Supplementary Applications of Phosphorus to Improve Yield and Fruit Quality of 'Le Conte' Pear Trees under Calcareous Soil Conditions

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ABSTRACT

Phosphorus (P) deficiency is one of the major problems in agricultural soils for crop production around the world. Mono ammonium phosphate (MAP) as foliar application used an effective tool to enhance nutritional status of fruit trees not only overcome leaf P deficiency but also improve flowering, increase yield and enhance fruit quality. However, use of bio fertilizers such as phosphorus solubilizing bacteria (PSB) proved to friendly environmentally and economical way for increasing P availability and improving P use efficiency under P deficiency conditions. Consequently, the aim of the present trail was to study the effects of MAP at 1% foliar application and/or soil application of phosphorus solubilizing bacteria (PSB) solely or in combination as supplementary P doses (beside H₃PO₄ common P fertigated source) under calcareous soil conditions on full bloom time, flowering %, yield (kg/tree) and fruit quality not only fruit physical properties i.e. fruit weight, length (L) and circumference (C), shape index (L/C) and fruit firmness but also fruit chemical components via TSS%, acidity%, and TSS/acid ratio as well as nutrient status of macro & micro leaf contents (N,P,K, Fe, Zn and Mn) of "Le Conte" pear trees. The experiment was carried out during the two successive seasons on 12 years old 'Le Conte" pear trees budded on betulifolia rootstocks (Pyrus betulifolia) grown in calcareous soil under drip irrigation system from Nile river source in a private orchid at Km 80 Alex-Cairo desert Road, El-Nubaria district, El-Behaira, Egypt. All trees received the standard horticultural practices & the experiment was designed in a complete randomized block and the treatments were as follows: (T1) control; H₃PO₄ common P fertigated source. (T2) T1 + MAP at 1 % as foliar application. (T3) T1 + Bacillus megatherium P solubilizing bacteria (PSB) as soil application. (T4) T2 +T3. The result showed that foliar MAP spray (T2) and PSB soil application (T3) independently improved all aforementioned parameters. However, both T2&T3 gave more or less similar result values and no significant differences were detected between them. In this respect, T2&T3 when applied together (T4) maximized to a grate extend enhancement in most studied parameters and increased yield (kg/tree) by about (167%) than the control. Improvement in leaf P nutritional status after MAP foliar spray to an adequate level (>0.3%) in the range of P and N fertilized plants as well as availability of P, Fe, Zn and Mn following soil PSB application improved nutritional status and help in better management of P fertilization in pear trees grown under calcareous soil condition. Generally, T4 (MAP + Psb) is recommended treatment since, it promotes effectively the nutrient status that achieved the shortest time to FBD, highest flowering %, yield and fruit quality of "Le-Conte" pear trees under calcareous soil conditions.

Keywords: MAP - Bacillus megaterium, H₃PO₄, calcareous soil, FBD, flowering%, yield, fruit quality, foliar spry.

1. Introduction

Pears (Pyrus communis L.) are favorites pome fruits in the temperate climate area. Pears are considered the 5th fruits among deciduous fruits after apples, grape, apricot and 'peach & nectarine' and...
the 8th fruits between all fruit crops after citrus, banana, apples, grape, 'mango & guava', apricot, and 'peach & nectarine' in distribution of fruits in the worldwide (Statista, 2019). The world production of pear reached to 23.92 million ton (Statista, 2019). In Egypt, 'Le-Conte' is the major cultivar, the total cultivated area fluctuated sharply during the last three decades. In 1990, the pear's cultivated area in Egypt was 6984 h. reduced in 1995 to 5601 h., while, in 2000 reduced again to 4173 h. and in 2005 reduced sharply to 2900 h. which presented the third of 1990's area due to the exaggerated infection of fire blight which detected for first time on a rare scale in 1962 in Egypt (Balabel et al., 2018).

In 2010, the pear area increased to 3631 and increased again to 4977 ha in 2017 which recorded the large area of pear in Egypt due to overcome fire blight infection with new resistant rootstocks and with some antibiotics spraying or horticultural practice for old orchards to give early flowering using dormant bud break agents and flower inducers by fertilization in starting growth stage. In 2019, the area reduced again to 4088 ha. (FAOSTAT, 2019). Recently, the pear planting area extended in newly reclaimed soil particularly in calcareous soils. Calcareous soils are hugely extending in the arid and semiarid regions, it is more than one-third world land surface area (FAOSTAT, 2019) and about 25-30% total area of Egypt (Taalab et al., 2019).

