	**B2**	**Average**	**B0**	**B1**	**B2**	**Average**
Season #1 2017	K0	1.817	2.797	2.780	2.465	1.830	2.947	2.827	2.535
	K1	2.513	2.480	2.910	2.634	2.910	2.980	2.110	2.667
	K2	2.833	2.640	3.787	3.087	2.720	3.353	2.663	2.912
	Average	2.388	2.639	3.159	2.729	2.487	3.093	2.533	2.704
	$LSD_{(P\leq 0.05)}$	V 0.2468	K 0.2861	B 0.1637	VK 0.3450	VB 0.2287	KB 0.3472	VKB 0.4530	
Season #2 2018	K0	1.633	2.507	2.430	2.190	1.017	3.163	2.217	2.132
	K1	2.183	3.510	3.490	3.061	2.190	2.710	2.770	2.557
	K2	3.820	2.850	3.910	3.527	2.210	3.750	3.850	3.270
	Average	2.545	2.956	3.277	2.926	1.806	3.208	2.946	2.653
	$LSD_{(P\leq 0.05)}$	V 0.1589	K 0.1119	B 0.0848	VK 0.1508	VB 0.1317	KB 0.1551	VKB 0.2163	

Values are means of three replicates. B0, B1 and B2 are boric acid at concentration levels of 0, 5 and 10 g/L, while K0, K1 and K2 are potassium soil treatment at 0, 100 and 150 Kg ha.

regulates the movement of solubles from water to carbohydrates from their leaf production areas to storage areas such as flowers and fruits. Its lack leads to the fall of flowers (Al-Abdi, 2010). The study of Govahi and Saffari, (2006) on the plant potassium fertilization led to increased seed weight and productivity. Therefore, the study aimed to evaluate the effect of the local variety compared to the adoption of a newly introduced variety on the production indicators and seed yield of table beet and the possibility of increasing these indicators by spraying with boron and or potassium fertilization at different levels.

Materials and Methods

The experiment was carried out in the province of Najaf / Kufa / Abbasiya in a private farm during the agricultural season 2017-2018 and 2018-2019. Seeds of two table beet varieties, local and foreign variety (produced by a Dutch company Pop Vriend) were used to be sewn on 10/8/2017 and 10/8/2018 for the first and second season, respectively. The seeds were planted in a hole 1.5 cm deep in the center of bottom third of the furrow. Three fruits were planted in each the hole with spacing of 20 cm between each two holes. At plant height of 5-7 cm, plants were thinned to one plant in each hole (Matloob *et al.*, 1980). Un-germinated holes were replanted 7 days after. All crop services and practices were performed, including irrigation, weeding and pest control whenever needed.

The experiment was split-split plots design according to Randomized Complete Block Design (R.C.B.D) with three replicates and three factors. The first is two plant varieties as formerly mentioned. The second is a three boric acid (17% B) (B0, B1 and B2) foliar spray at

Table 2: Effect of foliar application with boron and soil potassium on number of $seeds.fruit^{-1}$ in two varieties of table beet *Beta vulgaris*.

		Local variety				Imported variety			
		B0	**B1**	**B2**	**Average**	**B0**	**B1**	**B2**	**Average**
Season #1 2017	K0	2.000	2.733	3.200	2.644	2.600	3.300	4.100	3.333
	K1	3.067	3.967	2.200	3.078	4.200	4.100	3.267	3.856
	K2	3.400	3.733	4.867	4.000	4.200	4.300	5.000	4.500
	Average	2.822	3.478	3.422	3.241	3.667	3.900	4.122	3.896
	$LSD_{(P\leq 0.05)}$	V 0.2921	K 0.2224	B 0.2853	VK 0.2918	VB 0.3579	KB 0.4443	VKB 0.6226	
Season #2 2018	K0	2.400	2.733	4.733	3.289	2.633	3.633	4.833	3.700
	K1	3.400	4.733	5.067	4.400	3.933	5.067	5.533	4.844
	K2	3.733	5.433	5.767	4.978	5.300	5.767	6.000	5.689
	Average	3.178	4.300	5.189	4.222	3.955	4.822	5.455	4.744
	$LSD_{(P\leq 0.05)}$	V 0.4416	K 0.3541	B 0.1775	VK 0.4575	VB 0.3378	KB 0.4104	VKB 0.5524	

Values are means of three replicates. B0, B1 and B2 are boric acid at concentration levels of 0, 5 and 10 g/L, while K0, K1 and K2 are potassium soil treatment at 0, 100 and 150 Kg ha.

