Effect of Silicon Foliar Application and Sowing Dates on Faba Bean (Vicia faba L.) Productivity under New Valley Conditions – Egypt.

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INTRODUCTION

Faba bean (Vicia faba L.) is considered one of the most important legumes in Egypt. It has become one of the strategic crops that increase the farmer's income because it increases soil fertility, in addition to being an important source of protein as well as the possibility of using it for industrial purposes (Sharaan et al., 2014). Faba bean represent an essential component of the food system of the Egyptian people. Therefore, improving its productivity and quality is an important goal to keep pace with the population increase (Zeidan 2012).

Increasing the productivity of faba bean seed yield, in Egypt, is one of the main Egyptian Government objectives. Since the growing area in Egypt, is limited; so the priority must be given by the Government as well as the Egyptian agricultural institutes towards the improvement of faba bean productivity. The attainment of maximum yield of faba bean from the unit area of land is greatly affected by different cultural practices in addition to environmental conditions. Sowing date is considered to be one of the most important factors, which may affect the timing and duration of the vegetative and reproductive stages, which mainly contribute to seed yield. Herein, Badr et al., 2016 reported that early planting (1st Oct) resulted in a significant yield of faba bean by157 % because of cultivation at this date may be provides the plant with all the necessary the environmental needs in every stage of its growth over the late sowing date (end of December). They concluded that most of these advantages occurred due to the extended period of vegetative growth, which resulted in the improvement of several agronomical characters. Abou El-Yazied 2017 reported that yield increased significantly when planting was in early October, as it doubled compared to planting on January. But, El-Metwally et al., 2018 showed that sowing date on 25th Oct, recorded the highest values of growth characters and total chlorophyll, while, the greatest values of yield and its components were resulted from the sowing date on 25th Nov.

Plant in desert environments exposed to biotic stress (insect and pathological injuries) and abiotic stress (high temperature, soil salinity, soil salinity and drought) that negatively affect growth and yield. In this regard, several researchers have reviewed recent advances on the beneficial roles of silicon on plant growth in adverse environmental conditions and increasing yield and its components for several of crops (Guntzer et al., 2012 and Van et al., 2017). Silicon protects plants from a biotic and biotic stresses (Liang et al., 2017). Silicon relieves the salt stress on plants includes increased competence of antioxidant metabolism for reactive oxygen species (ROS) scavenging, prevention of lignin deposition, optimal ion balances, increased chlorophyll preservation, enhanced polyamine biosynthesis and delayed senescence (Yin et al., 2017). Also, drought stress (Gong et al., 2016), heavy metal toxicity (Shi et al., 2005) and high temperature (Hattori et al., 2015) could be alleviated by silicon.

Silicon enhances the ability of plants to tolerance water stress by increase the ability of leaves to retain water, leaf tissue integrity, stomatal conductance, and xylem construction under high transpiration rates and active photosynthesis (Gaouer et al., 2016 and Gong et al., 2016). Silicon can diminish the electrolyte leakage from plant leaves and therefore raised photosynthetic activity in plants grown under water stress conditions (Epstein 2011). Matoh et al., 2015 found that application of Si led to formation of a silica cuticle layer on epidermal tissue of leaf, which is...
responsible for greater leaf water potential under water deficit conditions. Different studies indicated the positive effect of Si application on growth, yield and quality of many plants (Jarosz, 2014), Mohaghegh et al., 2015, Lu et al., 2016; Sukkaew et al., 2016 and Gorecki and Danielski, 2018.

The objective of the present study was to recognize the suitable combination for sowing dates and foliar application of silicon for maximizing faba bean seed yield and its components under the conditions of New Valley Governorate, Egypt.