In calcareous soils where pH is high and CaCO₃ is dominated, plants suffer low availability of P would cause problems more serious than its deficiency. Increasing availability of P nutrient is important objective in plant nutrition (Khalefa, 2007). Therefore, nutrient management for fruit trees under calcareous soils differs from that in non-calcareous soils (Imas, 2000). However, mineral phosphorus (P) fertilization in calcareous soils is not efficient enough to ensure optimal plant growth. Therefore, a higher P input is generally needed (Pizzeghello et al., 2019). In this respect, supplementary applications of phosphorus fertilization as foliar application of mono-ammonium phosphate (MAP) and soil application of bio-fertilizer as phosphate (P)-solubilizing bacteria; Bacillus megaterium (Goldstein and Liu, 1987) may be an effective integrated P fertilization method under calcareous soil conditions with common soil application of H3PO4.

Mono ammonium phosphate MAP (NH₄H₂PO₄) fertilizer is a widely used source of phosphorus (P) & nitrogen (N) and it can be used effectively as foliar application under calcareous soils conditions because its characteristics i.e. crystalline powder, free of chloride and sodium, high purity & fully water-soluble elements, acidifying effect when use as soil application or fall on the soil after spraying that enhances nutrient availability such as K, P, Mg and micro-nutrients (Peterson, 1999; IPNI, 2021).

The mode of action of mono ammonium phosphate (MAP) as foliar application can be described as follows; upon dissolution of mono ammonium phosphate (NH₄H₂PO₄) fertilizer which is known as MAP separates to release NH₄⁺ cation and H₂PO₄⁻ anion; the low nitrogen content in the form NH₄⁺ (12%) is considered appropriate method to supply the phosphorus to plants and the high concentration of P in the form H₂PO₄⁻ (~61%) promotes effectively the optimal development of plant root system due to the rapid absorption by trees particularly in the stages of starting growth and flowering that effectively enhance the inflorescence and fruit set (Peterson, 1999; IPNI, 2021).

*Bacillus megaterium* as soil application enhances mineral uptake by plants through solubilizing insoluble P (Goldstein and Liu, 1987). The main mechanism of *Bacillus megaterium* recognized to be responsible for the solubilization of phosphorus is the production of different types of organic acids (gluconic, lactic, acetic and succinic). It produced high amount of lactic and acetic acids which had a direct influence on the amount of released phosphorus. *Bacillus megaterium* achieved high concentration of released phosphorus about 483 ± 5 mg/L (Saied et al., 2018).

The objective of this study was to evaluate the effect of mono ammonium phosphate (MAP) as a foliar spray alone or in combination with soil application of solubilizing insoluble P bacteria; *Bacillus megaterium* as supplementary dose beside the fertigated common P source; H3PO4 under calcareous soil conditions on the yield and fruit quality of fruit trees particular 'Le Conte' pear trees which are more suffering when P deficiency occurred under these soil condition.

**Materials and Methods Plant Materials**

The experiment was carried out during the two successive seasons of 2018 and 2019 on 'Le Conte' pear trees grown in a private orchard at 'Adam village', at Km 80 Alex-Cairo desert Road, El-Nubaria district, El-Beihaira Governorate, Egypt. The trees were 12 years old budded on *betulifolia* rootstocks (*Pyrus betulifolia*) and the selected trees were uniform in vigour, size and shape, planted at...
6 m between rows and 4 m between trees, grown in calcareous soil under drip irrigation system from Nile river source. All trees received the standard horticultural practices and the experiment was designed in a complete randomized block with three replications. Three trees were included per plot. Table (1) presented the physical and chemical analysis of experiment orchard soil.

Table 1: Physical and chemical properties of the experimental soil.

<table>
<thead>
<tr>
<th>Particle size distribution (%)</th>
<th>Texture</th>
<th>Ca CO₃ (%)</th>
<th>EC (1:1) dSm⁻¹</th>
<th>pH</th>
<th>Available nutrients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>Silt</td>
<td>Clay</td>
<td>19%</td>
<td>2.00</td>
<td>K⁺ 1.00  Na⁺ 5.4  Mg²⁺ 8.5  Ca⁺⁺ 13  SO₄⁻² 18.42  Cl⁻ 2.3  HCO₃⁻ 2.6  CO₂⁻ 0</td>
</tr>
<tr>
<td>70.32</td>
<td>18.30</td>
<td>10.38</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Treatments: the applications were as follows:

T1 (control) = H₃PO₄ (common fertigated P source in all treatments through drip irrigation).
T2 = H₃PO₄ + Mono ammonium phosphate (MAP) at 1%; NK (12/61) as foliar application.
T3 = H₃PO₄ + Bacillus megatherium P solubilizing bacteria (PSB) as soil application (bio-fertilizer).
T4 = H₃PO₄ + MAP as foliar application at 1% + Bacillus megatherium as soil application.

Where, T1 (control) presented adding H3PO4 as the common fertigated P source in the commercial orchids under calcareous soil conditions which added 50 cm³ per each m³ water irrigation.