Table 3: Effect of foliar application with boron and soil potassium on speed of seed germination in two varieties of table beet *Beta vulgaris.*

		Local variety				Imported variety			
		B0	**B1**	**B2**	**Average**	**B0**	**B1**	**B2**	**Average**
Season #1 2017	K0	0.590	0.710	0.640	0.647	0.647	0.673	0.647	0.656
	K1	0.740	0.673	0.677	0.697	0.707	0.723	0.703	0.711
	K2	0.690	0.673	0.710	0.691	0.683	0.677	0.720	0.693
	Average	0.673	0.686	0.676	0.678	0.679	0.691	0.690	0.687
	$LSD_{(P\leq 0.05)}$	V 0.0494	K 0.0333	B 0.0283	VK 0.0457	VB 0.0423	KB 0.0494	VKB 0.0695	
Season #2 2018	K0	0.670	0.723	0.710	0.701	0.690	0.723	0.690	0.701
	K1	0.717	0.707	0.727	0.717	0.700	0.737	0.720	0.719
	K2	0.727	0.703	0.737	0.722	0.700	0.720	0.740	0.720
	Average	0.704	0.711	0.724	0.713	0.697	0.727	0.717	0.713
	$LSD_{(P\leq 0.05)}$	V 0.0138	K 0.0096	B 0.0062	VK 0.0130	VB 0.0108	KB 0.0123	VKB 0.0171	

Values are means of three replicates. B0, B1 and B2 are boric acid at concentration levels of 0, 5 and 10 g/L, while K0, K1 and K2 are potassium soil treatment at 0, 100 and 150 Kg ha.

concentration levels of 0, 5 or 10 g/L, respectively applied twice (at stages of 4-5 true leaf and flowering) during the growing season (Gehan *et al.*, 2003). While, the third factor is soil application with potassium sulfate (50% K_2O) (K0, K1 and K2) at three concentration levels of 0, 100 and 150 kg.hectare^{-1} respectively added at 3 and 6 weeks post planting. Real leaves and second in the stage of flower formation after 26 weeks of planting (El-Assionty *et al.*, 2005). Each experiment was ended 120 days post planting and data were recorded for weight of 100 fruits, number of seeds.plant^{-1}, seed germination speed, total yield kg.h^{-1}, percent of pollen viability and productivity (yield per unit area ton.h^{-1}).

Seeds and pollen grain produced from plants of each treatment for each season were subjected to assess speed of seed germination and pollen viability, respectively. Both tests were performed in the laboratory belongs to the Directorate of Seed Testing and Certification in the province of Najaf. Speed of seed germination was assessed for seeds of 25 fruits from each treatment according to Aesa *et al.*, (1988) confirmed by Khalil, 2004), while pollen viability was evaluated according to Boughediri, (1987). Data were statistically analyzed and analysis of variance was performed using the GenStat (12th Edition) statistical computing system. Differences among means were compared based on the least significant LSD test at a 5% probability level.

Results and Discussion

Results showed that values of measured yield components including Weight of 100 fruits, number of seeds.plant^{-1}, seed germination speed, total yield kg.h^{-1}, percent of pollen viability and yield productivity ton.h^{-1} were affected by plant variety and concentration level of

Table 4: Effect of foliar application with boron and soil potassium on total yield kg.h^{-1} in two varieties of table beet *Beta vulgaris.*

		Local variety				Imported variety			
		B0	**B1**	**B2**	**Average**	**B0**	**B1**	**B2**	**Average**
Season #1 2017	K0	0.288	1.486	0.836	0.870	0.180	0.280	0.240	0.233
	K1	0.942	0.879	1.681	1.167	0.270	0.340	0.480	0.363
	K2	0.925	1.558	1.678	1.387	0.380	0.260	0.280	0.307
	Average	0.719	1.308	1.399	1.142	0.277	0.293	0.333	0.301
	$LSD_{(P\leq 0.05)}$	V 0.0225	K 0.0281	B 0.0256	VK 0.0336	VB 0.0313	KB 0.0435	VKB 0.0589	
Season #2 2018	K0	0.295	1.156	1.583	1.011	0.234	0.462	0.455	0.384
	K1	1.743	2.116	1.855	1.905	0.384	0.293	0.261	0.313
	K2	1.802	2.289	2.988	2.360	0.482	0.518	0.737	0.579
	Average	1.280	1.854	2.142	1.759	0.367	0.424	0.484	0.425
	$LSD_{(P\leq 0.05)}$	V 0.0108	K 0.0109	B 0.0088	VK 0.0134	VB 0.0115	KB 0.0157	VKB 0.0213	

Values are means of three replicates. B0, B1 and B2 are boric acid at concentration levels of 0, 5 and 10 g/L, while K0, K1 and K2 are potassium soil treatment at 0, 100 and 150 Kg ha.