MATERIALS AND METHODS

Location of Experiment

Two field experiments were carried out during the two successive winter growing seasons of 2018/2019 and 2019/2020 in the experimental station farm of Desert Research Center (D.R.C.) at EL-Kharga Oasis, New Valley Governorate. The main objective of this work was to study the effect of four different sowing dates and four silicon foliar levels on yield and its components of faba bean under New Valley conditions. The soil was sandy clay loam with pH 8.91 8.72, organic matter 0.61 and 0.55 %, EC 1356 and 1416 ppm, available nitrogen 52 and 60 ppm, available phosphorus 0.74 and 0.83 ppm and available potassium 45 and 57 ppm in the first and second seasons respectively. The previous crop was cowpea in both seasons.

Treatments and experimental design

Marriott 2 cultivar of faba bean used in this study. Treatments were four sowing dates (1st Oct, 15th Oct, 1st Nov, and 15th Nov) and four levels of silicon in the form of potassium silicate (K2SiO3 18 % silicon) as a foliar application (0, 100, 200 and 300 ppm). A strip split plot design, with three replications, was used. The sowing dates were assigned to the vertical strips, while, silicon foliar application were distributed between the horizontal strips. Each experimental unit (10.5 m2) consisted of five ridges, 60 cm apart and 3.5m long. The distance between plants was 20 cm with three seeds hill-1. After two weeks from emergence, seedlings were thinned two plants hill-1 to give a theoretical plants population of 46000 plants fed-1.

Agricultural practices

Faba bean seeds were inoculated with Rhizobium (Okadeen). During soil preparation and before each planting date, 5 m2 of poultry manure mixed with 37.5 kg P2O5 were applied. Potassium sulfate (K2SO4 48 %) was applied after 45 days of each sowing date at the rate of 50 kg fed-1. Nitrogen fertilizer was added at four equal doses in the form ammonium sulfate (20.5%), the first after four weeks from planting date and the other doses every two weeks as a solution with irrigation. Other cultural practices were applied as per the recommendations. The plants harvested by hand when the 60% of the pods are mature in both growing seasons.

Measurements

At harvest five plants were taken from each experimental unit of each sowing date and the following characters were studied: plant height (cm), number of pods plant-1, pod length (cm), seeds weight plant-1, 100 seed weight (g), harvest index (%), shelling (%), seed yield (kg/fed.), straw yield (Kg/fed.), water use efficiency (WUE) kg/m3, protein in seeds (%) and carbohydrates in seeds (%). Whereas, harvest index was calculated by the following formula: HI: (Seed yield) / (biological yield) X 100. Shelling percentage worked out by using the formula by dividing weight of seeds/ weight of pods x 100. Water use efficiency (WUE) which calculated using the equation of Vites (1965) for seed yield, as follows: WUE = Seed yield kg fed-1/actual consumptive use m3 fed-1. Protein of seed (%) was determined by using the Kjeldahl method (N %) with a conversion factor of 6.25.

Statistical analysis

The obtained data were subjected to the statistical analysis of the strip split plot design according to Snedecor and Cochran (1990). Treatment means were compared using least significant difference test LSD at 5% probability level.

RESULTS AND DISCUSSION

I.Effect of sowing dates:

Data presented in Table (1 and 2) indicated that planting faba bean at different sowing dates had a significant effect on all studied traits in both seasons. Number of pods plant-1, seed yield plant-1(g), 100 seed weight (g), harvest index (%), shelling (%) and seed yield (kg/ fed) were higher when planting on 15th Oct in both seasons. While, plant height (cm), pod length (cm), straw yield (kg/ fed.), water use efficiency (WUE) kg/ m3 and carbohydrates (%) in seeds were higher when planting on 15th Oct in both seasons. On the other hand, the highest value of the percentage of protein in seeds was on 15th Nov and the lowest on (1st Oct) in both seasons. The results also explained that planting of faba bean on 15th Oct was superior over other sowing dates and met the environmental needs of plant and attributed to the increase in number of pods plant-1, 100 seed weight (g) and seed yield plant-1(g). It is worthy to conclude that planting of faba bean in this date is a good time in order to explore its yield potential under New Valley conditions. While the late sowing dates (15th Nov) produced the lowest values of all traits in both seasons. The reason for decreasing values of yield and its components when the date of planting is late may be due to high temperature of late planting, which causes reach of leaves to early aging stage and a decrease in its total area, which negatively effects on the net assimilation rate of photosynthesis and dry matter formation.