Where, T2; MAP spray at 1 % applied two times; in the starting of growth stage in 2th week of Feb. and in full bloom time; 50% of flowering % while, Triton B at 0.1% as a wetting agent was added to the procedures and all trees were sprayed until the run off point. T3 (Bacillus megatherium P solubilizing bacteria; PSB) bio-fertilizer soil application conducted two times through drip irrigation; in the starting of growth stage (2th week of Feb.) and after fruit set immediately in 2nd week of April. Bacillus megaterium is provided by the Unit of Biofertilizers, Faculty of Agriculture, Ain Shams University, Shubra Al Kheimah, 11241 Al Qalyubia, Egypt. Where, B. megaterium was grown in batch culture to the late exponential phase of microorganism to give a cell suspension of 6 x 107 cell/ml. Each treated tree received 150 cm³ in its root zone.

Flowering behavior and yield parameters
(1) Full bloom date (FBD): no. days recorded from the starting growth stage until 50% flowering.
(2) Flowering Percentage (no. flower buds per shoot): Four branches from each side of tree were selected and labeled. No. flowering buds in full bloom was counted and the flowering % was calculated as the following equation which reported by Shaltout (1987): Flowering % = (No. of flowering buds/total No. of buds per shoot) x 100.

Yield: It expressed as weight of fruit/tree (kg) at the 1st August.

Fruit Physical Characteristics: Sample of 20 mature fruits were taken from each replicate tree of each treatment and determined the following physical characteristics: fruit weight (g), length (cm), circumference (cm), shape index (L/W), volume (cm³), specific gravity and fruit firmness (Lb./inch) by using pressure tester 5/16-inch plunger.

Fruit Chemical Characteristics: A juice of fruit samples used to determine chemical characteristics: Total soluble solids (TSS %) by using a hand refractometer, fruit acidity and TSS/Acid ratio according to AO.A.C. (2000).

Statistical Analysis
Data were analyzed by analysis of variance (ANOVA), and means were compared using Duncan's test at p < 0.05 to determine the significance of differences between the conducted treatments according to Duncan's (1955).
Results and Discussion

Table (2) shows the effect of mono ammonium phosphate (MAP) and/or *Bacillus megatherium* (BM), treatments on full bloom date (FBD), flower buds % per shoot and yield (kg/tree) of 'Le Conte' pear trees under calcareous soil during two seasons. It is clear from data that different treatments significantly varied on their effect from one to other than the control on the full bloom date (FBD) in the first and second season of study; where FBD is the number of days recorded from the starting growth stage until 50% flowering. In this respect, a particular trend was obviously noticed, MAP spray (T2) or BM soil application (T3) individually advanced full bloom date and gave similar time in the two seasons to reach full bloom and the number of days after treatment were significantly more advanced when both of them (MAP + BM) applied together (T4). T4 (MAP + BM) recorded the earliest full bloom date (FBD) which was 17 and 18 days after the treatment in both seasons. Meanwhile, T2 & T3 were similar in their effect on full bloom date (FBD) and recorded intermediate same days to reached full bloom; 23 and 24 days in both years for both treatments than the control which recorded the longest time to reach full bloom; 30 and 32 days in both years.

From the above result, it was noticed that a gradual decrease by all treatments T2 (MAP), T3 (BM) and T4 (MAP + BM) in number of days to full bloom than the control (T1), where the earliest time for full bloom was achieved by combined application of MAP + BM (T4). While, the individual treatment; T2 (MAP) and T3 (BM) came in the second order in decreasing the number of days from starting growth until 50% flowering (FBD). In other word, comparing with the control, present treatments; T2 (MAP), T3 (BM) and T4 (MAP + BM) significantly decreases the period of full bloom started from beginning the growth until the time of full bloom (flowering 50%). Furthermore, the combination treatment T4 (MAP + BM) gave the earliest time of full bloom compared with the individual application of T2 (MAP) or T3 (BM).

Table 2: Effect of phosphor treatments on full bloom date, flowering % and yield of 'Le Conte' pear trees under calcareous soil during two seasons.

<table>
<thead>
<tr>
<th>Treatments*</th>
<th>Full bloom date (FBD)** (No. days after treatment)</th>
<th>Flowering % (Flower buds % per shoot)</th>
<th>Yield (kg/tree)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st Season</td>
<td>2nd Season</td>
<td>1st Season</td>
</tr>
<tr>
<td>T1</td>
<td>30 c</td>
<td>32 c</td>
<td>13.1 c</td>
</tr>
<tr>
<td>T2</td>
<td>23 b</td>
<td>24 b</td>
<td>20.4 b</td>
</tr>
<tr>
<td>T3</td>
<td>23 b</td>
<td>24 b</td>
<td>19.9 b</td>
</tr>
<tr>
<td>T4</td>
<td>17 a</td>
<td>18 a</td>
<td>25.7 a</td>
</tr>
</tbody>
</table>

Means within a column followed by different letter (s) are statistically different at 5 % level.