Table 5: Effect of foliar application with boron and soil potassium on pollen viability in two varieties of table beet *Beta vulgaris*.

		Local variety				Imported variety			
		B0	**B1**	**B2**	**Average**	**B0**	**B1**	**B2**	**Average**
Season #1 2017	K0	78.93	98.19	81.41	86.18	81.88	99.41	90.68	90.66
	K1	81.17	93.80	94.99	89.99	88.46	99.13	85.88	91.16
	K2	99.71	90.03	99.01	96.25	94.26	100.00	98.67	97.64
	Average	86.60	94.01	91.80	90.80	88.20	99.51	91.74	93.15
	$LSD_{(P \leq 0.05)}$	V 2.216	K 2.680	B 3.437	VK 3.217	VB 4.092	KB 5.353	VKB 7.398	
Season #2 2018	K0	73.48	99.33	80.69	84.50	74.85	100.00	92.30	89.05
	K1	83.31	96.20	97.13	92.21	89.71	99.79	84.62	91.37
	K2	100.00	93.25	99.67	97.64	84.93	100.00	100.00	94.98
	Average	85.60	96.26	92.50	91.45	83.16	99.93	92.31	91.80
	$LSD_{(P \leq 0.05)}$	V 2.377	K 2.040	B 2.311	VK 2.589	VB 2.902	KB 3.695	VKB 5.133	

Values are means of three replicates. B0, B1 and B2 are boric acid at concentration levels of 0, 5 and 10 g/L, while K0, K1 and K2 are potassium soil treatment at 0, 100 and 150 Kg ha.

boric acid (B0, B1 and B2) and potassium (K0, K1 and K2). In case of weight of 100 fruits, results (Table 1) showed that the varieties did not differ in the 1st season, but they did in the 2nd season where the local variety had heavier weight of 100 fruits than the foreign variety. Boric acid treatments differed between seasons, B1 had higher value in the 1st season while B2 was higher in the 2nd. However, the 150 kg/h potassium treatments (K2) resulted in the highest weight of 100 fruits for the both seasons compared to other concentration levels.

Regarding the number of seeds per fruit, the imported var., regardless the type of treatment produced more seeds/fruit than the local var. similar to the weight of 100 fruits, number of seeds.fruit^{-1} was the highest in treatments of B2 and K2 and their interaction especially with the imported variety. Speed of seed germination was assessed and compared among treatments (Table 2). Similarly, the speed of seed germination was higher at the highest concentration levels of both boric acid and potassium (Table 3). In general, germination period was not affected by the interaction treatments for the 1st season, but was affected for the 2nd season especially at highest concentrations with both varieties.

Relative to total yield (Kg ha), the highest value was recorded with local variety compared to the imported one for both seasons (Table 4). The 2nd season resulted in the highest total yield than the 1st one. Interaction treatment was not consistent and was affected by variety and season. The B2K1 with the local variety was the highest total yield on the 1st season, while B2K2 resulted in the highest total yield for the 2nd season (2.98 Kg ha) with significant difference from the same treatments with the imported variety (0.73 Kg ha) and the control (0.294 Kg ha), respectively (Table 4).

In case of pollen viability, the local variety in the 1st season had the highest value of pollen viability and significantly differed from the imported variety, while pollen viability did not differ between varieties for the 2nd season (Table 5). The B1 and K2 treatments individually were more effective than the other treatments in increasing pollen viability with significant difference from the control (Table5). Highest rate of pollen viability (100%) was recorded in the interaction treatments of B0-K2-local variety for the 2nd season which was similar to B1-K2-imported variety for the 1st season, B1-K2-imported variety and B2-K2-imported variety for the 2nd season resulted in 100% pollen viability (Table 5).

Fruit yield per unit area (tons/ha) was also affected by plant variety (Table 6). The local variety had always higher yield values regardless type of treatment. Compared to the control treatment, K2 for both seasons resulted in significantly higher yield per unit area. Similar effects were also recorded in case of highest application rate of potassium (K2). Interaction treatment of B2-K2 in the 1st season had the highest yield per unit area that resulted in 1.28 tons/ha for the local variety and 0.36 tons/ha for the imported variety. While in the 2nd season, B2-K2 resulted in significantly higher yield among all the treatments that of 2.28ton.h^{-1} for the local and 0.562 tons/ha for the imported variety compared to 0.224 and 0.178 tons/ha from the control for both varieties, respectively (Table 6).