The increases percentages outcome planting of faba bean on (15th Oct) compared with planting in (15th Nov) with regard to: number of pods plant-1 were 49.5 and 47.4, seed yield plant-1(g) were 48.7 and 46.0, 100 seed weight (g) were 48.4 and 47.8, harvest index (%) were 58.5 and 56.3, shelling (%) were 14.9 and 14.0 and seed yield (kg/ fed.) were 45.8 and 44.0in the first and second seasons, respectively. However, the percentage of increase as a result of planting on (1st Oct) compared with planting in (15th Nov) with regard to: plant height (cm) were 21.1 and 20.8, pod length (cm) were 37.5 and 32.3, straw yield (kg/ fed.) were 56.9 and 54.7, (WUE) kg/m3 were 55.6 and 52.6 and carbohydrates (%) in seeds were 22.2 and 17.5 in the first and second seasons, respectively. While, the
percentage increase in seed protein (%) due to cultivation of faba bean on (15th Nov) compared to cultivation on (1st Oct) were 38.3 and 36.65 in the first and second seasons, respectively. In this regard, Zain et al., 2014 reported that faba bean sowing in mid-October gave the highest values of yield and its components due to favorable environmental conditions for seed germination and long growing season upon sowing in early sowing.

Likewise, Turk and Tawaha 2017 pointed out that shortening the growing season when planting at the late date leads to a decrease in the amount of dry matter accumulated and number of pods per plant, which leads to a lack of yield. Similar findings were reported also by (Kawochar et al., 2011, Khalil et al., 2011 and Sharaan et al., 2014). EL-Metwally et al., 2018 found that the highest values of faba bean yield components were obtained when sowing was on 20th Oct. However, the lowest values were recorded at 10th Dec. sowing date. Abou-Taleb 2014 found that yield of faba bean and its components significantly decreased with the late sowing date. This is due to the differences between temperatures of day and night during plant growth stages.

2. Effect of silicon foliar application:

As for the effect of silicon foliar (potassium silicate) levels on some faba bean traits, data in Table (1 and 2) illustrate that excess foliar application of silicon levels up to 300 ppm led to a significant increase in all studied traits except pod length (cm) in both seasons. The highest value of these measurements can be obtained when spraying at a rate of 300 ppm silicon as compared with nil silicon (control) in both seasons. The increase percentages obtained with foliar silicon as 300 ppm compared with the control treatment were 18.0 and 16.7 % in plant height (cm), 42.0 and 39.8 % in number of pods plant<sup>-1</sup>, 39.1 and 35.0 in seed yield plant<sup>-1</sup>(g), 37.8 and 36.7% in 100 seed weight (g), 72.2 and 68.5% in harvest index (%), 21.9 and 18.7% in shelling (%), 38.7 and 37.1% in seed yield (kg/ fed.), 40.2 and 34.4% in straw yield (kg/ fed.), 19.0 and 18.1% in (WUE) kg/ m<sup>3</sup>. 8.0 and 7.3% in seed protein (%), as well as 49.8 and 48.4 % in seed carbohydrates (%) in the first and second seasons, respectively.

Results indicated that foliar application of 300 ppm silicon is quite enough to achieve the highest values of the studied parameters under the current experiment. Where, the good effect of silicon on plants is due to the fact that silicon increases the strength of building cell walls and participates in the activation of many important physiological processes within plant. Several studies indicate that the enhancing effect of silicon is evident under different stress conditions which plants are exposed, so it increases the plant's defense systems against low (Epstein 2011) and high temperatures (Hattori 2015), salinity (Van et al., 2017) and heavy metal toxicity (Shi et al., 2005). Silicon enhances the ability of plants to tolerate water stress by increase the ability of leaves to retain water, leaf tissue integrity, stomatal conductance, and xylem construction under high transpiration rates that leads to greater water use efficiency and active photosynthesis (Gao et al., 2016).