Concerning flowering % (flower buds % per shoot), the highest percent was achieved by T4 which significantly increased flowering % compared with all other treatments and was 25.7% and 25.6 % in both seasons. While, T2 and T3 recorded less values comparing with T4 and were 20.4% 19.9% in the 1st year and 21.2% and 19.8% in the 2nd one, respectively.

The least percent flowering per shoot was obtained by the control (T1); 13.1% and 13.7% in both seasons. Regarding the yield as shown in Table (2), MAP was applied as foliar spray (T2), BM was added as soil application (T3) and the combination between them (T4) increase the yield (kg/tree) over the control (T1).

The highest yield was achieved by T4; 32.2 and 30.6 kg/tree in both years, however, T2 and T3 gave intermediate yield values with no significance between them, where the values were 27.9 and 26.2 kg/tree in 1st season and 25.4 and 24.7 kg/tree in 2nd season, respectively. Meanwhile, the control (T1) recorded the lowest yield; 18.6 and 19.2 kg/tree in both seasons. Generally, T4 increased the yield about 167 % (average of both seasons), followed by T2 (141%) and T3 (133%) with the same significant values.

However, flowering percent and yield (kg/tree) in "Le-Conte" pear increased significantly by different treatments than the control. The impact of MAP and BM application individually (T2&T3) or in combination (T4) followed by the same trend obtained by different treatment on time of full bloom (parameter) in the two seasons of this experiment. It is seen that a synergistic effect was detected on most studied parameters when BM as a biofertilizer was concluded with MAP foliar application than
applied each of them individually and this effect of combination recorded the highest flowering % (25.7% and 25.6%) and yield (32.2 and 30. 6 Kg/tree) compared with the control which recorded the lowest flowering buds % per shoot (13.1% and 13.7%) and fruit yield (18.6 and 19.2) in the 1st year and 2nd year, respectively. Table (3) revealed that effect of phosphor treatments on fruit weight, length, circumference and fruit shape index of 'Le Conte' pear trees under calcareous soil during two seasons. Concerning fruit weight, T2, T3 & T4 gave the higher significant fruit weight than the control (T1) in both seasons; whereas fruit weight values of T2 was 180.3 & 175.9 gm, T3 was 185.7 & 168.5 gm and T4 was 177.5 & 188.4 gm; with the same significant values compared to T1 that recorded the lowest fruit weight values; 123.1 & 135.6 gm in the 1st and 2nd seasons, respectively. The same trend was observed in other studied parameters i.e. fruit physical characteristics as fruit length, and circumference with no significance particular trend between them.

The values of fruit length ranged from 10.3 to 10.6 cm in the 1st season and from 9.6 to 10.5 cm in the 2nd seasons. Regarding fruit shape index, there were no differences between all treatments and the values ranged from 0.55 to 0.58 in the 1st year and from 0.53 to 0.62 in the 2nd year. Physical parameters of 'Le-Conete' pear fruit in 2018 and 2019 seasons as shown in Table (3) revealed that fruit weight (gm), fruit length (cm), fruit circumference (cm) and fruit shape index (L/C) increased significantly than the control, except shape index which was not affected by any treatments comparing to the control or between each of them.

Table 3: Effect of phosphor treatments on fruit weight, length, circumference and fruit shape index of 'Le Conte' pear trees under calcareous soil during two seasons.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Fruit Weight (g)</th>
<th>Fruit length (cm)</th>
<th>Fruit circumference (cm)</th>
<th>Fruit shape index (L/C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st Season</td>
<td>2nd Season</td>
<td>1st Season</td>
<td>2nd Season</td>
</tr>
<tr>
<td>T1</td>
<td>123.1b</td>
<td>135.6b</td>
<td>8.3 b</td>
<td>8.6 b</td>
</tr>
<tr>
<td>T2</td>
<td>177.5 a</td>
<td>188.4 a</td>
<td>10.6 a</td>
<td>10.5 a</td>
</tr>
<tr>
<td>T3</td>
<td>185.7 a</td>
<td>168.5 a</td>
<td>10.3 a</td>
<td>9.6 a</td>
</tr>
<tr>
<td>T4</td>
<td>180.3 a</td>
<td>175.9 a</td>
<td>10.4 a</td>
<td>10.1 a</td>
</tr>
</tbody>
</table>

Means within a column followed by different letter (s) are statistically different at 5 % level.