The results in the tables showed that the two tested beet varieties varied in their response to different treatments of boric acid spraying and potassium fertilization. The local variety exceeded the foreign one in terms of the weight of 100 fruit, the total yield and fruit produced per unit area while the foreign variety resulted

Table 6: Effect of foliar application with boron and soil potassium on fruit yield per unit area (t.h^{-1}) in two varieties of table beet *Beta vulgaris.*

		Local variety				Imported variety			
		B0	B1	B2	Average	B0	B1	B2	Average
Season #1 2017	K0	0.2197	1.1410	0.6380	0.6662	0.1333	0.2140	0.1853	0.1775
	K1	0.7193	0.6703	1.2823	0.8906	0.2077	0.2617	0.3670	0.2788
	K2	0.7057	1.1893	1.2807	1.0585	0.2910	0.1953	0.2163	0.2342
	Average	0.5482	1.0002	1.067	0.8718	0.2106	0.2236	0.2562	0.2301
	LSD$_{(P\leq 0.05)}$	V 0.0269	K 0.0137	B 0.0154	VK 0.0219	VB 0.0230	KB 0.0247	VKB 0.0359	
Season #2 2018	K0	0.2243	0.8820	1.2077	0.7713	0.1787	0.3520	0.3470	0.2925
	K1	1.3310	1.6147	1.4160	1.4539	0.2930	0.2233	0.1987	0.2383
	K2	1.3753	1.7470	2.2820	1.8014	0.3670	0.3943	0.5623	0.4412
	Average	0.9768	1.4145	1.6352	1.3422	0.2795	0.3232	0.3693	0.3240
	LSD$_{(P\leq 0.05)}$	V 0.0082	K 0.0082	B 0.0067	VK 0.0101	VB 0.0088	KB 0.0119	VKB 0.0162	

Values are means of three replicates. B0, B1 and B2 are boric acid at concentration levels of 0, 5 and 10 g/L, while K0, K1 and K2 are potassium soil treatment at 0, 100 and 150 Kg ha.

in higher values in seed number and germination speed. The reason for this difference may be mainly due to the different genotype of the species under study. The results showed that plants treated with potassium fertilizer had the highest average of number of seeds per fruit. This is mostly due to the importance of potassium in the stages of development of flowers and seeds production when added to the plant in sufficient quantities. The presence of potassium leads to increase in photosynthesis and protein metabolism (Issa *et al.*, 1988). Although potassium does not participate in any plant cell compounds or organic compounds, it is considered to be what called a "transport minister" because it plays a regulating role in movement of soluble contents of water and carbohydrates from their production sites in leaves to storage sites in flowers and fruits, which leads to the production of seeds with good qualities (Abdi, 2010).

The results of the tables indicate the superiority of boron spray in the form of boric acid in parameters of weight of 100 fruits, germination speed, total yield and fruit yield per unit area. The reason for this can be attributed to the role of boron in stimulating some plant hormones such as gibberellin GA3, involved to improve seed germination by enhancing activities of enzymes responsible for converting the nutrients stored in the seeds into available nutrients for the embryo germination. These include alpha-amylases α, cellulose (s) and proteases, which stimulate the process of embryonic cells division and expanding and so facilitate and accelerate embryonic axis to form the primary epicotyl and radicle and eventually seedling emergence (Mohammed and Younis, 1991; Taiz and Zeiger, 2010).

Boron also has an important role in the reproductive organs in terms formation of pollination tube and fertilization of flowers (Blevins and Lukaszewsk, 1998). (Ahmad *et al.*, 2014) noted the important role of boron in the process of cellular wall, cell division of meristemic tissue, formation of vegetative and reproductive buds, metabolism of phenolic compounds, nitrogen fixation, pollen germination and seed growth and development. The importance of boron was also reported (Havlin *et al.*, 2005) in development of fruits and producing higher numbers of seeds with high quality. The increase in the number of seeds is due to the direct effect of boron on the growth of reproductive parts as the inoculation tube requires high concentrations of boron in the ovary. Therefore, boron in this case plays an additional important role as chemotactic directorates the growth of pollen tube during reproductive tissues towards the ovary and thus formation of seeds, confirming that boron sufficiency increases plant fertility (Bidwell, 1979).

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