Table 1. Effect of sowing dates, Silicon foliar application and their interactions on yield and quality of faba bean during 2018/ 2019 and 2019/ 2020 growing seasons under New Valley conditions.

<table>
<thead>
<tr>
<th>Char.</th>
<th>Treatments</th>
<th>Plant height (cm)</th>
<th>Number of pods plant&lt;sup&gt;-1&lt;/sup&gt;</th>
<th>Pod length (cm)</th>
<th>Seed yield plant&lt;sup&gt;-1&lt;/sup&gt; (g)</th>
<th>100 seed weight (g)</th>
<th>Harvest index (%)</th>
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</thead>
<tbody>
<tr>
<td>Seasons</td>
<td>S&lt;sub&gt;1&lt;/sub&gt;</td>
<td>S&lt;sub&gt;2&lt;/sub&gt;</td>
<td>S&lt;sub&gt;1&lt;/sub&gt;</td>
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<td>S&lt;sub&gt;2&lt;/sub&gt;</td>
<td>S&lt;sub&gt;1&lt;/sub&gt;</td>
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<tr>
<td>Sowing dates</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 October</td>
<td>132</td>
<td>128</td>
<td>13.4</td>
<td>12.9</td>
<td>9.9</td>
<td>8.6</td>
<td>37.3</td>
</tr>
<tr>
<td>15 October</td>
<td>127</td>
<td>124</td>
<td>14.5</td>
<td>14.2</td>
<td>9.1</td>
<td>8.8</td>
<td>40.3</td>
</tr>
<tr>
<td>1 November</td>
<td>117</td>
<td>114</td>
<td>11.3</td>
<td>11.1</td>
<td>8.5</td>
<td>8.1</td>
<td>31.5</td>
</tr>
<tr>
<td>15 November</td>
<td>109</td>
<td>106</td>
<td>9.7</td>
<td>9.5</td>
<td>7.2</td>
<td>6.5</td>
<td>27.3</td>
</tr>
<tr>
<td>LSD at 5%</td>
<td>4</td>
<td>3</td>
<td>1.1</td>
<td>1.4</td>
<td>0.5</td>
<td>0.6</td>
<td>1.9</td>
</tr>
<tr>
<td>Silicon foliar application</td>
<td>0 (control)</td>
<td>111</td>
<td>108</td>
<td>10.0</td>
<td>9.8</td>
<td>6.7</td>
<td>6.2</td>
</tr>
<tr>
<td>100 ppm</td>
<td>117</td>
<td>114</td>
<td>11.5</td>
<td>11.3</td>
<td>7.1</td>
<td>6.9</td>
<td>31.9</td>
</tr>
<tr>
<td>200 ppm</td>
<td>125</td>
<td>123</td>
<td>13.1</td>
<td>12.5</td>
<td>7.8</td>
<td>7.6</td>
<td>36.4</td>
</tr>
<tr>
<td>300 ppm</td>
<td>131</td>
<td>126</td>
<td>14.2</td>
<td>13.7</td>
<td>8.3</td>
<td>8.0</td>
<td>39.5</td>
</tr>
<tr>
<td>LSD at 5%</td>
<td>2</td>
<td>1</td>
<td>0.6</td>
<td>0.5</td>
<td>NS</td>
<td>NS</td>
<td>1.8</td>
</tr>
</tbody>
</table>

Table 2. Effect of sowing dates, Silicon foliar application and their interactions on yield and quality of faba bean during 2018/2019 and 2019/2020 growing seasons under New Valley conditions.