It is shown from Table (4) that all supplemented treatments; foliar application of mono ammonium phosphate (T2), Bacillus megatherium soil application (T3) or together (T4) had positive effect on fruit physical parameters; fruit volume and fruit firmness of 'Le Conte' pear trees under calcareous soil during the two seasons. However, different studied treatments had no effect on specific gravity values. In this regard, supplemented treatments T2, T3 & T4 had significant increase in fruit volume values i.e.185.2 & 176.1 and 178.6 cm³ in the 1st season and 165.6 & 185.3 and 175.1 cm³ in the 2nd season, respectively over the control (T1) that recorded 120.3 & 135.0 cm³ in the 1st season and 2nd season, respectively. Concerning fruit firmness, it was clear that the supplementary applications; T2, T3 & T4 decreased significantly fruit firmness that ranged between 11.3, 12.2 and 7.8 lb./inch² in the 1st season and 12.0, 11.1 and 6.7 lb./inch² in the 2nd season than T1 which was 19.1 and 16.6 lb./inch² in both seasons. However, this effect was clearly noticed in T4 that recorded the lowest significant values in both seasons; 7.8 and 6.7 lb./inch².

Table 4: Effect of phosphor treatments on fruit volume, specific gravity and fruit firmness of 'Le Conte' pear trees under calcareous soil during two seasons.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Fruit volume (cm³)</th>
<th>Specific gravity (g / cm³)</th>
<th>Fruit firmness (lb./inch²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st Season</td>
<td>2nd Season</td>
<td>1st Season</td>
</tr>
<tr>
<td>T1</td>
<td>120.3 b</td>
<td>135.0 b</td>
<td>1.02 a</td>
</tr>
<tr>
<td>T2</td>
<td>185.2 a</td>
<td>165.6 a</td>
<td>1.00 a</td>
</tr>
<tr>
<td>T3</td>
<td>176.1 a</td>
<td>185.3 a</td>
<td>1.01 a</td>
</tr>
<tr>
<td>T4</td>
<td>178.6 a</td>
<td>175.1 a</td>
<td>1.01 a</td>
</tr>
</tbody>
</table>

Means within a column followed by different letter (s) are statistically different at 5 % level.

It is obvious from Table (5) that supplement treatments application (T2, T3 & T4) had gradual
increase on T.S.S. and T.S.S./acid ratio comparing with T1 during the two years of this study. The values of T.S.S. for T2, T3 & T4 were 12.8, 13.2 and 13.8 % in 1st year and 11.5, 12.8 and 13.5% in 2nd year, respectively comparing with T1 which was 10.5 and 9.5 % in both seasons. In this respect, T.S.S. / acid ratio followed the same trend of supplement treatments effects on T.S.S during the two studied seasons. T.S.S. / acid ratio values recorded 53.13, 73.40 & 86.16 in 1st season and 44.37, 58.63 & 71.20 in 2nd season, respectively compared with T1 which estimated 26.21 & 25.7 in both years.

Table 5: Effect of phosphor treatments on total soluble solids (T.S.S), acidity and T.S.S/acid ratio

<table>
<thead>
<tr>
<th>Treatments</th>
<th>T.S.S (%)</th>
<th>Acidity % (mg/gm)</th>
<th>T.S.S/acid ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>10.5 c</td>
<td>0.40 a</td>
<td>26.21 c</td>
</tr>
<tr>
<td>T2</td>
<td>12.8 b</td>
<td>0.24 ab</td>
<td>53.13 bc</td>
</tr>
<tr>
<td>T3</td>
<td>13.2 ab</td>
<td>0.18 ab</td>
<td>73.40 ab</td>
</tr>
<tr>
<td>T4</td>
<td>13.8 a</td>
<td>0.16 b</td>
<td>86.16 a</td>
</tr>
</tbody>
</table>

Means within a column followed by different letter (s) are statistically different at 5 % level.

In the contrary, the supplement treatments application (T2, T3 & T4) had gradual decrease in acidity% than T1 that recorded the highest fruit acidity i.e. 0.40 & 0.38 mg/g, meanwhile T4 recorded the lowest significant acidity % i.e. 0.16 & 0.19 mg/g than T1 in both seasons. However, T2 & T3 gave intermediate acidity % values (0.24 & 0.18 mg/g in 1st season and 0.26 & 0.22 in mg/g 2nd season, respectively). From our results, it is clear that T4 not only increased yield but also improved fruit quality with early harvest. From the obtained results, it is obviously noticed that full bloom date (FBD), flowering shoot buds %, yield and firmness followed the same trend in both seasons of the experiment. In this respect, MAP (T2) or BM (T3) applied individually increased most studied parameters than the control with no significance between them, while when MAP + BM as supplementary application (T4); significantly increased the studied parameters and recorded the highest significant values. This may be due to the role of mono ammonium phosphate (MAP) which act as a flower bud inducer and consequently occurred the early flowering. Moreover, BM may act as a soil conditioner under calcareous soil and it impacts on availability of nutrients in root zone, specially microelement i.e. Fe, Zn and Mn that reflected on improving the nutritional status in the lowest level to the optimum level that increased flowering %, yield and fruit quality. This result may explain the superiority of combination applied of MAP + BM than those when applied individually.

It is clear from Table (6) that leaf content of NPK increased significantly in pear cv. "Le Conte" than the control in the two seasons of experiment. The highest N%, P% and K% in leaves were taken from pear trees sprayed with MAP + BM soil application (T4) and recorded 2.09 & 2.02% leaf N content; 0.32 & 0.34% P leaf content and 1.42 & 1.60% leaf K content than the control which recorded 1.62 & 1.51% N leaf content, 0.14 & 0.15% P leaf content and 1.15 & 1.33 K leaf content in 1st year and in 2nd year, respectively. As shown in Table (6), spraying MAP (T2) or BM (T3) individually significantly increased NPK content in leaves compared with the control. This was true in both studied seasons. More significant increase in N, P and K content in leaves was recorded when MAP spraying combined with BM soil application (T4).

Table 6: Effect of phosphor treatments on NPK leaf content of 'Le Conte' pear trees under calcareous

<table>
<thead>
<tr>
<th>Treatments</th>
<th>N %</th>
<th>P %</th>
<th>K %</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>1.62 c</td>
<td>0.14 c</td>
<td>1.15 c</td>
</tr>
<tr>
<td>T2</td>
<td>1.96 b</td>
<td>0.23 b</td>
<td>1.27 b</td>
</tr>
<tr>
<td>T3</td>
<td>1.91 b</td>
<td>0.24 b</td>
<td>1.26 b</td>
</tr>
<tr>
<td>T4</td>
<td>2.09 a</td>
<td>0.32 a</td>
<td>1.42 a</td>
</tr>
</tbody>
</table>

Means within a column followed by different letter (s) are statistically different at 5 % level.

It is shown from Table (7) that supplement treatments; T2, T3 & T4 had clear increasing in Fe, Zn and Mn leaf content comparing with T1 during the two years of this study. Leaf content of Fe, Zn and Mn followed in somewhat effect of treatments on N, P and K except BM soil application (T3) gave mor or less similar Fe, Zn and Mn leaf content to those obtained by MAP spray + BM soil application (T4).
In other words, T3 and T4 effects on leaf content of Fe, Zn and Mn were similar from the statistical stand point, where "Le Conte" pear trees treated with BM soil application in both applications of this investigation. This means the increasing in Fe, Zn and Mn leaf content of "Le Conte" pear trees was mainly referred to BM which may be act as soil conditioner for release the fixed micro nutrient under calcareous soil condition.

From above mentioned parameters, the gradual significant increase in N, P and K in 'Le Conte' pear leaves may be most the enhancement in studied parameters of full bloom date (FBD), flowering %, yield (kg/tree), physical and chemical fruit characteristics and leaf content of N, P, K, Fe, Zn and Mn could be refer to the role of the applied materials; N and P used as foliar application in the form of MAP (NPK; 12/61/0) and biofertilizer used as BM as a source not only for P soil released but also K soil released and microelement availability to uptake cause the biofertilizer reduce the soil pH. These material applications include many nutrient sources; MAP (NP) and BM (release nutrient soil of P, K, Fe, Zn and Mn) and this may explain the improve in most studied parameters. As for application of biofertilizer which released fixed nutrients under calcareous soil conditions, particularly micro elements; Fe, Zn and Mn in root zone be available to translocation to plant parts, enhancing nutritional status in leaves, improving fruit flowering, yield and fruit quality.

From the obtained results, it is obviously noticed that full bloom date (FBD), flowering % (no. flower buds per shoot), yield (Kg/tree) and fruit physical and chemical parameters followed the same trend in 12 the two seasons of study In this respect, MAP (T2) or BM (T3) applied individually increased most studied parameters than the control with no significance between them, while when MAP + BM as supplementary application (T4); significantly increased the studied parameters and recorded the highest significant values. This may be due to the role of mono ammonium phosphate (MAP) which act as a flower bud inducer and consequently accelerate full bloom date (FBD) and occurred the early flowering. Moreover, BM may act as a soil conditioner under calcareous soil and it impacts on availability of nutrients in root zone, specially microelement i.e. Fe, Zn and Mn that reflected on improving the nutritional status in the lowest level to the optimum level that increased flowering %, giving high yield and improved fruit quality by advancing fruit maturity in the term of decrease fruit firmness and increase T.S.S. & T.S.S acid ratio and enhanced nutrition status of N, P, K, Fe, Zn, Mn. This result may explain the superiority of combination applied of MAP + BM than those when applied individually. Generally, the soil application of *Bacillus megatherium* (bio fertilizer) companied with H3PO4 as common fertigated P source had a positive effect on all studied parameters. This effect was maximized by foliar application of mono ammonium phosphate (MAP). On other words, the presence of *Bacillus megatherium* (bio fertilizer) as soil application companied with foliar application of mono ammonium phosphate (MAP) as foliar application plus H3PO4 as soil application had a synergic effect on studied parameters.