<table>
<thead>
<tr>
<th>Character Treatments</th>
<th>Sowing dates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 October</td>
</tr>
<tr>
<td></td>
<td>S1</td>
</tr>
<tr>
<td>Seedling (%)</td>
<td>73.8%</td>
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<tr>
<td>Yield (kg/fed.)</td>
<td>628</td>
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<tr>
<td>Straw Yield (kg/fed.)</td>
<td>71.3</td>
</tr>
<tr>
<td>WUE kg/m²</td>
<td>68.5</td>
</tr>
<tr>
<td>Protein (%)</td>
<td>1.4</td>
</tr>
<tr>
<td>Carbohydrate (%)</td>
<td>0.1</td>
</tr>
</tbody>
</table>


Silicon can diminish the electrolyte leakage from plant leaves and therefore raised photosynthetic activity in plants grown under water stress conditions (Epstein 2011). Yin et al., 2017 found that addition of silicon leads to the formation of silica in the epidermal tissues of the leaves, which is responsible for increasing the leaves’ water retention under conditions of water shortage. Puti et al., 2017 found that foliar application of silicon increased 100 seed weight of faba bean by 120 %, seed yield by 65 %, number of pods plant⁻¹ by 42 % and protein by 23 % as compared with control, they concluded that the significant effect of using foliar application of silicon on yield and its components on faba bean may be due to alleviating the damage of both drought and heat stresses.

4. Effect of the interaction between sowing dates and silicon foliar application levels:

Results in Table (1 and 2) indicated that the interaction between sowing dates and silicon foliar application levels had a significant effect on all studied characters except, pod length (cm) don’t affected significantly by the interaction between the two studied factors in both seasons. The highest values of studied traits in concerning the number of pods plant⁻¹, seed yield plant⁻¹(g), 100 seed weight (g), harvest index (%), shellling (%), seed yield (kg/ fed.) and seed carbohydrates percentage were obtained when faba bean had sown on 1st Oct and spraying of plants by silicon at the rate of 300 ppm in both seasons. However, the highest values in concerning plant height (cm), pod length (cm), straw yield (kg/ fed.) and WUE (kg/m²) were obtained when faba bean had sown on 1st Oct and spraying of plants by silicon at the rate of 300 ppm in both seasons. On the other side, the highest values of seed protein (%) were obtained when faba bean had sown on 15th Oct and spraying of plants by silicon at the rate of 300 ppm in both seasons. Therefore, this study recommends the cultivation of faba bean on 15th Oct with spraying of 300 ppm silicon in the form potassium silicate to obtain the highest possible productivity under New Valley conditions.

REFERENCES


أتثر الرش بالسيلانيك ومواد الزراعة على أنتاج القش البلدي تحت ظروف الرياعي الجديد - مصر

حسام الدين أحمد فاروق شومان وعاء محمد محمود بغدادى

قسم الإنتاج النباتي - مراكز حميات الصحراء - القاهرة

أجريت تجربة تقييمية على المحطة الحقلية بمحافظة الجيزة خلال موسمي 2019-2020، وذلك لدراسة تأثير مواد الزراعة (1 أكتوبر 15 أكتوبر) وأثر الرش بالسيلانيك على نسبة الفاتورة ومحصول القش، والماء، وزن الألف بذرة، كفاءة نبات، وزن الألف بذرة، نسبة الكربوهيدرات في البذور، وكمية البروتين في البذور. حيث تم إعداد تواليات بذر برتقال، فراولة، برتقال، وزيتون، بناءً على نظام محدد للزراعة في كل من المطرية وأرياح الرياعي.

1. مقدمة

أدخل عنوان.

2. الدراسات السابقة

اقدم نظرة على الدراسات السابقة المتعلقة بالرش بالسيلانيك وزراعة الفول البلدي.

3. المواد والأساليب

أدخل النص على المواد والأساليب المستخدمة في التجربة.

4. نتائج

أدخل النص على النتائج التي تم الحصول عليها من التجربة.

5. الختم

أدخل النص على الختم والشكر.

ملاحظات إضافية

1. مراجعات:

اكتب النص على المراجعات التي تعدك.

2. قوائم الكلمات المفتقة:

اكتب النص على القوائم المفتقة التي تغطي الكلمات المفتقة المستخدمة في الدراسة.

3. الشخصيات المتوقعة:

اكتب النص على الشخصيات المتوقعة التي قد تكون مقتصرة على الدراسة.

4. الختام:

أدخل النص على الختام والشكر.

5. الختام:

أدخل النص على الختام والشكر.

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