Concerning P foliar spray, our results is in harmony with those mentioned by Koontz and Biddulph (1957) determined the effects of variants affecting the absorption and translocation of P foliar spray; (1) wetting agents, (2) P spray concentration, (3) surface of leaf (upper vs lower surface), (4) various P compounds (pH and cation), (5) Duration, (6) hygroscopic of agent, (7) area size that sprayed, (8) leaf age and position that sprayed, and (9) P plant level. A spray application method proves superior to leaf vein injection and droplet methods. P amount translocated from the treated leaf in a 24-hour period increased as the amount applied increased; and it was independent of leaf area treated, except possibly at the highest concentration, and of the leaf surface treated (upper or lower).

More phosphorus was translocated from older (lower) leaves than from younger (upper) leaves.
(very young leaves did not export phosphorus), and the leaves contributed phosphorus to the root in proportion to their proximity to it. All leaves which exported phosphorus contributed approximately equal amounts to the stem apex. Translocation of applied phosphorus was greatest with NH4PO4 and followed by the following compounds: KH2PO4 > K2HPO4 - Na2HPO4 - NH4H2PO4 (MAP) - (NH4)2HPO4 (DAP) > H3PO4 (injury) > KH2PO4 - Na2PO4. The amount of phosphorus translocated from a given compound appeared to be directly related to the drying time of the solution on the leaf. Glycerin increased the translocation from KH2PO4 to the level of NH4PO4 but reduced the translocation from K2HPO4, probably because a complex was formed.

Also, Reddy and Majmudar (1983) noticed that sprayed 'Langra' mango trees with orthophosphoric acid (0.5%) improved fruit set, yield and fruit quality as well as P leaf content and gave higher yields when applied P spray with urea 2%. In addition, Kassem et al. (2010) found that spray of orthophosphoric acid (3 ml/L) increased fruit weight, T.S.S. %, total sugars, reducing sugars, carotene and V.C contents as well as decreased fruit acidity% and tannin contents in persimmon trees cv. Costata. Moreover, Mullins and Sikora (1990) evaluate nine fertilizers of MAP which produced in Florida, Idaho and North Carolina, USA compared with reagent grade MAP. They found that leaf P content and yield was affected by all sources of MAP and the yield differences among MAP sources. MAP sources performance was not related to water-soluble P percentage or the content of metallic elements. Therefore, the MAP is recommended for improving yield and fruit quality.

Furthermore, Raese (1998) stated that mono ammonium phosphate fertilizer increased P leaf content of apple and pear trees upon soil-surface applications. In addition, Neilsen et al., (2008) found that leaf P content of apple consistently increased by the P treatments that achieved 20% increase in yield and improve fruit quality attributes. i.e. fruit size, T.S.S% and acidity however, red coloration was unaffected by P application. The applications of 20 g P as ammonium polyphosphate annually at bloom. Moreover, Erel et al. (2008) studied effect of N, P and K on flowering and fruit set of olive.

They found that the availability of N, P, and K was found to influence flowering intensity in the olive trees. Fruit set was affected by N and P, but not K levels. The yield and the final number of olives per tree increased appreciably as leaf P and K. These findings confirmed our results in use (MAP); NP: 12/61 as foliar application as well as use BM as a source not only for P soil released but also for K soil released and microelement availability to uptake cause the MB reduce the soil pH. Therefore, MAP includes NP and BM release nutrient soil of P, K, Fe, Zn and Mn and this may explain the improvement of most studied parameters in our study specially yield (kg/tree). Meanwhile, Schreiner (2010) sprayed MAP (NH4H2PO4) on 'Pinot noir' grapevines and found increasing P content in leaf blade and petiole. Moreover, Hidaka and Kitayama (2013) confirmed that plants optimize the allocation of P among foliar P fractions for maintaining their productivity and growth and for reducing demand for P as their adaptation to P-poor soils.

Our results are also in parallel with Rajasekar et al., (2017) mentioned that foliar fertilization is nutrition through leaves, is a very efficient technique of supplementary fertilization. It is very important because it facilitate easy and quick consumption of nutrients by penetrating the stomata or leaf cuticle and enters the cells. It is used as a means of supplying supplemental doses of macro and micro-nutrients, plant hormones, stimulants, and other beneficial substances. It is determined that during plant growth supplementary foliar fertilization increase mineral status and improve yield. Also, Shaheen (2019) sprayed the trees of Picual and Kalamata olive cultivars with 1% of mono ammonium phosphate (MAP), mono potassium phosphate (MKP) and urea phosphate (UP). She found a positive effect in improving flowering, yield, fruit attribute, fruit oil content and reduction in no. dropped fruits.

Concerning P solubilizing bacteria (PSB), our results are in agreement with many researches. In this regard, Young (1990) reported that a synergistic effect is noticed by P solubilizing bacteria (PSB) on promoting the vegetative growth of tree species in subtropical-tropical soils as well as PSB improved availability of P in theses soils. Moreover, Khan et al., (2008) confirmed that P solubilizing bacteria plays a great role in P nutrition by increasing its availability to plants through release from inorganic and organic soil P pools by solubilization and mineralization. Principal mechanism in soil for mineral phosphate solubilization is lowering of soil pH by microbial production of organic acids and mineralization of organic P by acid phosphatases. Use of P solubilizing bacteria as inoculants enhances P uptake. These bacteria also increase prospects of using phosphatic rocks in crop production. Greater efficiency of P solubilizing bacteria has been shown through co-inoculation with other beneficial bacteria and mycorrhiza. Furthermore, Park et al., (2010) isolate 19 phosphate solubilizing bacteria
(PSB) from different soils and evaluate their potential for P solubilization from insoluble P compounds. The uptake of P by plants is limited due to its strong adsorption onto soil particles and low solubility of phosphate compounds in soil solution and found that six strains solubilized more than 250 mg/L of P from tricalcium phosphate. Direct inoculation of PSB to rock phosphate increased the citric acid solubility of rock phosphate indicating that the isolated PSB strain was effective for P solubilization in soil.

Meanwhile, Liang et al., (2020) conducted a novel phosphate-solubilizing bacteria (PSB) consist of 18 microbial strains on eight plant species planted at P-deficient soils in Southern China and found after application, the microbial phosphate-solubilizing bacteria (PSB) enhanced P-cycling potential and P leaf content of plants were higher in the treated soils than the untreated one. In addition, Song et al., (2021) reported that phosphate-solubilizing bacteria (PSB) improved growth of Ulmus chenmoui trees in Eastern China and had regulated its microbial community of rhizosphere. Therefore, PSB could be effective to promote the high yield and fruit quality and the cultivation of Ulmus chenmoui trees.

Concerning the effect of PSB on pear trees, Perazzoli et al., (2020) found that biofertilizer application (PSB) raised the P leaves content and gave favoring pear fruit production, however it reduces fruit dry matter content, T.S.S and boron content percentages as well as it has no effect on fruit firmness and titratable acidity. Generally, biofertilizer application (PSB) has positive effect on the mineral N dynamics in the soil as well as promotes microelements availability in the soil that increases the mineral nutritional status of trees and reflects on improving the productivity of pear trees.

In the other side, Veberic et al., (2005) stated that P spraying reduced photosynthesis and K transpiration of apple leaves than untreated ones. However, PK spraying is considered a benefit tool to maximize the water use efficiency throughout the summer. Schreiner (2010) found that MAP spray had no influence on vegetative growth, yield and fruit quality parameters of 'Pinot noir' grapevines and there is a little benefit to spray P on the canopy of vines, even in vineyards with low P status. Brunetto et al., (2015) and Nava et al., (2016) mentioned that phosphorus application on the soil of pear trees cv. Rocha' grafted onto the rootstock Pyrus caleriana as well as Fuji apple increased the nutrient content of soil and leaf, but did not affect the fruit quality and yield. In addition, Chatzitheodorou et al., (2004) reported that fruit yield and quality of the peach cvs. 'Red Haven' and 'Spring Time' reach to 15 years-old did not respond in to P fertilizer alone or in combination with K, indicating a genotypic effect since, the lowest yield (kg/ trees) of peach cvs. 'Red Haven' and Spring Time' was recorded in the treatments with P, PK, and the control.

Conclusion

All supplemented treatments; mono ammonium phosphate (MAP) as foliar application (T2), Bacillus megatherium (BM) as soil application (T3) or together; MAP + BM (T4) had positive effect on full bloom date (FBD), flowering percentage, yield, fruit quality and nutritional status of 'Le Conte' pear trees under calcareous soil during the two seasons compared with the control. T4 recorded the shortest time to FBD with the highest flowering percentage and yield as well improved fruit quality by advance fruit maturity, followed by T2 and T3 which were significantly similar in their effect on all studied parameters with intermediate values. This improving in all studied parameter by supplemented treatments; T2, T3 & T4 may be due to the role of MAP which act as flower bud inducer and consequently accelerate full bloom date (FBD) and occurred the early flowering. Moreover, BM may act as a soil conditioner under calcareous soil and it impacts on availability of nutrients in root zone, specially microelement i.e. Fe, Zn and Mn that reflected on improving the nutritional status in the lowest level to the optimum level that increased flowering %, giving high yield and improved fruit quality by advancing fruit maturity in the term of decrease fruit firmness and increase T.S.S. & T.SS acid ratio and enhanced nutrition status of N,P,K, Fe, Zn, Mn. The combination applied of MAP + BM (T4) was superiority than those when applied individually. Therefore, T4 is the recommended treatments since it has a synergic effect on all studied parameters.

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